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Patterns and Drivers of Health Spending Efficiency

Mercedes Garcia-Escribano, Pedro Juarros, and Tewodaj Mogues

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ABSTRACT: Demands for ramping up health expenditures are at an all-time high. Countries' needs for additional health resources include responding to the COVID-19 pandemic, closing gaps in achieving the Sustainable Development Goal in health in most emerging and developing countries, and serving an ageing population in advanced economies. Facing limited fiscal space for raising health spending focuses policymakers' attention on ensuring that resources are used efficiently. How sizable are the potential gains—in terms of freeing up resources and delivering better health outcomes—from improving health spending efficiency? How has efficiency evolved over the past decade? What can policymakers do to boost it? This paper estimates health spending efficiency across countries using bias-corrected data envelopment analysis and finds sizable differences in efficiency across countries, in particular among emerging and developing countries compared to advanced economies. The examination of the evolution of efficiency reveals that important efficiency gains have been made in the majority of countries. The paper also explores some of the key drivers of efficiency and finds that lower income inequality, less corruption, and health interventions oriented at expanding population access to basic health services are associated with greater efficiency.

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WORKING PAPERS

Patterns and Drivers of Health Spending Efficiency

Prepared by Mercedes Garcia-Escribano, Pedro Juarros, and Tewodaj Mogues[1]

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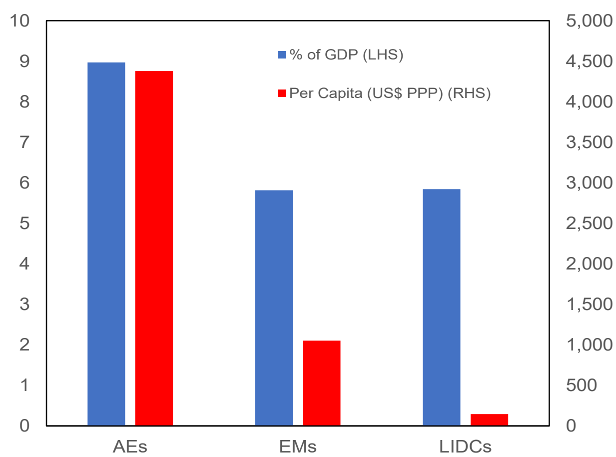
I. Introduction

The COVID-19 health emergency has raised global awareness that countries differ in their ability to respond to calls for additional health spending. In response to the demand for further health expenditures amidst the pandemic and reflecting differences in the availability of fiscal space, selected advanced economies (AEs) increased health expenditures by an average of 1.5 percent of GDP in 2020 while the increase averaged 0.9 percent of GDP both in emerging markets (EMs) and in low-income developing countries (LIDCs).[2] Yet, there is a call for even more resources across all income groups, as the 2020 significant budget boost compares unfavorably with the estimated additional health spending that still would be needed to combat the pandemic, including production and distribution of vaccines, treatments, and health care infrastructure.

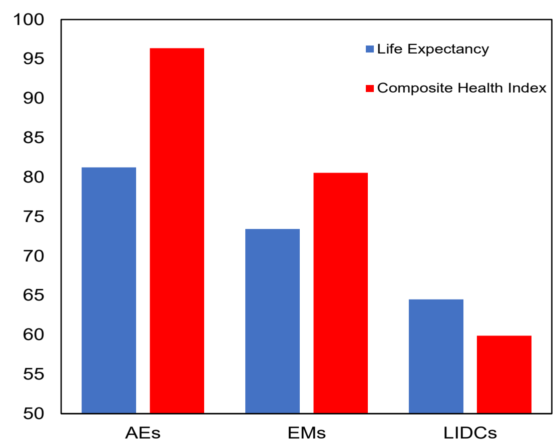
The differences across income groups in the health fiscal support in response to COVID-19 are also mirrored in the pre-COVID health spending levels. On average, EMs and LIDCs dedicated a smaller share of their GDP to healthcare than did AEs (Figure 1). Correspondingly, we find that life expectancy and a composite index of health outcomes[3] is higher in AEs than in EMs and LIDCs (Figure 2). This positive correlation between health spending levels and health outcomes, combined with low levels of the latter in many countries, is suggestive of health spending levels' inadequacy in these countries. Consistent with this observation, previous IMF work showed that LIDCs would need to increase, on average, their annual health spending by 4.6 percent of GDP by 2030 in order to meet the Sustainable Development Goal on health (SDG3), while more modest increases are required in many EMs (Figure 3).

