

PHASE III REPORT

Equitable Access Initiative

Institute for Health Metrics and Evaluation

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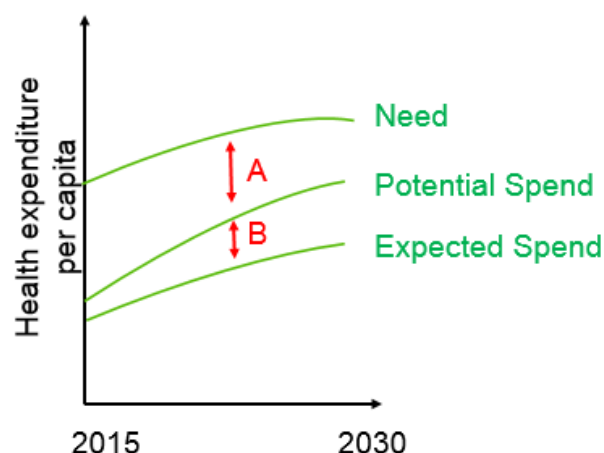
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EXECUTIVE SUMMARY

The framework developed by the Institute for Health Metrics and Evaluation (IHME) is an easily understood, forward looking assessment of the resources needed to reach a health goal. This framework takes into account expected and potential government spending, as well as how efficiently countries are utilizing resources. The framework addresses limitations of existing frameworks, is grounded in empirical evidence, and can be flexibly adapted to an organization's specific goals. This is accomplished through use of datasets such as the Global Burden of Disease (GBD) that provides a systematic comparison of health burden across a comprehensive set of diseases and injuries. Using this cause-specific data allows the framework to be tailored to prioritize the specific aims of each organization. During Phase III, IHME has refined the theoretical framework, provided more detail on the framework itself and its two applications – child and maternal health, and further developed our measurement of potential spending. Potential spending is a valuable gage that indicates the amount of resources a country could have available for health or a specific health priority area. Potential spend estimates are akin to a country's ability to pay or fiscal capacity. Complementing these additions, more information has been added to the annexes of this document. These annexes provide information about methods used to estimate expected and potential spending, as well as our estimates of resources needed.

Our framework is built on three elements (Figure 1). It highlights the gap between resources needed to reach a specific goal (*N*), a country's government's expected spending (*ES*), and a country's potential government spending relative to peers (*PS*). Identifying these gaps provides valuable information that governments and donors can use to assess financial sustainability, and aid allocation and eligibility. These elements are intended to be health focus area specific, and are described in further detail below. This framework is "incentive compatible" such that stakeholders can differentiate between resources that could be achieved locally (*B*) and total amount of resources needed to meet the health goal (*A+B*). If an outside funder (aid agency or federal government) focuses on filling gap *A*, it does not take away the incentive for local policymakers to spend more and fill gap *B*. Similarly, outside funders can utilize creative financing methods to incentivize local resources to meet the need in gap *B*.

Figure 1: Comparing financial resources expected to be spent, potentially spent, and needed



Needed Resources (*N*):

Needed resources is the expenditure required to reach a specific goal. For the case studies, we leverage the GBD 2013 study which systematically produces prevalence, incidence, mortality, morbidity, and health burden estimates for over 300 causes of illness for each country in the world, from 1990 through 2013. These estimates highlight where changes are needed to reduce avoidable mortality and morbidity.

We combine these existing estimates of health burden with a prospective target based on the Sustainable Development Goals (SDGs).

To estimate the resources needed to reach the stated health goals, we utilize historical expenditure data on health combined with trends in key health outcomes. These estimates take into consideration complex contextual factors such as health system capacity and efficiency. Estimated costs, for example, are lower in countries with more capacity and greater efficiency.

GBD measures the overall health of the population. Reducing health inequality is also an important health system goal. The IHME health framework can be utilized to prioritize health equity separately or in conjunction with goals of improving overall population health. For example, ongoing GBD research is estimating child mortality for each square kilometer for sub-Saharan countries. These granular estimates will illustrate health inequity, and can be used to prioritize where governments and donors invest.

Expected Spending (ES):

Expected spending is government expenditure that targets a specific health focus area, such as spending on the prevention and treatment of HIV/AIDS, or child immunizations. Building on IHME's financing and forecasting work, government health expenditure and GDP per capita forecasts are utilized to estimate health focus area spending through 2030. More information on how spending is forecasted is provided below and in the accompanying methods annexes.

Potential Spending (PS):

Potential spending identifies the amount of resources that a government is expected to be able to pay. These estimates are also referred to as a country's ability to pay or its fiscal space. These estimates are valuable because they indicate a health spending benchmark against which a country's spending could be compared. In situations where calculating need is impossible because of data limitations or lack of explicit goals, potential spending can itself be used as an indicator of where more funds are needed. In addition, juxtaposing potential spending with actual spending highlights where increased local spending can be incentivized.

For the two applications of the IHME framework, potential spending is forecasted through 2030 to identify the gap that exists between the resources needed to reach the child and maternal health SDGs. Because of the prospective nature of these forecasts, potential spending is calculated in a very simple manner and the amount of spending per person is determined simply as a function of the country's level of development. In addition to this, we illustrate in this report a more comprehensive measurement of ability to pay that adjusts the data for outliers, considering a broader set of potential health spending drivers, and model specification. This complementary example is based on 2012 data, but highlights how historic health spending can be compared with one measure of a country's ability to pay. Information on the methods used for the potential spending forecasts and the more comprehensive 2012 analyses are included below and in the accompanying methods annexes.

BACKGROUND

The Equitable Access Initiative (EAI) aims to provide a framework for health investment. This work focuses on low- and middle-income countries; and underlines how, despite economic development, major health gaps and inequities remain in these countries. To aid in this work, the Institute for Health Metrics and Evaluation (IHME) has developed an easily understood framework to measure where additional resources are needed to reduce avoidable mortality and morbidity and to meet health goals. It is founded on the principle that objective measurement provides the clearest guide to improve health and save lives.

The IHME framework is multidimensional and dynamic, assessing health burden and need for health resources over time. The framework hinges on comprehensive, comparable data and forward-looking objective goals. Building from this base, the framework highlights gaps between how much is expected to be spent on health, how much could potentially be spent on health, and how much is needed to achieve specific health goals. The IHME framework is highly flexible so that it can be used by a diverse set of national and local governments, donors, policy advocates, or policymakers. The intent is that the IHME framework can be customized to meet the needs of any ministry or agency balancing the demand for health resources and assessing financial sustainability. Using comparable health burden data, the framework can be adapted to provide objective evidence in the short- or long-run, cross-national or sub-national level, and across all health areas or focusing on specific health focus area.

The cornerstone of the IHME health framework is comparable and comprehensive data. These data are integral to providing an objective evidence base for the investment of health resources. Understanding how health burden varies across causes of illness, across countries, and across subnational units is foundational for the provision of objective guidance on where health resources are most needed. The Global Burden of Disease (GBD) 2013 Study provides comparable prevalence, incidence, mortality, and morbidity estimates for all age-groups, all countries, and a comprehensive set of more than 300 causes of illness. Because these estimates are produced in a systematic and comprehensive manner, they provide a foundation for comparing health burden and need for health resources. The GBD 2013 projects involves more than 1,000 researchers from 108 countries, synthesizing over 1 billion data points.

In addition to measurements of population health status, current, expected, and potential health spending estimates are also key for evaluating and identifying health spending gaps. The objective of this work is to provide a framework for systematically combining these data – health burden, costs, and spending data – to generate a comprehensive perspective on where resources for health are most needed.

OVERVIEW OF THE FRAMEWORK AND INTRODUCTION TO THE CASE STUDIES

The IHME framework revolves around measuring the gaps between three principle measurements: resources needed to reach an objective health goal (*need; N*), government resources currently being spent to achieve that health goal (*expected spending; ES*), and government resources that could be potentially spent to achieve that health goal (*potential spending; PS*). Identifying the gaps between these three measures, highlighted in Figure 1, quantifies the investments needed to reach critical health goals. These three elements can be measured so that they are health focus area specific, utilizing cause-specific health burden, cost, and spending data to generate cause-specific estimates.

The framework is forward looking and goal-oriented. Identification of the resources needed can only be done with a specific future goal in mind; and the framework takes into account the likely trajectory of government spending on a particular health area given past spending patterns and future economic growth.

To provide a detailed explanation of the IHME framework, this report focuses on each of the three principle measurements – need, expected spending, and potential spending – in turn. To demonstrate the power of the framework, two case studies are also provided. The two case studies are for child mortality and maternal mortality, both of which have clear 2030 targets articulated in the preliminary versions of the SDGs. This report walks step-by-step through the application of the framework to these two health focus areas, highlighting important conclusions at the end. The purpose of these case studies is not to provide exact estimates for allocation of health resources for any one government or agency, rather to provide two illustrations of how the framework might be applied.

FRAMEWORK

A. Resources needed to meet an objective health goal (*N*)

The first principle measurement needed for the IHME framework is a measurement of the resources needed to meet an objective health goal. This measurement is based fundamentally on population health data, measured nationally or sub-nationally to reflect health equity. In addition to this, marginal cost data measuring the costs associated with improving health outcomes is needed.

Population health

The two case studies we have produced are for child mortality and maternal mortality. For the case studies, we leverage the GBD 2013 study which systematically produces prevalence, incidence, mortality, morbidity, and health burden estimates for over 300 causes of illness for each country in the world from 1990 through 2013. These estimates highlight where changes are needed to reduce avoidable mortality and morbidity. We combine these existing estimates of health burden with a prospective target based on the Sustainable Development Goals (SDGs).¹ Using the GBD, needed resources for other health focus areas could be produced. Figures 2 through 4 highlight the diversity in health burden across the globe. These figures are merely examples, and a nearly infinite set of estimates can be extracted from the publically available GBD databases focusing on specific age groups, sexes, or causes of illness, with measurements for prevalence, incidence, mortality, morbidity, or Disability Adjusted Life Years (DALYs).