Figure 1. Health Expenditures
2017



Source: IMF staff calculations using WDI (2020).

Figure 2. Health Outcomes
(Life Expectancy (years) in 2017 and Composite Index 2014–17)



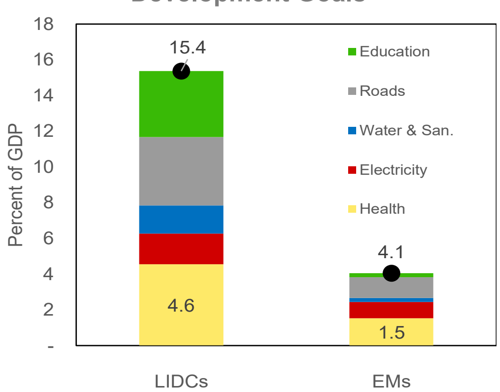
Source: IMF staff calculations using WDI (2020).

[2] Fiscal Monitor Database of Country Fiscal Measures in Response to the COVID-19 Pandemic (accessed September 2021).

[3] The composite health index uses the following variables, averaged over the indicated year ranges: (i) maternal mortality rate (2014–17), (ii) neonatal mortality rate (2015–18), (iii) under-5 mortality rate (2015–18), (iv) incidence of tuberculosis (2015–18), (v) HIV incidence (2015–18), (vi) cardiovascular/cancer incidence (2010–16), (vii) adolescent fertility rate (2014–17), and (viii) HALE (2016).

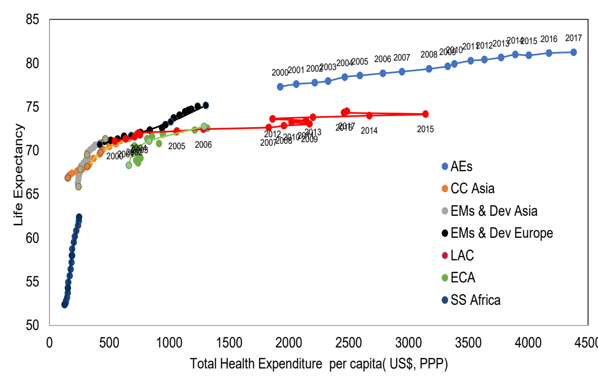
Due to limited fiscal space, barriers to reallocate spending, and calls to ensure that health systems become adequately resourced, policymakers are turning their attention to health spending efficiency—the core topic of this paper. Indeed, as important as spending more resources in health continues to be—discussed for example in Gaspar et al. (2019), it is also crucial spending those well. Inefficient spending results in poor outcomes or unnecessarily high outlays. Simply increasing public expenditure in the health sector may not yield the expected health outcomes if the efficiency of this spending is low. In fact, the health expenditure estimates to reach the SDG on health quoted above assume that the additional spending is accompanied by higher spending efficiency. Should improvements in efficiency not take place, the health spending required to reach SDG3 would be even larger. Figure 4 shows that the relationship between resources and outcomes is "flatter" for AEs (that is, additional spending over time results in smaller gains in life-years than is the case for Sub-Saharan Africa, for instance), due to the concavity of the production frontier. The fact that some countries achieve higher levels of output with the same input level (vertical axis) or the same outcome with less resources (horizontal axis) provides an indication of efficiency.

Figure 3. Spending to Reach Sustainable Development Goals



Source: Gaspar et al. (2019).
Note: GDP-weighted average for countries, by income group.

Figure 4. Trends in Health Expenditures and Life Expectancy, 2000–17



Source: IMF staff calculations using WDI (2020).