Figure 2: HIV/AIDS DALY rate per 100,000 in 2013

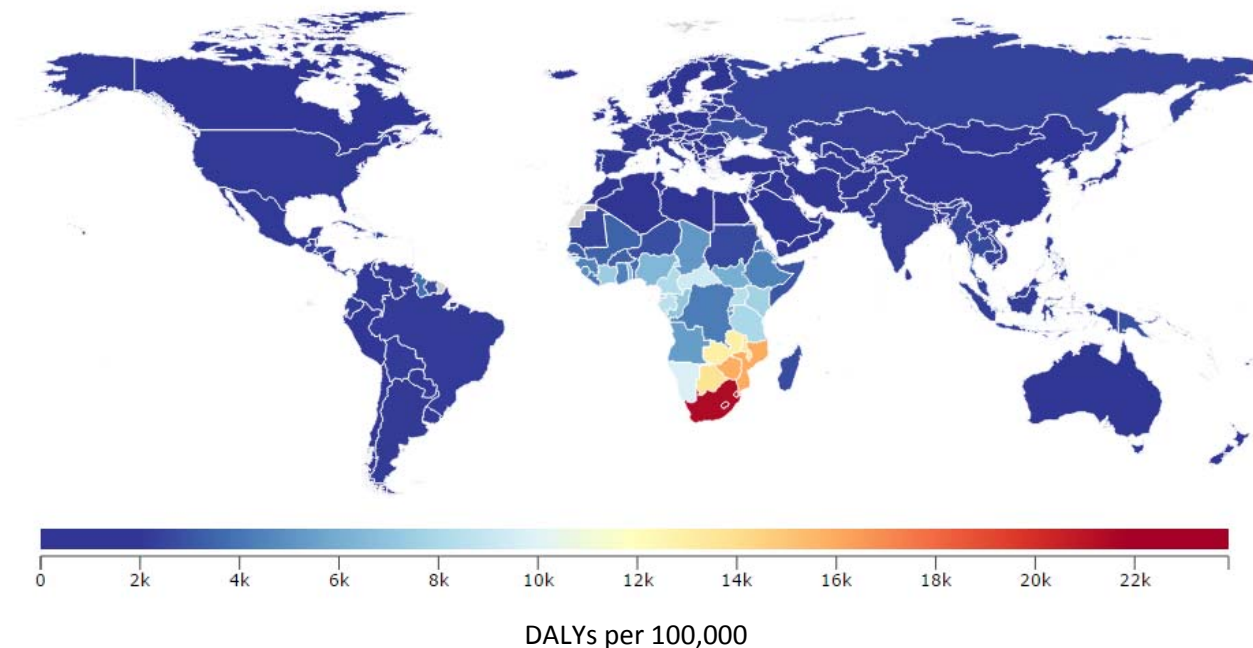


Figure 3: Non-communicable disease DALY rate per 100,000 in 2013

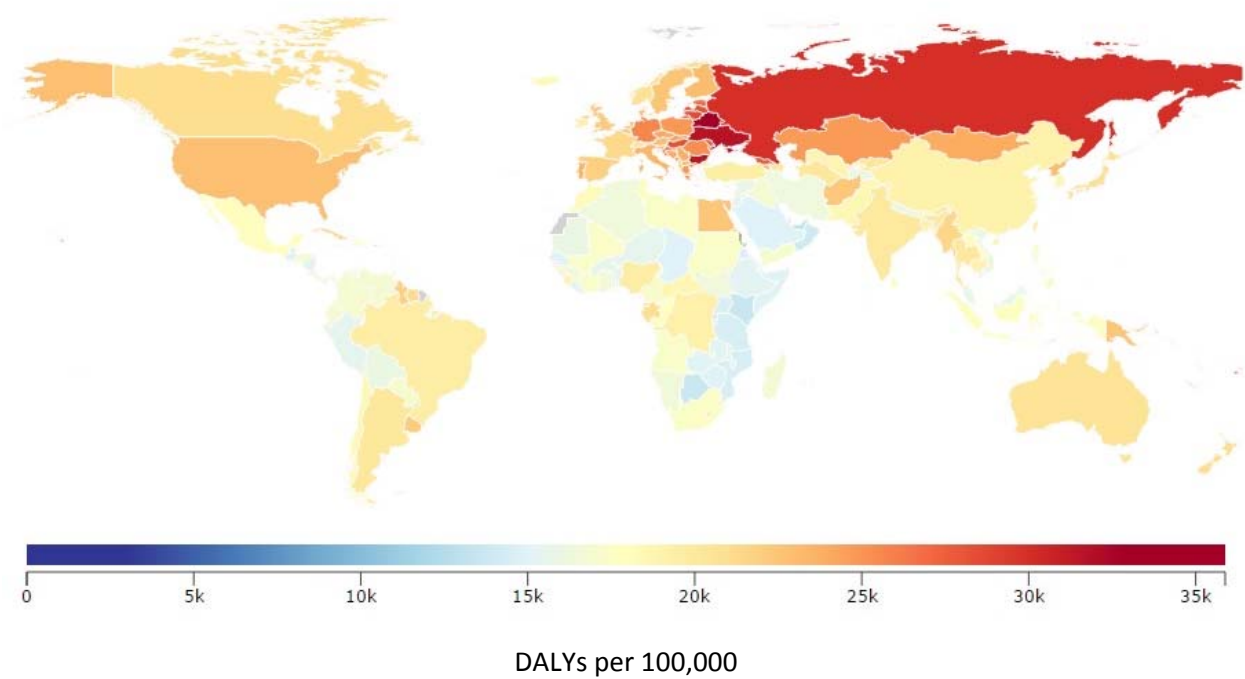
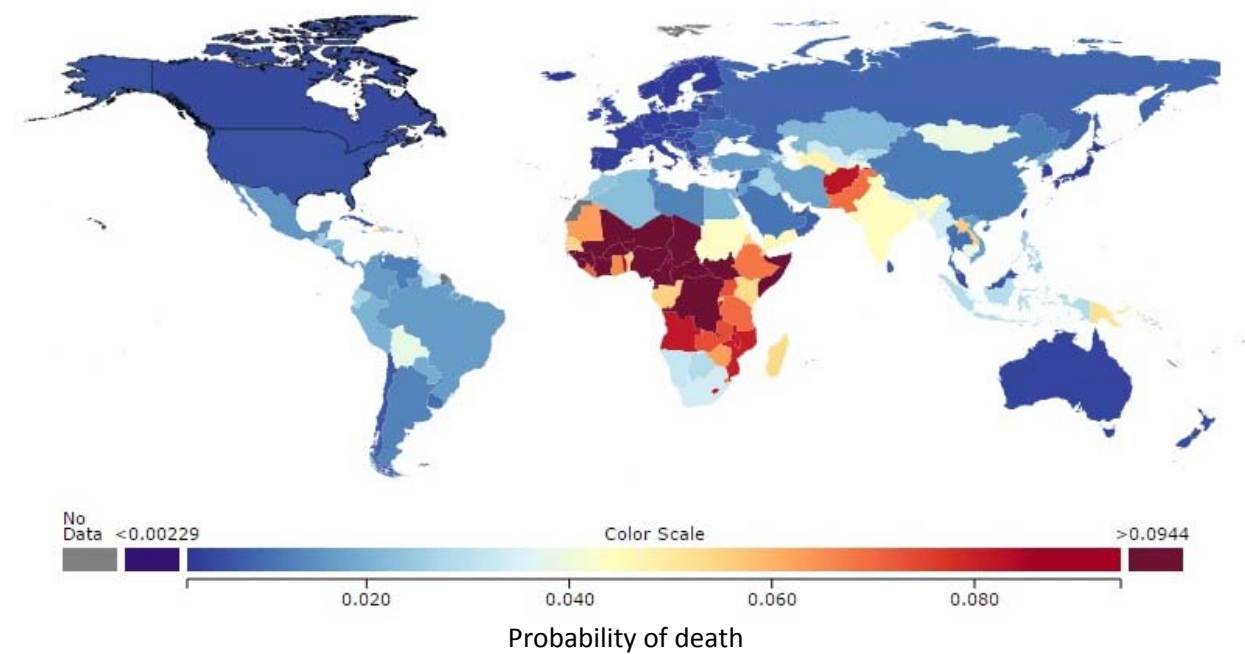


Figure 4: Child mortality (5q0) in 2013



Health equity

In addition to providing national estimates, ongoing GBD research is providing subnational estimates. These estimates illustrate subnational inequality. Figure 5 and 6 illustrate subnational variation in child mortality rates in China and Nigeria. Figure 7 illustrates subnational estimates for child mortality measured for each 10 square kilometers of Kenya. These tremendously granular estimates illustrate how the IHME framework can be used to assess health equity. While maps such as Figures 5-7 do not highlight the causes of health inequity, they highlight where it exists and where investments are needed to reduce health inequity.

Figure 5: Subnational estimates of child mortality (5q0) in China

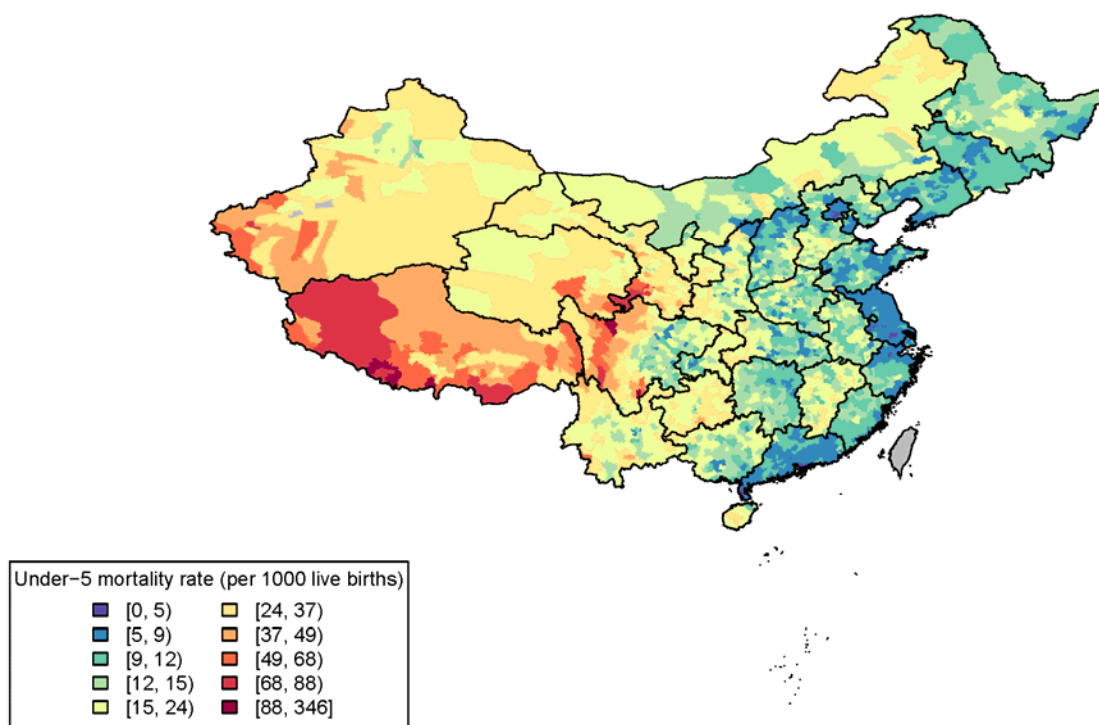


Figure 6: Subnational estimates of child mortality (5q0) in Nigeria

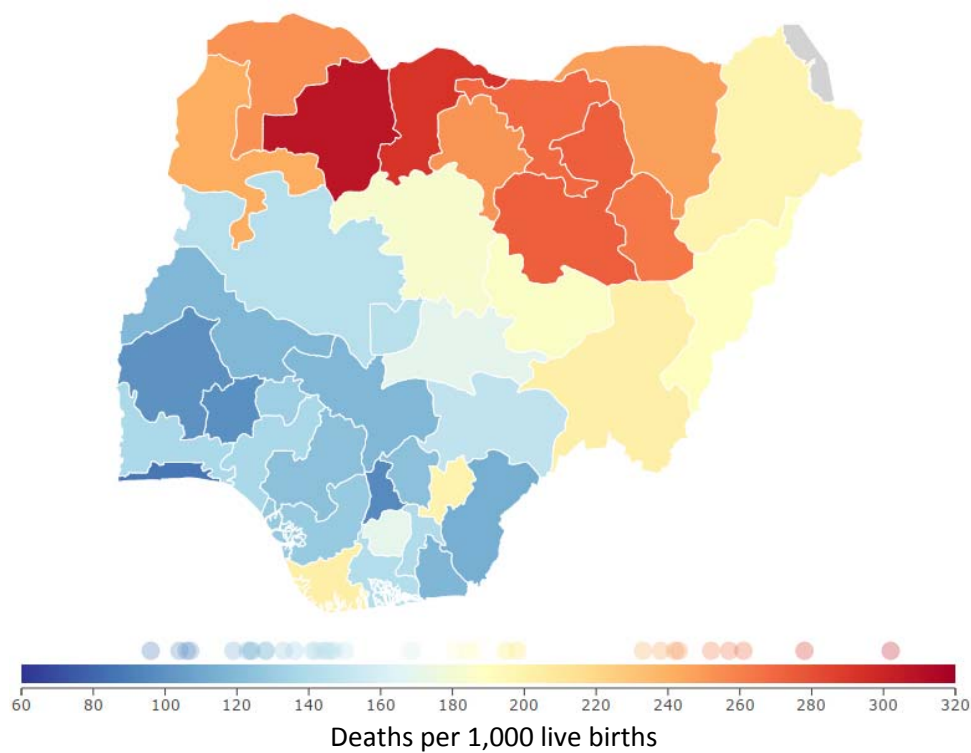
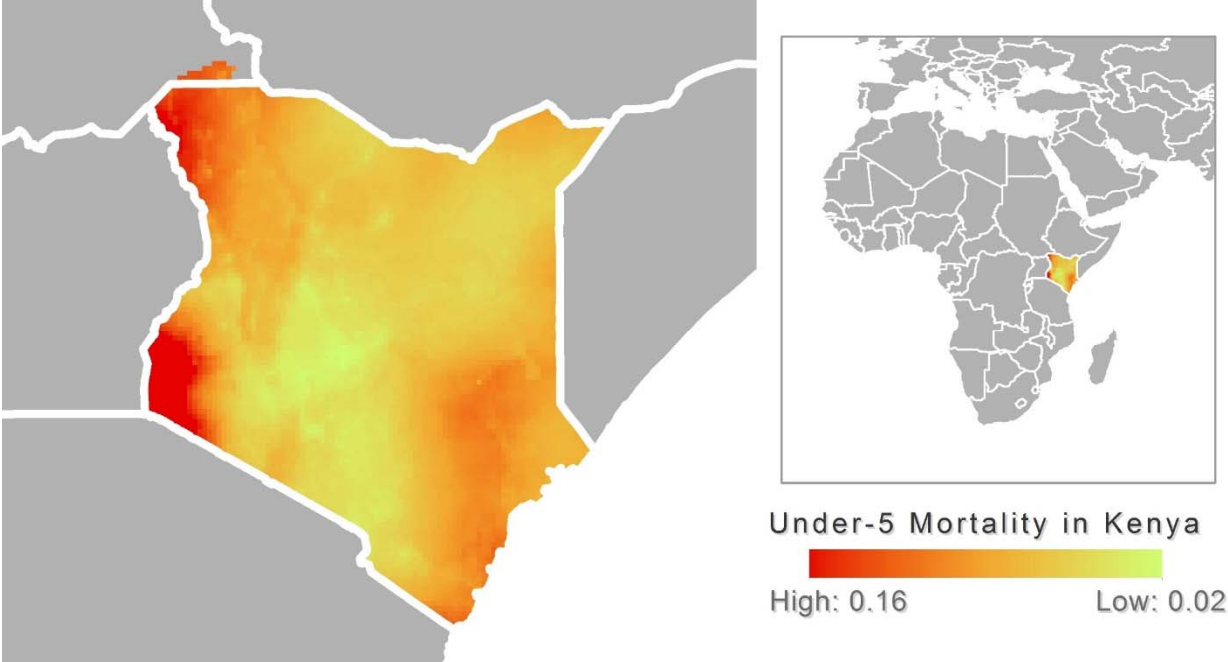


Figure 7: Subnational estimates of child mortality (5q0) in Kenya



To estimate the resources needed to reach the stated health goals, we utilize historical expenditure data on health, combined with trends in key health outcomes. For our case studies, these cost estimates are extracted from recent work completed by Murray and Chambers.² These estimates take into consideration complex contextual factors such as health system capacity and efficiency. Estimated costs, for example, are lower in countries with more capacity and greater efficiency. For further details, see the Technical Annex at the end of this document.

Figures 8 and 9 highlight the resources needed in 2014 for each country to reach the SDG.

Figure 8: Child health resources needed per child in 2014

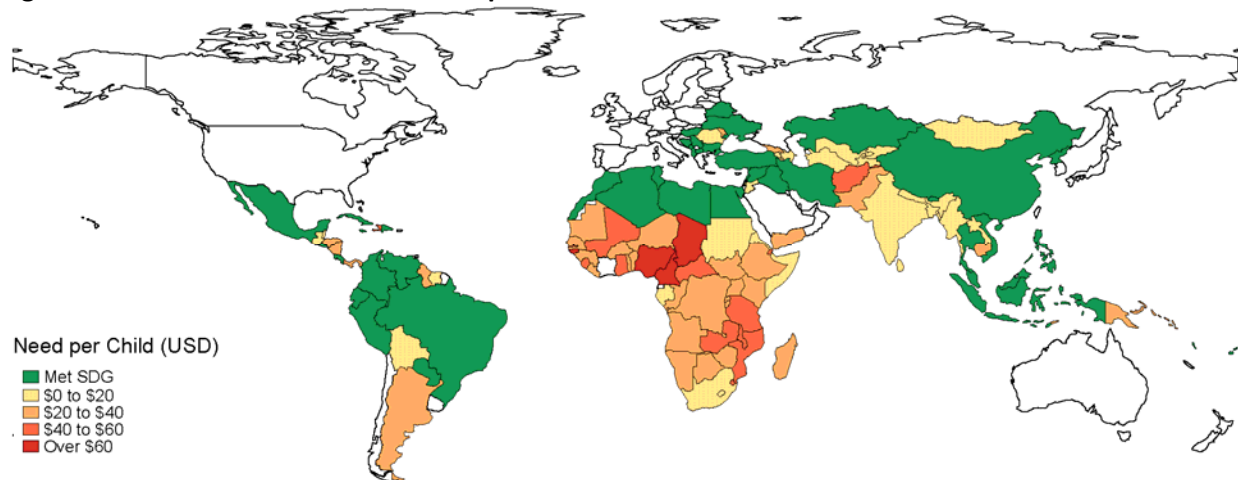
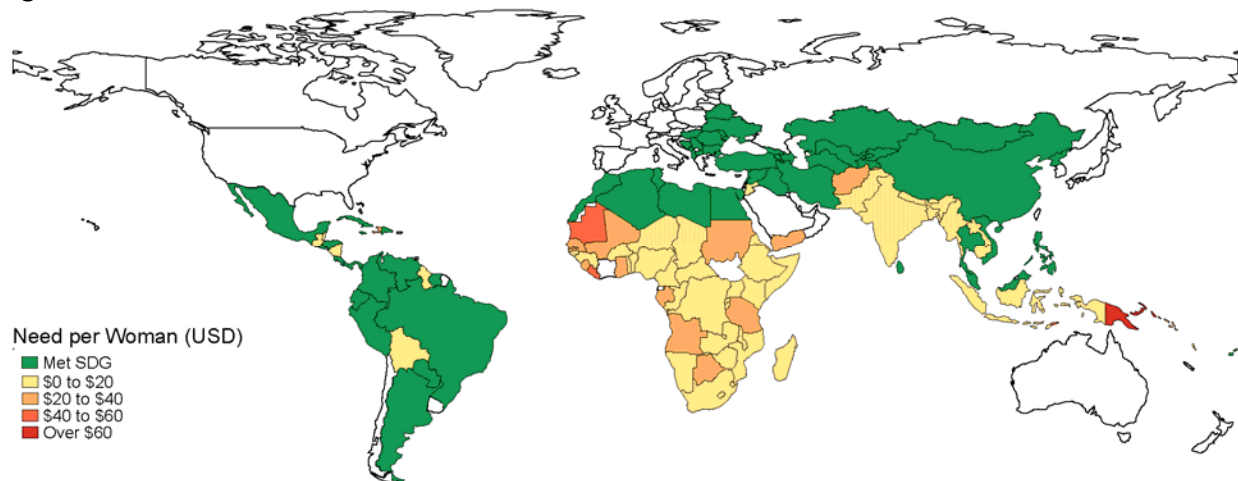


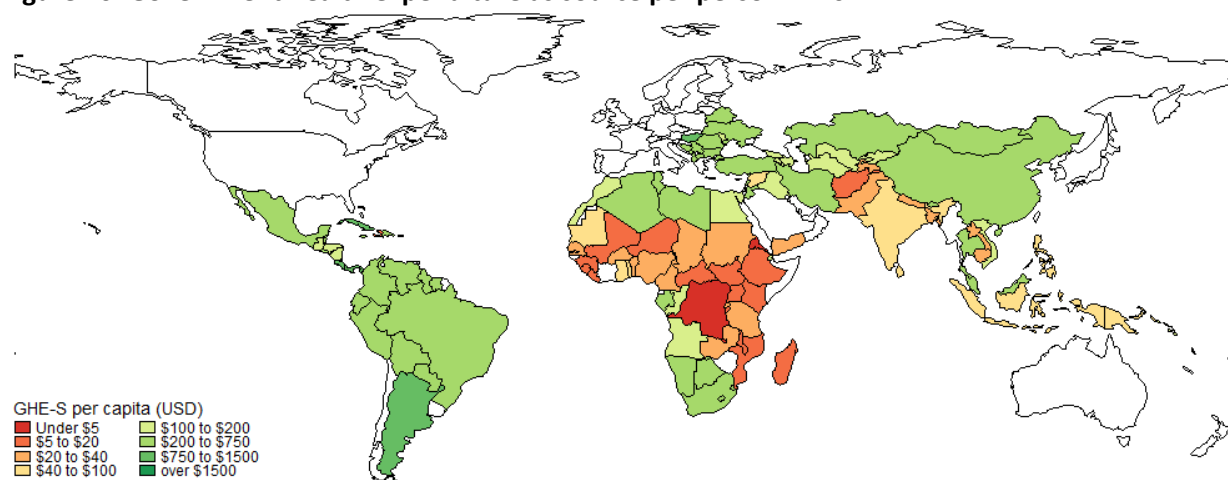
Figure 9: Maternal health resources needed in 2014