In this paper, we derive countries' input- and output-oriented efficiency scores using bias-corrected data envelopment analysis (DEA) and find significant variation among countries.[4] Our quantitative results are in line with previous empirical research. On average, AEs are the most efficient income group compared to LIDCs and EMs. LIDCs as an income group, and the Sub-Saharan African region, lose the most in terms of life expectancy due to their inefficient use of health resources: 8.2 and 10.5 life-years on average, respectively. The income group of EMs and the region of Caucasus and Central Asia, in turn, suffer the greatest waste of health resources—1.4 and 1.9 percent of GDP, respectively. Results are robust to alternative output variables.[5]

[4] Bias-corrected Data Envelopment Analysis (DEA) is a non-parametric linear programming method that measures relative efficiency across units constructing a piecewise linear envelopment frontier over the data points. It does not impose a functional form over the production possibility frontier. To correct for bias of measurement error, we use bootstrap DEA (Simar and Wilson, 2007). See Section III for a detailed explanation of this methodology.

[5] Appendix II shows results for health-adjusted life expectancy (HALE) and Appendix III reports results on a composite health index constructed with eight health outcome indicators (maternal mortality rate, neonatal mortality rate, under-5 mortality rate, incidence of tuberculosis, HIV incidence, cardiovascular/cancer incidence, adolescent fertility rate, and HALE).

We find that the vast majority of countries' health systems became more efficient over a span of a decade (2007–17). LIDCs were particularly successful in achieving improved health outcomes over time for their spending levels, while AEs as an income group saw the greatest share of countries that were able to improve over time the amount of resources saved while keeping achieved levels of life expectancy. In the course of this decade, not only did efficiency rise on average, so did technological progress—that is, a favorable shift of the production frontier in the health sector. Thus, over this time period, the Malmquist productivity index—a metric that combines the two measures of efficiency change and technical change—saw global gains.

Given the significant cost of suboptimal spending in the sector, this paper examines some important drivers of health inefficiency. Directing health funds more toward a universal health coverage of essential services (UHC) significantly raises the overall efficiency of health expenditures, in particular in EMs and LIDCs, where baseline essential health services are relatively poor compared to AEs. Reallocating resources within the health sector so as to elevate countries' UHC to their respective income group's 75th percentile would increase LIDCs' average life expectancy by 3.4 years, or alternatively enable them to save 0.37 percent of GDP without compromising life expectancy. We also assess the role of broader economic and institutional factors on health spending efficiency. Our results reveal that addressing overall income inequality and controlling corruption has an impact on stemming inefficiency, albeit a somewhat more modest one than moving toward UHC. For example, improving LIDCs' Gini coefficient to the 75th percentile (with the 100th percentile defined as the most equal country) of this income group will increase life expectancy by 2.1 years, and increasing EMs' control-of-corruption index to the group's 75th percentile will enable countries to save 0.27 percent of GDP in health spending while maintaining the same health outcomes.

The remainder of the paper proceeds as follows. The next section presents key findings from the literature relevant to our study. Section III lays out the methodology used to derive input- and output-oriented efficiency—first intuitively, then formally—and describes the data for the empirical analysis. The first set of results on patterns across country groups, and the loss in terms of outcomes and resources arising from inefficiency, are given in Section IV. This is followed by an examination of how health efficiency has changed in the span of the recent decade (Section V). In Section VI, we assess the key factors that could impede health spending inefficiency and quantify the influence of these drivers. The final section concludes.

II. Existing Evidence on Health Spending Inefficiency

There is a large and growing literature that documents significant inefficiencies in the health sector across the world. For comparisons across countries, life expectancy and infant mortality rates are the most common output variables used in the literature, for data availability reasons. A global analysis finds a mean efficiency score of 0.80 (Greene, 2004),[6] meaning that on average, countries could increase health outcomes by 20 percent without using any more health resources (an in-depth discussion of the measures of efficiency is offered in Section III). In OECD countries, Afonso and St. Aubyn (2005) estimate an average efficiency score of 0.83.[7] A meta-analysis of the peer-reviewed literature shows that averaging over 99 studies' results on

[6] The author's preferred specification reports an inefficiency score of 0.196 using a heterogeneous random-effects stochastic frontier model, in which the outcome is disability-adjusted life expectancy.

[7] This is an average input-oriented DEA score assuming variable returns to scale.

hospitals' efficiency gives a score of 0.84 (Hollingsworth, 2008). A country-level study estimates that those hospitals that are not fully efficient could save 7 percent in the number of physicians and 14 percent of nurses if they were fully efficient, and conversely would be able to double the number of daycare health services without expanding inputs (Puig-Junoy, 2000).

Underlying these averages are variations by country group and within countries. Gupta and Verhoeven (2001) conclude that African countries' health spending efficiency level lags far behind that of Asia and of Western Hemisphere emerging markets and developing economies (EMDEs), with the latter two regions' average scores similar to each other. Hollingsworth et al. (2002) identified discrepancies between local government areas of Australia, with a production efficiency mean score of 0.71 and 0.80 in rural and urban areas, respectively, possibly reflecting the higher cost of delivering services in rural areas. Grigoli and Kapsoli (2018) find similar results with African economies that could benefit the most from eliminating inefficiencies, gaining anywhere from 4.0 to 8.2 health-adjusted life years, while the least gains accrue to countries in the Western Hemisphere and in the Asia and Pacific region (ranging from 1.2 to 4.7 health-adjusted life-years). Madeiros and Schweirz (2015) estimate that on average in the EU, life expectancy at birth could be increased by 2.3 percent, or 1.8 years (1.2 years at age 65), when moving from current positions to the efficiency frontier. Relatively few studies have given attention to the evolution of health spending efficiency over time. In EMDEs as a whole, Gupta and Verhoeven (2001) do not find much change from the second half of the 1980s to the first half of the 1990s, although improvements were discerned in the Western Hemisphere region. Annual analysis over the 2000s in OECD countries shows that health care efficiency increased mildly up to mid-decade, only to steadily fall, arriving at a lower level by 2010 than at the start of the decade (Samut and Cafri 2016). This decline in efficiency was accompanied by a regress in technology, resulting in an overall decline in the Malmquist Productivity Index, which combines the measures of technical and efficiency changes (this index is further discussed in Section III).

Turning to the factors affecting efficiency, specific types of health service provision seem to play a role. For instance, immunization of children (Pérez-Cárceles et al., 2018; Alexander et al. 2003) is found to enhance health outcomes for given amounts of resources. An exploratory study of Zimbabwe's health system showed that an emphasis on integrated care—in which multiple health conditions are simultaneously addressed—would bring about much-needed improvements in allocative efficiency (Hou et al. 2021). The arrangement and governance of health systems matter as well (Savedoff (2011) for a conceptual treatment of the topic). Results from hospitals in Spain point to higher market concentration (e.g. hospitals operating de facto as monopolies) eroding health service efficiency (Puig-Junoy, 2000). An aspect of the structure of health systems is the balance between public and private health care provision. Samut and Cafri (2016) conclude from their analysis of OECD countries that while higher prevalence of private hospital care is associated with greater health care efficiency, the reverse is true with regard to public care. Qualitative World Bank analysis of health spending efficiency in Vietnam points to the inefficiencies inherent in a hospital-centric system, whereby provision at the primary health care level in many cases could serve patients with the same quality at lower cost (Teo and Huong, 2020).

Various broad factors not specific to the health sector have also been found to play a role for health care efficiency. These include institutional quality, income levels, and economic distribution. Cavalieri et al. (2017) find that worse values of a synthetic measure of corruption in public contracts are associated with poorer results in the efficient execution of health infrastructure projects in Italy. Inequality in income, measured by the Gini coefficient, is also assessed to be detrimental to efficient health provision in a cross-country panel analysis

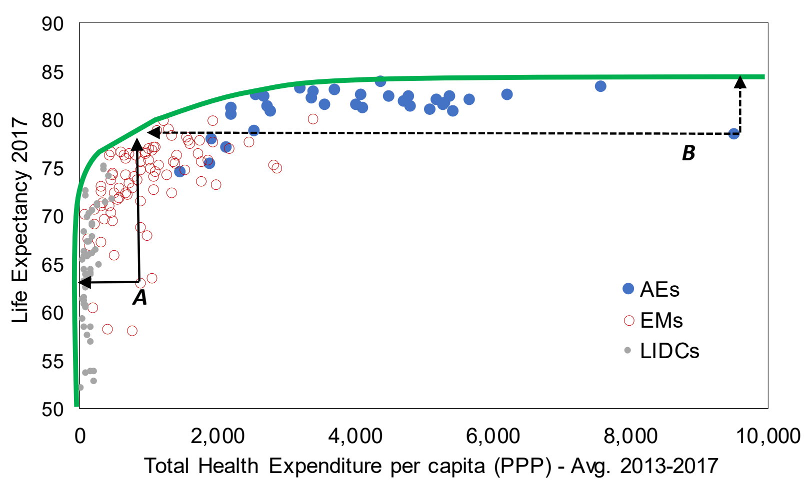
(Greene, 2004). The latter study also concludes that having higher overall income leads to a more productive process in transforming health resources into improved health outcomes.