B. Government resources expected to be spent to achieve the health goal (ES)

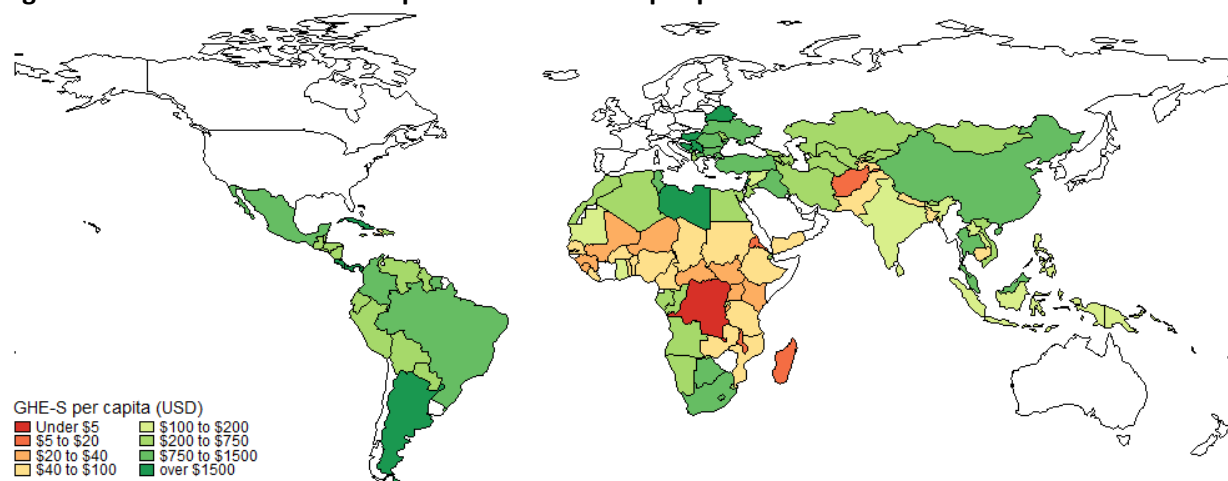
The second principle measurement for the IHME framework is government resources expected to be spent to achieve health goals. To estimate current spending, we utilized government health expenditure as a source, as estimated by IHME annually and provided in its *Financing Global Health 2014* report.^{3,4} This metric is generated by subtracting IHME's estimates of development assistance for health disbursed to governments from World Health Organization data on general government health expenditure. Current spending, therefore, does not capture any out of pocket spending. Figure 10 illustrates government health expenditure as source for each country in the world.

Figure 10: Government health expenditure as source per person in 2014



To project current spending to 2030, we harnessed the GDP per capita forecasts already developed by IHME. These forecasts are available for 188 countries, spanning 1980 to 2040, and utilize information about projected demographic dividends and change in technology. More information is provided in the methods annex. Figure 11 shows government spending estimates for each country in 2030.

Figure 11: Government health expenditure as source per person in 2030



While Figures 10 and 11 illustrate total government spending on health, increasingly data are available to estimate government spending on specific health focus areas. In the Technical Annex, we detail how we generated government spending estimates for child and maternal health. While relatively basic, these estimates illustrate one implementation of our framework.

Cases studies: measuring expected government spending

Figures 12 and 13 illustrate the spending on child and maternal health in 2014. Figures 14 and 15 illustrate the expected spending on child and maternal health in 2030.

Figure 12: Current spending on child health in 2014

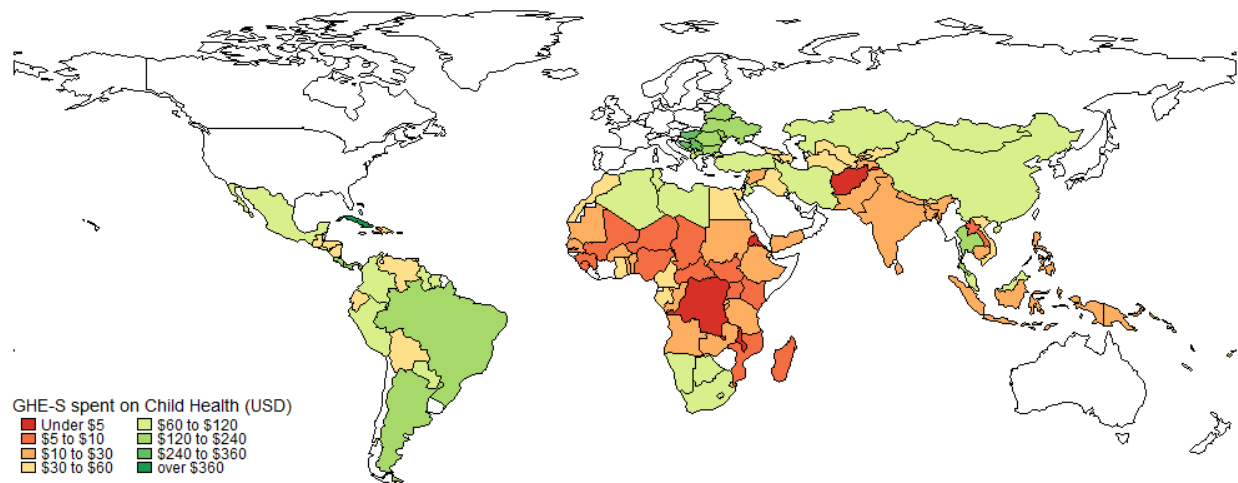


Figure 13: Current spending on maternal health in 2014

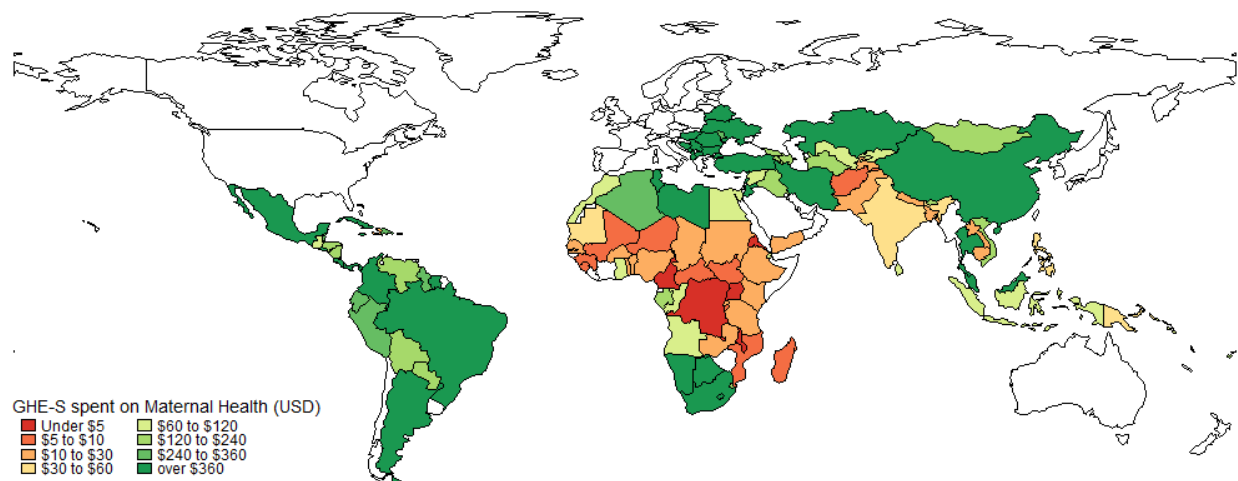


Figure 14: Expected spending on child health in 2030

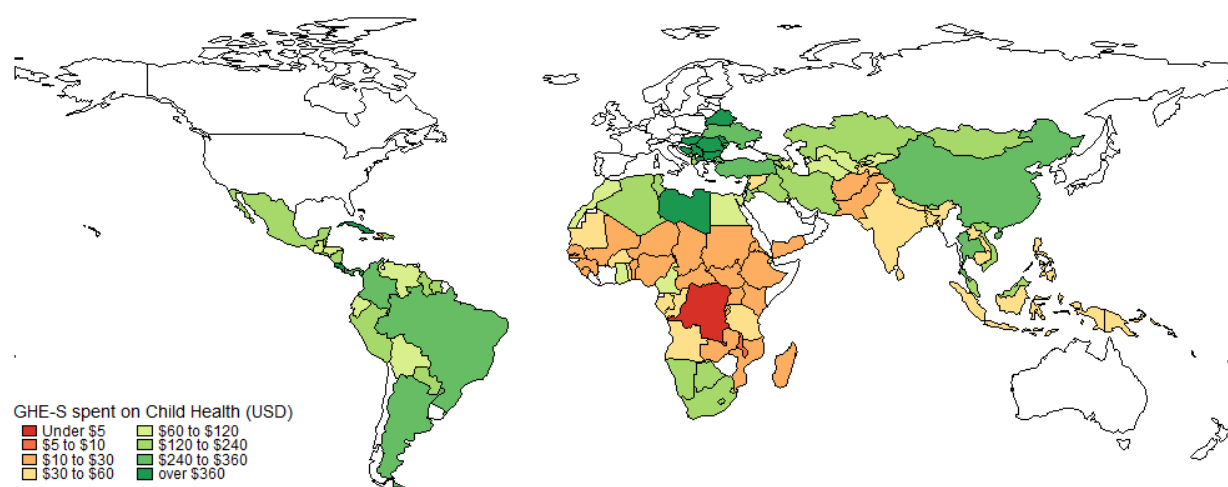
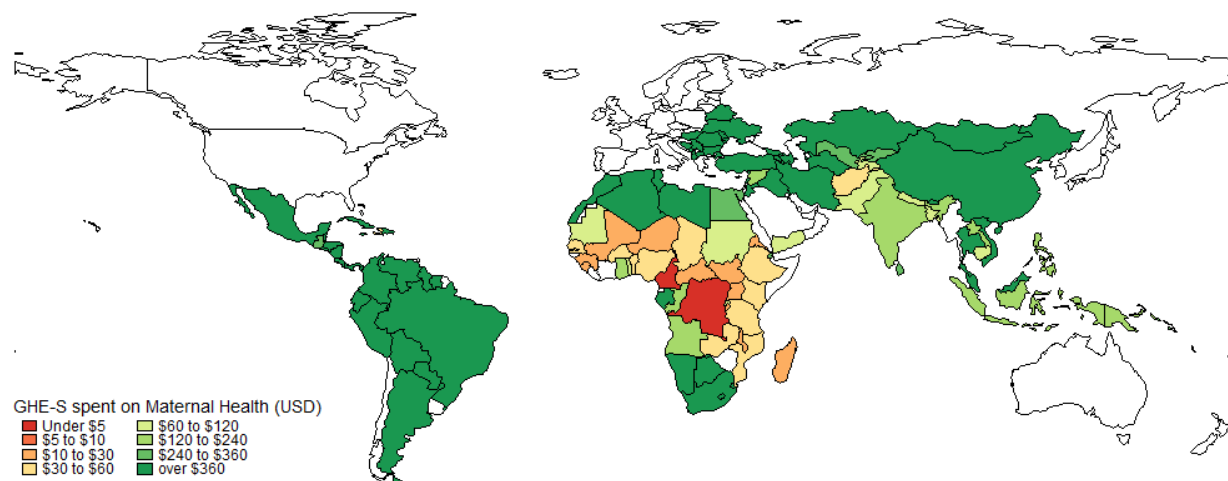


Figure 15: Expected spending on maternal health in 2030



C. Potential government resources to meet a health goal (*PS*)

The third principle measurement for the IHME framework is potential government spending to achieve health goals. Potential spending is a country's ability to pay for health services. Understanding potential spending is valuable because it splits the total gap between resources needed and resources expected to be available into two. (See Figure 1.) This bifurcation is valuable for outside agencies that wish to incentivize local spending and avoid crowding out local investments. In the IHME framework, a donor which considers gap A when making development assistance allocation and eligibility decisions (Figure

1), does not penalize increased local investment (which would close gap B in Figure 1). In this way, estimating potential spending makes the IHME framework “incentive compatible,” meaning it can be used to incentivize increased local spending. Knowing how much a country is capable of funding locally, relative to best peer-performers, is tremendously valuable. Calculating potential spending provides an objective benchmark against which local health spending can be compared.

Because of its importance for goal setting and incentivizing local spending, we focus on two sets of potential spending estimates in this report. First, we report the potential spending estimates that correspond to the two applications of the IHME framework – child and maternal health. These results are highlighted in Figures 16 and 17. These potential spending estimates are forecasted through 2030, and thus dependent upon only a single variable – gross domestic product per capita. We implemented unrestricted data envelopment analysis (DEA) with the output variable being expected health spending and the input variable being expected GDP per capita, for each year from 2015 to 2030. Data envelopment analysis is a method based on linear programming, and is commonly used to measure production frontiers and relative efficiency of production. Like all estimation methods, this methodology is imperfect and subject to critique. It is implemented here as an example of the importance of estimating potential spending and to highlight the value of the IHME framework.

In addition to the potential spending estimate calculated through 2030 for child and maternal health, we calculate a more comprehensive, retrospective analysis of potential health spending. We do this for spending on child health, maternal health, and total health spending using 2012 data. Because these estimates are based on historic data, they leverage a broader set of input variables. This broader set more fully characterizes the country’s ability to pay for healthcare. In addition to being based upon more input variables, these estimates utilize a number of additional methods meant to make the estimates more robust. More information regarding these methods are provided in the methods annex. Figure 18 identifies potential health spending as measured for 2012 for each low- or middle-income country, while Figure 19 maps the ratio of actual spending relative to the 2012 potential spending estimate. A note of caution is encouraged when interpreting these figures. The confidence intervals around these estimates, not illustrated in the maps, are very large. These large confidence intervals suggest a great deal of imprecision in this simple estimation. Because of this, IHME is developing a comprehensive methodology for measuring potential spending and technical efficiency. Unfortunately, these methods are currently under review and were not able to be used for this report.

Figure 16: Potential and current spending on child health for 10 countries with most need

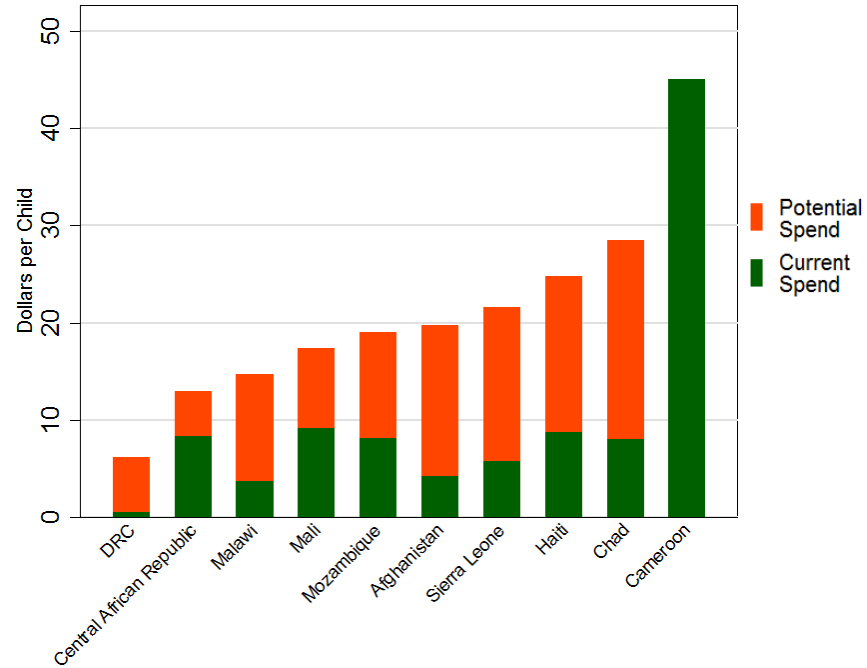


Figure 17: Potential and current spending on maternal health for 10 countries with most need

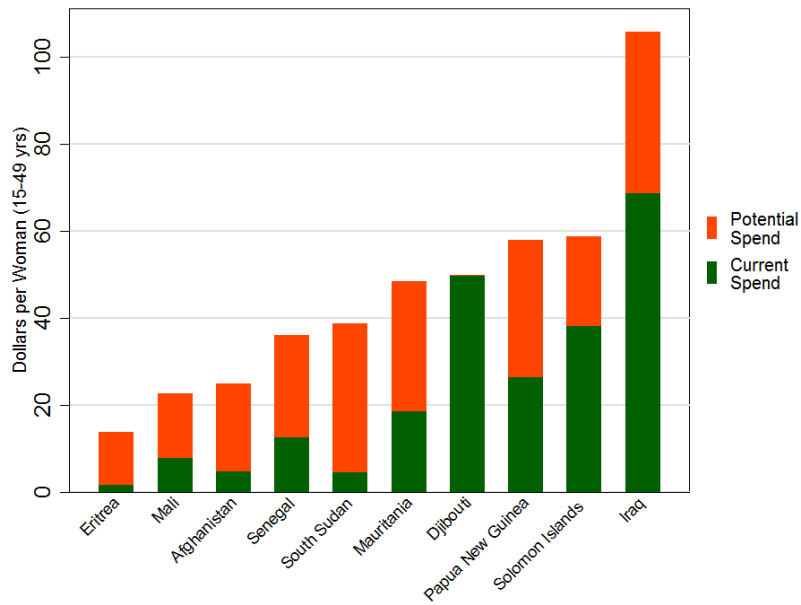


Figure 18: One measurement of potential total health spending per capita - 2012

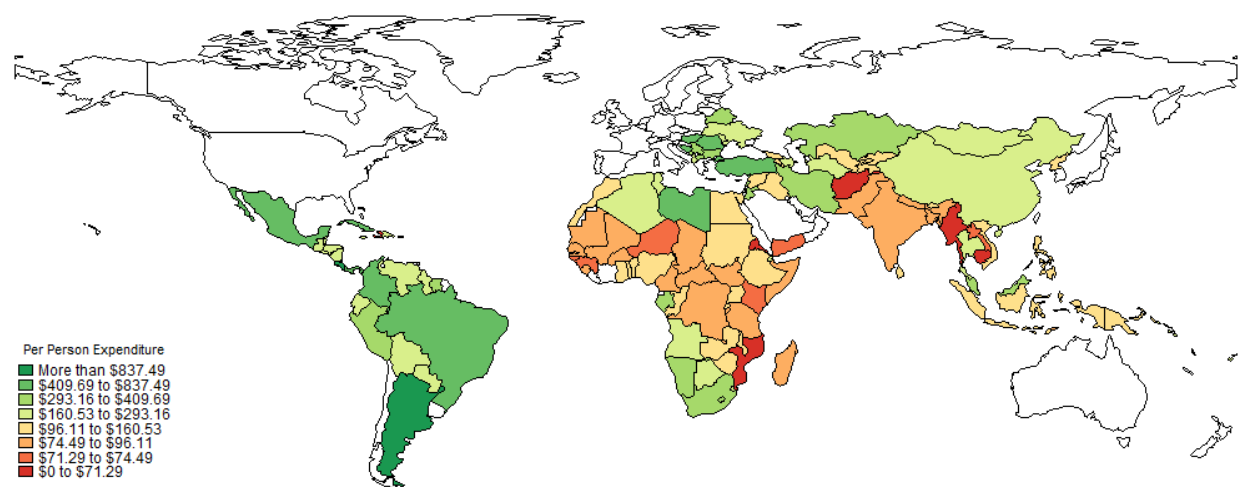
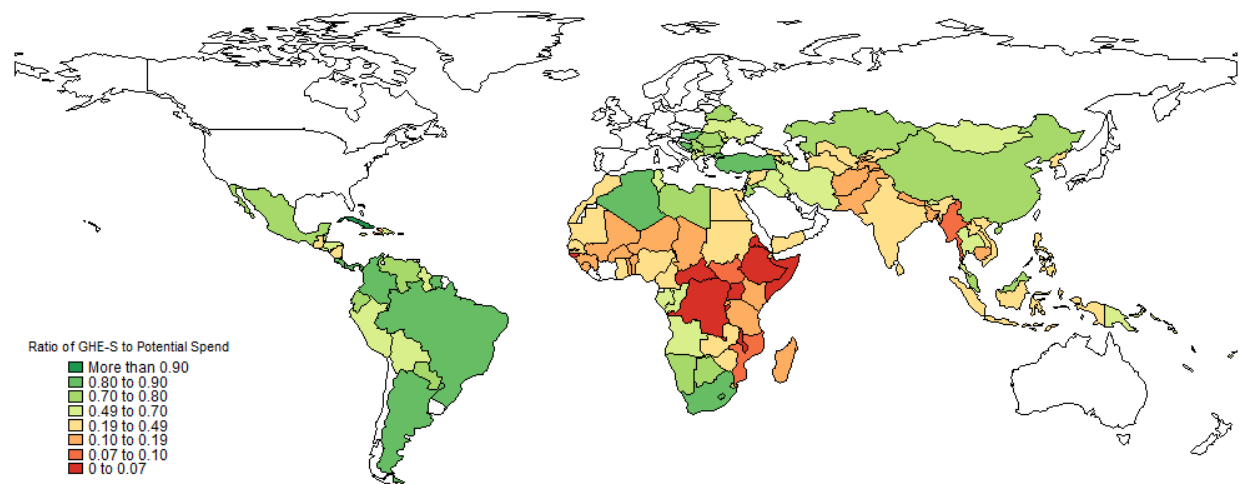


Figure 19: The ratio of health spending to potential total health spending- 2012



Case studies: measuring gaps between resources needed, potential resources, and expected resources

A primary contribution of our framework is the identification of financing gaps that exist between resources needed to reach critical health goals, actual expected spending, and the potential for increased spending. Figure 1 shows how the three basic measurements can be put together to highlight critical health financing gaps. The gap between resources needed and potential spend highlights where external resources may be needed to reach objective health targets. The gap between current government spending and potential government spending highlights where governments should be placing more resources. Both these gaps are depicted across time, showing how and when additional national and donor support might be necessary.

Credible estimates of the resources needed to meet health related SDGs, coupled with estimates of resources available and potential resources, allow policymakers and donors to assess where health gaps exist. For our case studies, we see substantial financing gaps for both child health and maternal health. Figures 20 and 21 illustrate ten example countries.