Service provision in other sectors can also improve how effectively health spending is deployed to improve outcomes. Higher levels of education may result in better health outcomes given existing health spending, as education may induce behavioral changes toward better life-style choices, as Samut and Cafri (2016) found across OECD countries, and Alexander et al. (2003) in developing countries. In lower-income countries in particular, where hygiene facilities are often inadequate and nutrition security a particular concern, greater service provision in sanitation can control diseases without the need of additional spending in the health sector, as found for example in India (Kathuria and Sankar, 2005). Improving services that reduce undernourishment lessens the susceptibility to illness and thus enhances the effectiveness of existing health resources in developing countries (Alexander et al. 2003).

III. Data and Methodology

We start with an intuitive treatment of the concept and measurement of efficiency. Figure 5 presents data on countries' health expenditures per capita on the horizontal axis, and life expectancy on the vertical axis—similar to Figure 4, but in cross-sectional form with groups disaggregated into individual countries. The green curve in Figure 5 is an illustrative (i.e. not analytically derived; analytical treatment follows later in this section) non-decreasing quasi-concave frontier such that all countries are below and to the right of the curve, or else lie on the frontier. The latter type of countries is considered fully efficient, while all others are inefficient to varying degrees.

Figure 5. Illustrative Efficiency Frontier



Source: IMF staff calculations.
Note: The curve is drawn for illustration, not derived analytically.

We consider two measures of efficiency: input- and output-oriented. The degree of input-oriented efficiency of a country is captured by the extent to which it could reduce spending if the country were on the frontier, while achieving the same level of life expectancy. This is illustrated by the solid horizontal arrow for country A in Figure 5. Conversely, the output-oriented efficiency of this country conveys how much more life expectancy it could maximally gain while keeping health spending constant, represented by the solid vertical arrow. It is not necessarily the case that input- and output efficiencies change in the same direction when comparing two countries or, for that matter, averages between country groups. To appreciate this intuitively, consider that country A has a relatively lower amount of health spending and achieves a lower life expectancy than country B. A's output-efficiency is also lower than B's (the solid vertical arrow is longer than the dashed one). However, B is more input-inefficient than A, as can be seen by their respective horizontal arrows. This simplified illustration is on the basis of one input (health expenditures) and one output (life expectancy), but measures of efficiency can in principle accommodate the use of multiple inputs and outputs, which however cannot be as easily visualized in a chart.[8]

There are two broad approaches—parametric and non-parametric—for estimating efficiency. Parametric methods use econometric models and as such make assumptions about the functional form of the efficiency frontier and the distribution of the stochastic errors. Non-parametric approaches do not impose such assumptions as they are based on mathematical programming. They have merit when conducting efficiency analysis on broad categories such as the whole health sector, as there are limited priors on what functional form underpins the relationship between inputs and outputs. Also, nonparametric results are not as easily undermined by having a limited number of observations. Most importantly, parametric methods only enable the analysis of output-oriented efficiency, while in this study, of interest is the derivation of both input- and output-efficiency.