Figure 20: Case Study - Resources needed, available, and potential for meeting the child health SDG with most need

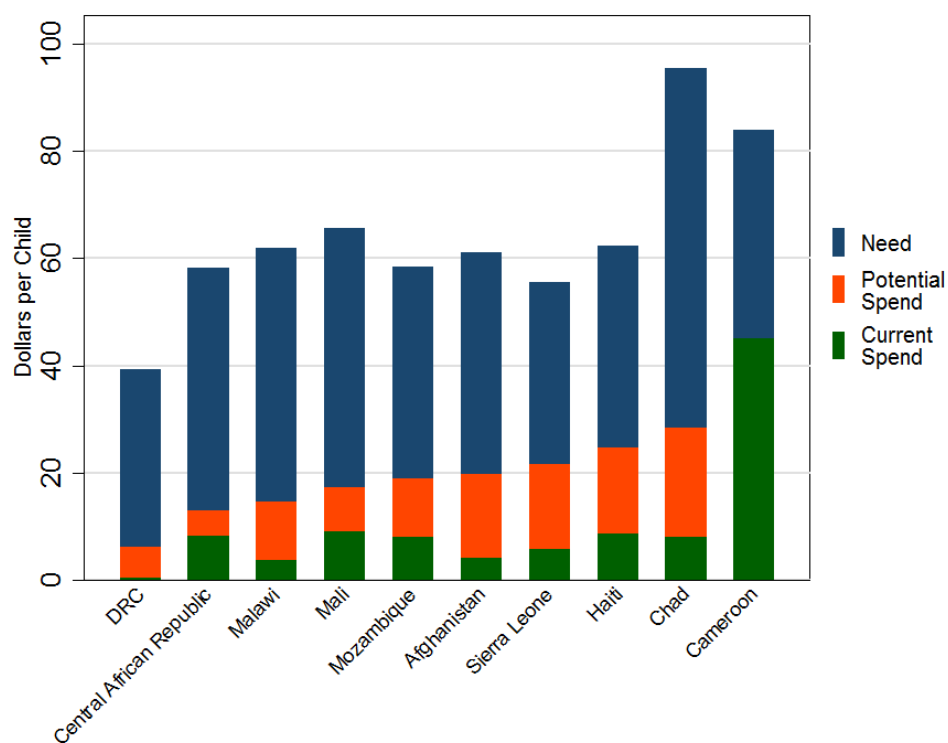
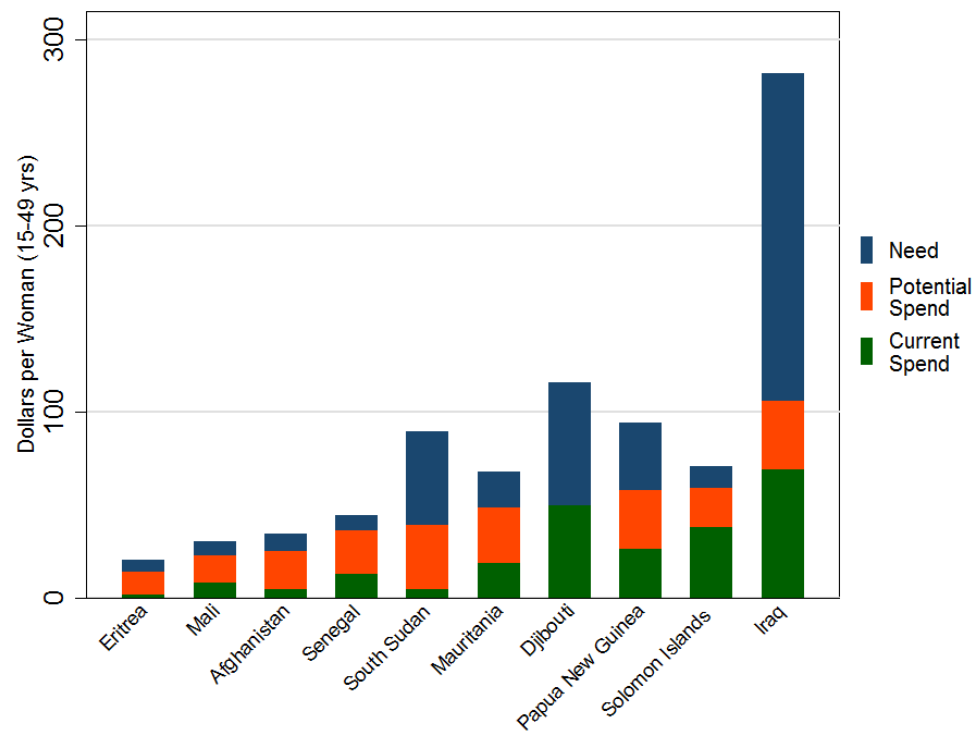


Figure 21: Case Study - Resources needed, available, and potential for meeting the maternal health SDG with most need



FLEXIBILITY OF THE FRAMEWORK

There are several ways in which this framework can be tailored to consider the unique priorities of each user. First, each of the three principle measurements on which the framework builds should be measured to reflect the health focus areas of primary interest. This requires population health metrics, cost estimates, and government spending estimates measured for each health focus area. The GBD 2013 measures health burden for all major health focus areas, so at a minimum the need can be a function of the focused interest of the user. To supplement this, costs and expenditure data for specific health focus areas are increasingly available. Through credible resource tracking exercises such as NHA disease accounts, National AIDS Spending Assessments, disease expenditure research, and costing studies, valuable cause of illness specific financial information is ever improving and more readily available.

Second, the measurement of resources needed is determined in relation to a predetermined goal set by the user of the framework. These goals should reflect the actual goals of organizations and agencies investing in health. In addition to the flexibility relative to choosing specific or general health focus areas, users of the framework can make short or long-term goals that reflect their planning horizon, investment scope, and broader institutional goals.

Third, because users of the framework define their own goals, there is flexibility for the user to focus on increasing population health, health equity, or both. Subnational estimates are becoming increasingly granular and provide indications of health inequity. By incorporating specific goals for populations with the largest health burden, users of the framework can actively invest to reduce health inequity.

Finally, the IHME framework makes an important distinction between resources needed, expected government resources available, and potential government resources available. These principle measurements together provide incentives for both donors and local governments. We believe that combining these distinct metrics abstracts inappropriately from the ability for financiers to assess the true complexity related to the allocation, eligibility, and sustainability of. Gaps between expected and potential government resources highlight tangible goals for government spending. In addition, it provides donors with valuable information related to the allocation of their own support. For example, donors can decide how they want to incentivize more local government spending. By assessing only the gap between need and potential government spending (space A in Figure 1), they can incentivize governments to reach towards their potential spending, as measured when compared to peer countries (space B in Figure 1). Conversely, local governments or donors interested in filling financing gaps to meet health goals could focus on attempting to fill the entire space between resources needed and currently available (the sum of A and B in Figure 1) rather than incentivizing spending from other agencies. Measuring the gaps separately allows users of the frameworks to decide for themselves how to respond to each of these distinct gaps.

COMPARING THE FRAMEWORK TO EXISTING NORMS

As annual growth in development assistance for health tapers,^{3,4} donors must focus their resources on the specific problems they seek to address. Aid allocation and eligibility criteria based exclusively on gross national income or gross domestic product miss contextual nuances critical to channeling aid efficiently and effectively. Using GNI or GDP leads to singular conclusions that incorrectly equates economic development with less need for resources for health. Furthermore, it assumes that a single indicator is appropriate for all health focus areas, abstracting from the reality that countries may have focus area specific shortfalls. As a consequence, aid may not be directed to where it is most needed. More precise models should predict need, and quantify financial gaps that specifically address the target the donor's priority areas.

Additionally, basing aid allocation on economic development is not incentive compatible, and penalizes a country for economic growth. To address this, the IHME framework distinguishes from expected spending and potential spending. Basing aid allocation and eligibility on the gap between need and potential spending allows donors to incentivize increases in domestic spending.

To illustrate the importance of utilizing a framework that is focused acutely on specific health focus areas and is incentive compatible, we provide three figures (Figure 22-24) that compare different aid allocation and eligibility models. For simplicity, we focus here on the rank of each country, highlighting the rank order in which we would expect aid agencies to engage with the country. It is not expected that aid agencies would work through the ranked list in order, rather that this ordering would provide context for important allocation and eligibility decisions. The fact that the ranking is different between the two columns of each figure highlights how different frameworks lead to different conclusions in the manner in which countries might be prioritized, and highlights the importance of basing allocation and eligibility decisions upon criteria that is specific to the interest of the donor.

Figure 22 compares a framework based on economic development to an application of IHME framework to child health. The economic development framework is based merely on GDP per person and typifies the prevailing framework employed by many aid agencies, where aid allocation and eligibility is based on economic development. The right column shows a version of the IHME framework in which donors are focusing on child health and are simply concerned with filling the financing gap between need and expected resources. The figure shows that by focusing solely on GDP per person, a donor could miss the amount of need a local government can be expected to cover domestically. Furthermore, a country such as Chad or Nigeria, which has larger GDP per person but still has pervasive child mortality would be missed. As such, countries could end up prioritized or deprioritized within an exclusively GDP based aid context, in a way that does not reflect actual need and current spending. Focusing pointedly on actual need for resources for child health, and the amount expected to be spent by the government, highlights critical financing pitfalls that are abstract from when one considers solely economic development.

The IHME framework is also flexible enough to allow donors to focus on alternative health financing gaps. In particular, aid agencies may want to incentivize a country to pay for some portion of their own nation's health care. In order to do this, an aid agency would focus on financing the gap between need and potential spending, where potential spending is a reflection of how much a national government could be expected to spend based on their level of economics development. Figure 23 highlights how constructing the model based on potential government spending, rather than expected government

spending, leads to a different ranking of countries. For example, Mali is a country where the gap between need and potential government spending is greater than the gap between need and expected spending, relative to other countries. Thus, by focusing on potential spending, a donor might prioritize Mali when focusing on the gap between need and potential spending. Basing an aid allocation or eligibility on expected spending deprioritizes Mali because it penalizes the existing national government child health spending. Figure 23 highlights that focusing on potential spending rather than expected spending changes the ranking of potential aid recipients.

Lastly, need, expected spend, and potential spend all vary substantially depending on the health focus area. Looking at generic metrics absent of health focus area specific information could misinform the estimation of need for aid. Figure 24 compares a framework based on need for resources for child health and need for resources for maternal health. The many crossed lines highlight that donors with specific priority areas must use health focus area specific data for aid allocation and eligibility decisions. A country such as Chad or Mali, which has a large gap between needed resources and potential spending for child health has, relatively speaking, less of a financing gap for maternal health. Conversely, Iraq and Djibouti has a distinct need for resources for maternal health, but less of a financing gap for child health. If a donor were using the financing gap for child health as a proxy for maternal health, aid allocation or eligibility decisions would be misinformed. In order to most accurately consider the countries in most critical need for additional resources, donor must understand the nuances of the need related to a specific health focus area.

Figure 22: Comparison of country rank - GDP per capita compared with gap between need and expected government expenditure for child health

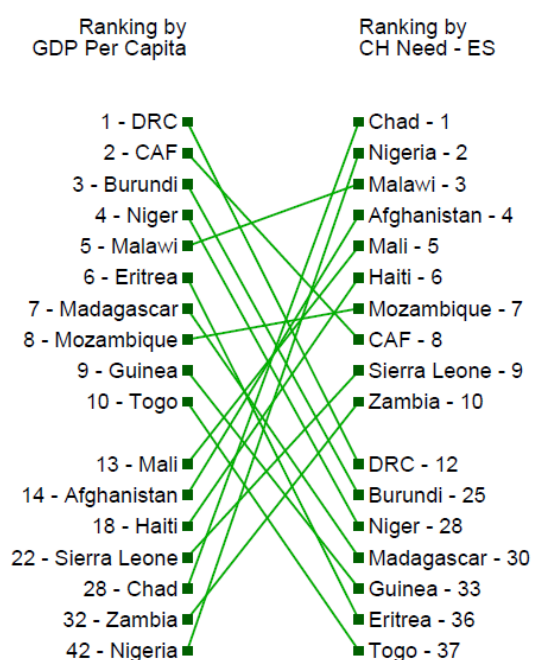


Figure 23: Comparison of country rank - gap between need and expected government expenditure for child health compared with gap between need and potential government spend for child health

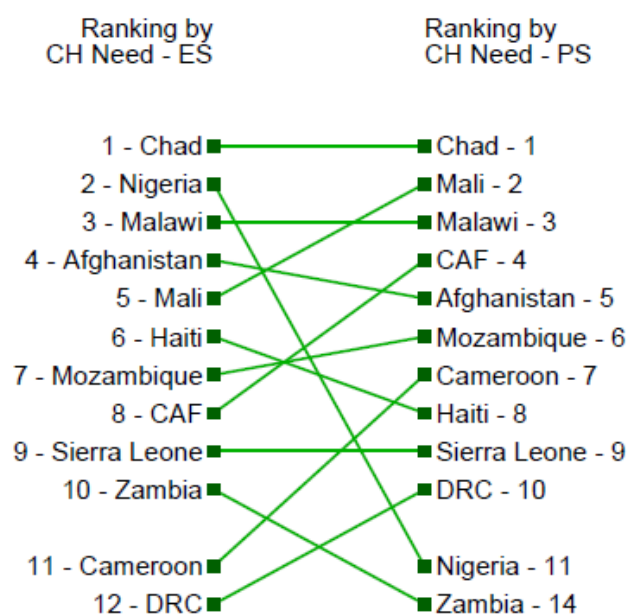
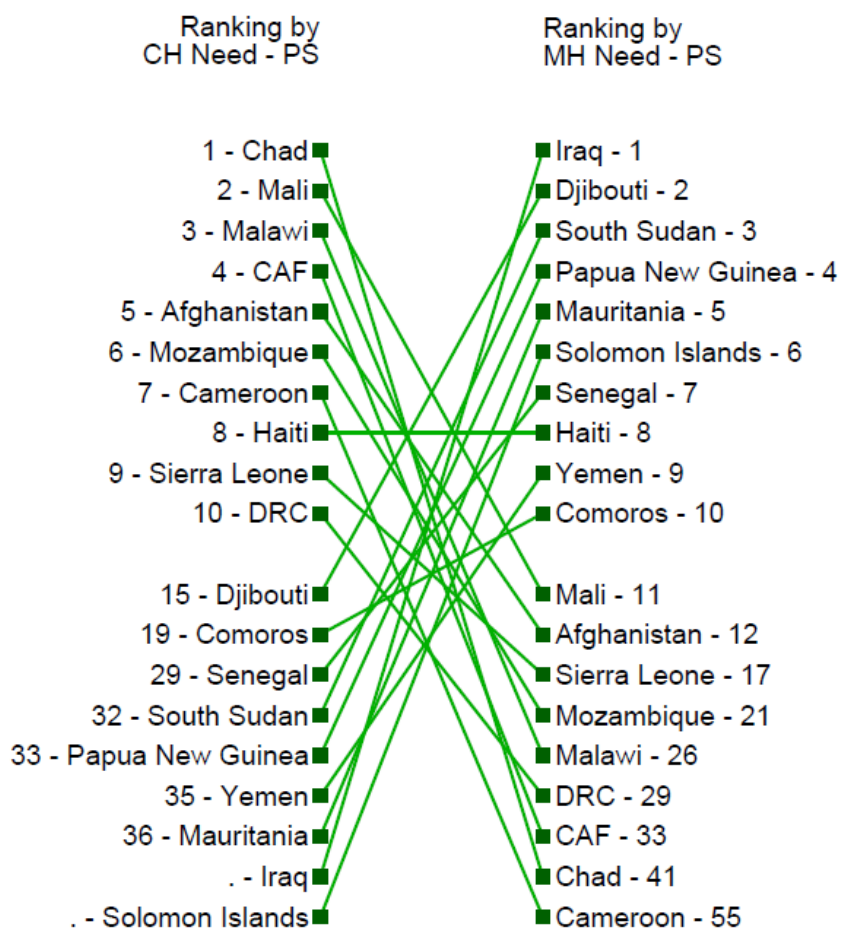


Figure 24: Comparison of country rank - gap between need and potential government spend for child health compared with gap between need and potential government spend for maternal



CONCLUSIONS: STRENGTHS AND LIMITATIONS

Our framework highlights the gap between resources need to reach a specific goal (N), a government's expected spending (ES), and a country's potential government spending relative to peers (PS).

Identifying these gaps, highlighted in Figure 1, provides incentive for governments and donors to increase funding for life saving investments in health.

While we believe in the potential behind this framework, we recognize its limitations. The amount of data needed to execute on this framework is substantive, and may not be available for every focus for each stakeholder. Additionally, the availability and quality of cause specific and costing data is improving; but it still needs substantial improvements to be considered comprehensive. For anything beyond the most basic estimation, some modeling will be needed.

Ultimately, prioritizing and allocating resources across health focus areas, countries, and subnational units is complex and should be based on objective data and objective targets. We propose a framework that rests on current health outcomes, and is augmented by actual government health spending and potential health spending. With the right data, this framework can be expanded to assess other key priority health spending and health outcome objectives.

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- 3 Institute for Health Metrics and Evaluation. Financing Global Health 2014: Shifts in Funding as the MDG Era Closes. Seattle, WA, 2015.
- 4 Dieleman JL, Graves C, Johnson E, et al. Sources and focus of health development assistance, 1990–2014. *JAMA* 2015; **313**: 2359–68.

TECHNICAL ANNEX

This annex provides details on data sources and analytical methods used to produce case study estimates for the three components of IHME's framework.

Resources needed to meet an objective health goal (*N*)

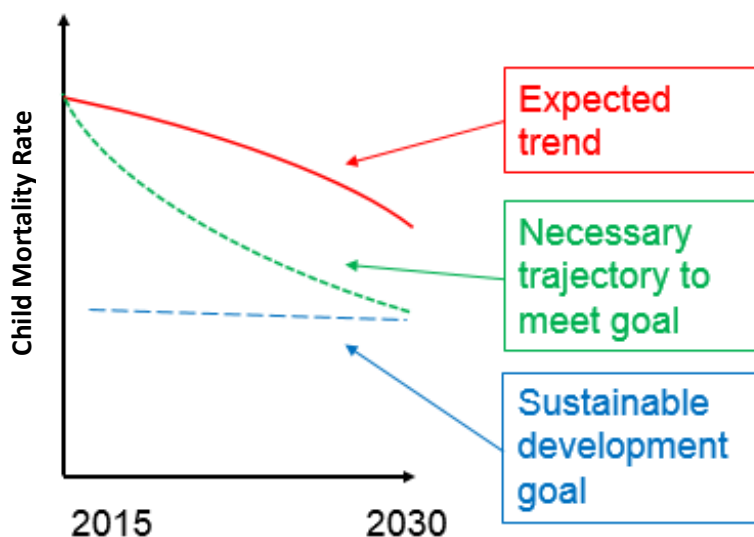
The first principle measurement needed for the IHME framework is a measurement of the resources needed to meet an objective health goal. Resources needed is determined by a country's current health burden, expected future health burden, marginal costs associated with making health improvements, and capacity to absorb additional resources, and program efficiency. Below we describe data sources and estimation of resources needed.

Population health

The GBD 2013 Study provides comparable prevalence, incidence, mortality, and morbidity estimates for all age-groups, all countries, and a comprehensive set of more than 300 causes of illness. Because these estimates are produced in a systematic and comprehensive manner, they provide a foundation for comparing health burden and need for health resources. GBD estimates are measured at the national level and in some cases at the subnational level. Estimates are available for all low- and middle-income countries. All causes of illness can be considered in aggregate as a measure of total health. Alternatively, these data can be parsed to reflect a subset of causes or even a single cause so that the application of the framework is health focus area specific. Mortality and morbidity estimates are combined to provide an overall metric of health burden, measured using disability-adjusted life-years. Because these data are stratified by country and cause of illness, GBD 2013 estimates highlight countries with high demand for causes-specific investments.

Resources needed

Figure 25: Calculating resources needed to close health gaps and achieve health goals (example child mortality rates for hypothetical country and goals determined by the SDG)



This framework measures the resources needed to achieve a predetermined health goal. The framework is flexible enough to accommodate a variety of health goals, which in most cases will be cause or country specific and determined by those investing in health – generally the Ministry of Health or donors. In addition to an explicit and empirically defined goal, the framework relies on an explicit timeline during which the goal is hoped to be achieved. As illustrated in Figure 22, additional resources needed to achieve the goal within the set timeline can be found by

estimating the gap between the expected “business as usual” population health trajectory, and the trajectory needed to achieve the goal throughout the time allowed. To convert these health gaps into financing gaps, the framework recommends using cost data to estimate the costs associated with closing the health gap and achieving the health goal.

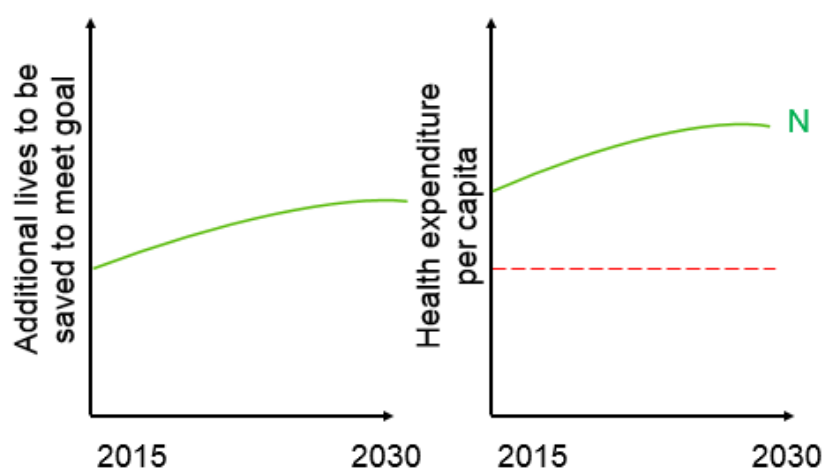
Observed efficiency and resources needed

In calculating resources needed, the framework implicitly considers the efficiency of the health system or a specific intervention, because the costs used to calculate expenditure needed are derived from observed costing data. Countries that are less efficient, or have less capacity to absorb new resources, will have costs that are higher. In these cases, countries that have had recent periods of inefficiency, and thus higher costs, are assumed to have similarly inefficient programs in the future. These inefficiencies will result in higher estimates for resources needed.

Measuring resources needed to meet health goal

To demonstrate the power and flexibility of the framework, two case studies are also provided: child mortality and maternal mortality. For these two case studies we use targets set in the Sustainable Development Goals (SDGs).¹ As shown in Figure 8, the need for additional health resources is measured by assessing the gap between forecasted health burden and the trajectory needed to reach the goal. The forecasted health burden considers the expected trajectory of health gains, holding constant current health spending. The expected trend is downward, even while holding spending constant, because we expect ongoing gains in technical innovation, economic development, and social determinants in health that are not controlled by health spending investments. The difference between the expected trend and the trajectory necessary to reach the goal represents the additional health gains needed. To estimate the resources needed to achieve this gain, we multiply the gains needed by the incremental cost of achieving those gains. For our case studies, these cost estimates are extracted from recent work completed by Murray and Chambers.² This is shown in Figure 23.

Figure 26: Resources needed to achieve gain for a hypothetical country



For these case studies, we extract under-five and maternal mortality estimates from the 2013 GBD study. To estimate expected trend for these mortality rates, we regress the mortality rates (natural log transformed) on gross domestic product (GDP), gross domestic product per capita, maternal education, development assistance for health per capita, government health expenditure as source per capita, and technology (proxied by a linear time trend). To generate the estimated trends without changes in health spending, we use our fitted model to predict the mortality rates based on forecasted GDP per capita, education rates, and the changes in technology. The trajectory to reach the SDG goals is found by calculating the needed percent reductions in mortality each year to reach the target.

To estimate the number of additional lives needed to be saved in order to meet the SDG, we multiply the child and maternal mortality rates by the appropriate population numbers, and take the difference between the expected trend and trajectory necessary to reach the SDG. We then extract the previously estimated country-specific estimates of the cost to save a child life or maternal life.² These estimates implicitly include the added cost of saving a life in countries with less capacity or inefficient health systems. Multiplying the cost to save a life by the number of additional lives that need to be saved generates our estimates of the resources necessary to meet the Sustainable Development Goals for child and maternal health.

Government resources expected to be spent to achieve the health goal (ES)

National Health Accounts (NHAs) are an internationally agreed upon accounting framework used to systematically measure health expenditure within a country. NHA sub-accounts provide more detailed information about spending on specific health focus areas. 52 country-years of data were found in NHA sub-accounts providing information on government spending for child health. 45 country-years of data were found providing information on spending for maternal health. Using data for these countries, the fraction of total government spending (GHEA) allocated to child health (CH) was estimated using regression analysis. The share of government spending on maternal health was estimated using a similar framework. Using estimated coefficients from these models, government health spending on child health and maternal health is forecasted through 2030.

Equation 1:

$$\text{logit}\left(\frac{GHEA \text{ on } CH_{it}}{GHEA_{it}}\right) = \alpha + \beta_1 \ln(GHESpc_{it}) + \beta_2 \ln(GDPpc_{it}) + \varepsilon_{it}$$

Total government health spending as source (GHES) is predicted for each country in the world through 2040 as part of IHME's broader forecasting project. Government health spending is forecasted using an ensemble model that averages across a broadest feasible set of models. These models vary the potential model determinants and specification, but each meet an empirical inclusion criterion based upon observed changes between 1995 and 2012.

Gross domestic product per capita is also forecasted through 2040. The model used for these forecasts predicted future changes in GDP per capita (natural logarithm transformed) as determined by an autoregressive term and a convergence term.

Government resources potentially spent to achieve the health goal (PS)

Unrestricted DEA is a nonparametric method used in operations research and economics to estimate production frontiers and efficiency. A production frontier suggests the optimal amount of production based on a specified amount of inputs. In the child and maternal health applications of our framework, we assume the allocation of government health expenditure (the product), as predicted by that country's level of development, as measured by GDP per capita (the input). As the level of development increases, the potential government spending increases. This method highlights the capability that each country has for domestic health financing, conditional on national income, independent of what the country is actually spending. Equation 2 reports the maximization and constraint of the DEA estimation.

Equation 2:

$$\max eff_i = \frac{u(GHESpc_i)}{v(GDPpc_i)} \text{ subject to } uv \geq 0 \text{ and } \frac{u(GHESpc_i)}{v(GDPpc_i)} \leq 1, i = 1, \dots, 135$$

We independently use DEA to estimate equation 1 for child health spending and maternal health spending. This method estimates how much a country could be spending on child and maternal health, relative to its economic development. We complete this estimate for each year of the forecast in order to estimate potential spend for each country, health focus areas, and year. Figures 24 and 25 show the frontier of child and maternal health spending in 2014. In the case of one input, we allow for super-efficiency by systematically excluding each individual country observation and estimating a frontier. We set our threshold for super-efficiency such that the top 10% of countries that are most efficient at producing GHE-S as a function of GDP are deemed super-efficient and allowed to be over the estimated frontier.

Figure 27: Case Study - Dollars per child of potential government spend on child health

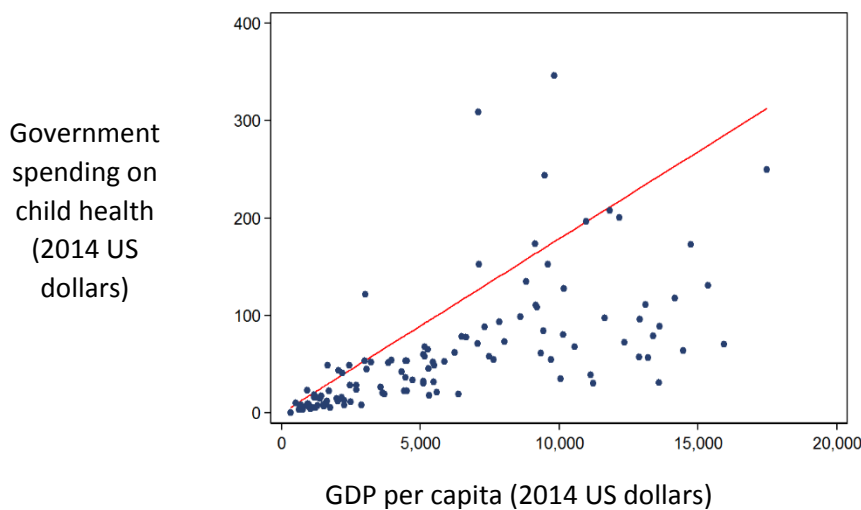
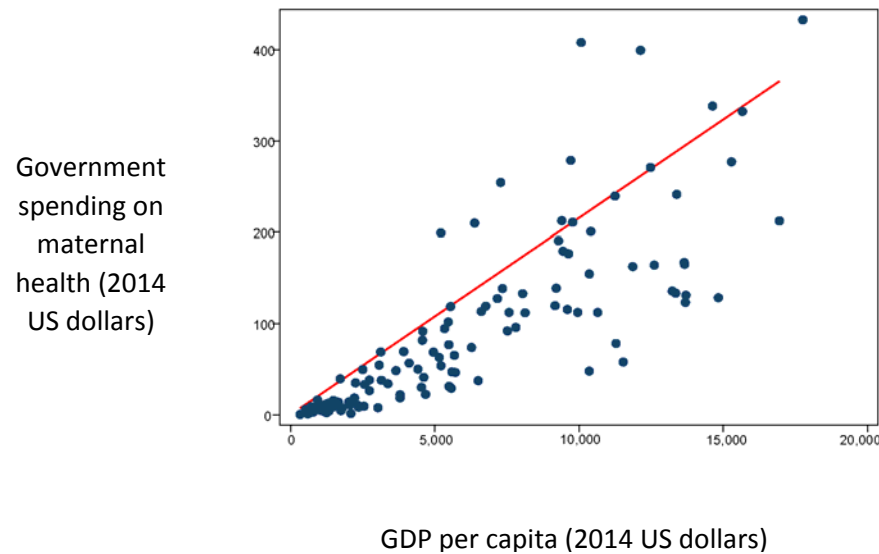


Figure 28: Case Study - Dollars per woman of potential government spend on maternal health



Because of the prospective nature of the IHME framework, potential spending was forecasted through 2030. To complement the maternal and child health applications of the IHME framework and to extend the ability to pay analysis, IHME completed an additional, more thorough analysis of ability to pay for health, maternal health, and child health for 2012. This section of the annex explains this complementary analysis. Because the analysis is static and retrospective, more models and inputs were considered than the applications described above. These estimates of potential spending estimate how much country health spending could be mobilized domestically, focusing exclusively on government spending. The analysis was completed separately for total health spending, maternal health spending, and child health spending, each for 2012.

We consulted an expert at the World Bank to develop a broader, tractable set of variables to consider using to measure potential spending. The variables suggested were:

- GDP per person (measured in 2005 PPP)
- Government revenue per person (measured in 2005 PPP)
- Government deficit per person (measured in 2005 PPP)
- Government debt per person (measured in 2005 PPP)
- Share of government expenditure that is interest payments
- Economic growth (percent annual increase)
- Share of government spending that is health expenditure (only included for child and maternal spending ability to pay analyses)
- Exports to debt ratio

These data were collected from the World Bank's World Development Indicators database and the Institute for Health Metrics and Evaluation. Due to low data availability for more recent years, 2012 data were used. Missing values were imputed using Gary King's Amelia computer software for multiple

imputation in R, creating ten complete, imputed datasets. The relationship between each candidate variable and government health spending was tested using a multi-variate log-log linear regression. Variables were included as inputs if they had a statistically significant relationship with government health expenditure per capita ($\alpha = 0.1$). GDP per capita, economic growth, share of government spending that is health expenditure, and the export to debt ratio were statistically significant and included.

We considered two modelling methods:

- Stochastic Frontier Analysis (SFA)
- Data Envelopment Analysis (DEA)

Both SFA and DEA are heavily influenced by outliers in the data and the choice of inputs included in the model. To address this concern, we ran SFA and DEA 10,000 times, each using a diverse set of inputs and bootstrapped data. For each iteration:

1. We randomly select one of the ten imputed datasets from which to base the analysis.
2. The country-level 2012 observations were bootstrapped, meaning a random sample of countries were drawn with replacement to generate a single bootstrapped sample equal size as the original data set.
3. In addition to this, the set of inputs was randomly selected, such that each variable had a 0.5 probability of being selected. Input sets that randomly had no inputs selected were rejected and a new input set was randomly drawn.

Bootstrapping the observations and potential inputs leads to a broad set of models being run. This estimates a wide uncertainty interval that is substantially less influenced by outliers and input selection. In addition, the analysis was completed using SFA and DEA. Mean results and uncertainty intervals (the 5th and 95th percentiles of the distribution) were reported for SFA and DEA to facilitate across method comparisons. Our implementation of SFA utilizes a Cobb-Douglas production function with half-normal distribution for the inefficiency term. The weights on DEA are unrestricted.

Unfortunately, unrestricted SFA and DEA may assign and be dependent upon improbably small weights. In this analysis, both SFA and DEA generate weights that are zero or are close to zero. This is a major concern and limitation of these methods. In these cases, it is likely that the ability to pay is being underestimated for a specific country. The very large uncertainty intervals associated with our estimates are evidence that this is a problem for these data. A remedy to this problem is utilizing restricted SFA or DEA. IHME is in the process of developing a unified framework for Restricted Data Envelopment Analysis (rDEA) and Restricted Stochastic Frontier Analysis (rSFA). These are novel approaches to estimating efficiency, but are still in development. At this point, applying these methods or additional methods used to restrict SFA or DEA is out of scope for this supplementary work. Given the size of the uncertainty estimates, this is work that should be strongly considered in the future if these methods and the ability to pay estimates are to be used as evidence for policymaking.