The most commonly used technique in the nonparametric family of methods—and the one we use in this paper—is the data envelopment analysis (DEA). The DEA derives a piecewise-linear frontier based on the highest performing decision-making units (or DMUs) and then assesses the performance of all DMUs relative to the frontier. The solution to the following mathematical programming processes produces the DEA input- and output-oriented efficiency scores:

Output-oriented efficiency

$$\max_{\eta,\delta^{out}} \delta^{out} \quad (1.i)$$

subject to:

$$X_{hr} \geq \sum_{k=1}^{K} \eta_k X_{kr} \quad (1.ii)$$

$$\delta^{out} Y_{ho} \leq \sum_{k=1}^{K} \eta_k Y_{ko} \quad (1.iii)$$

$$\eta_k \geq 0 \quad (1.iv)$$

$$\sum_{k=1}^{K} \eta_k = 1 \quad (1.v)$$

Input-oriented efficiency

$$\min_{\eta,\delta^{in}} \delta^{in} \quad (2.i)$$

subject to:

$$Y_{ho} \leq \sum_{k=1}^{K} \eta_k Y_{ko} \quad (2.ii)$$

$$\delta^{in} X_{hr} \geq \sum_{k=1}^{K} \eta_k X_{kr} \quad (2.iii)$$

$$\eta_k \geq 0 \quad (2.iv)$$

$$\sum_{k=1}^{K} \eta_k = 1 \quad (2.v)$$

where X_{hr} and Y_{ho} are the amounts of input *r* and output *o* used/produced by the decision-making unit *h*, and η_k are weights associated with the k^{th} DMU. The linear programming problem for output-efficiency produces an

[8] Efficiency measures in the context of just one output and one input are not simply derived on the basis of the arrows in Figure 5, which are just shown to convey the intuition; the detailed methodology is laid out later in this section.

efficiency score for DMU *h* that is as large as possible given a set of constraints. For each input type, the weighted sum of the *K* DMUs' inputs can be no larger than DMU *h*'s input (1.ii); *h*'s output multiplied by δ remains less than the weighted sum of the DMUs' outputs (equation 1.iii); and the above-mentioned *K* weights (one for each DMU) are nonnegative (1.iv) and add up to 1. The latter constraint ensures a variable returns to scale model, that is, each DMU is assessed against other DMUs of similar size (Banker, Charnes and Cooper, 1984). The inverse of the maximized factor, i.e. $1/\delta^{out}$, is then the technical output-efficiency score that ranges from 0 (fully inefficient) to 1 (fully efficient). The process for input-oriented efficiency is analogous (Equations 2.i to 2.v) with the exception that the input-efficiency score that ranges from 0 (fully inefficient) to 1 (fully efficient) is the minimized objective function δ^{in} (and not its inverse).

One of the limitations of standard DEA is that it does not account for measurement error and does not involve statistical inference. The frontier relies heavily on the best performers, and as such, the method produces efficiency scores that are biased upwards. To adjust the approach into an inferential methodology and overcome this bias, we use bootstrapping, which considers the sensitivity of the efficiency scores to sampling variation (Simar and Wilson, 2007). While the standard DEA frontier can be seen as an estimate of the true frontier based on a single sample drawn from an unknown population, the bootstrapped DEA frontier is based on *B* independent samples (with replacement) drawn from the original dataset, used as a basis of bias-corrected efficiency scores (Bogetoft and Otto, 2011).

The main efficiency analysis in this study is based on one input and one output measure for countries.[9] See Appendix Table AI.1 for a description of the variables and data sources. The output is life expectancy at birth, measured in years, for the latest year available, 2017. The input is total (that is, public plus private) health expenditures per capita, measured in purchasing-power parity (PPP) dollars and averaged over a five-year period. The latter is for multiple reasons: to smooth over strong spikes/troughs in a given year, due to missing values in any given cross-section, and to recognize that health spending bears on health output with a lag. The five-year period used for calculating the input is 2013–17 so that it ends in the year for which the output is measured. Our sample comprises 173 countries: 34 AEs, 84 EMs, and 55 LIDCs. We derive both input- and output-oriented efficiency scores using the bootstrap DEA method.[10] The primary findings of this paper are also presented using health-adjusted life expectancy (HALE) as the output variable as a robustness check (Appendix II).[11]

IV. Patterns in Health Spending Efficiency

The results on the magnitude of efficiency reveal cross-country and cross-group heterogeneities as well as, to some extent, different patterns for input- and output-oriented scores. AEs are on average more efficient in transforming resources into health outcomes than EMs, and the latter in turn have a clearly higher output efficiency than LIDCs (Figure 6.a). The general patterns observed in averages also hold up when considering median levels of efficiency. The pronouncedly higher efficiency of AEs over EMs and LIDCs also obtains when

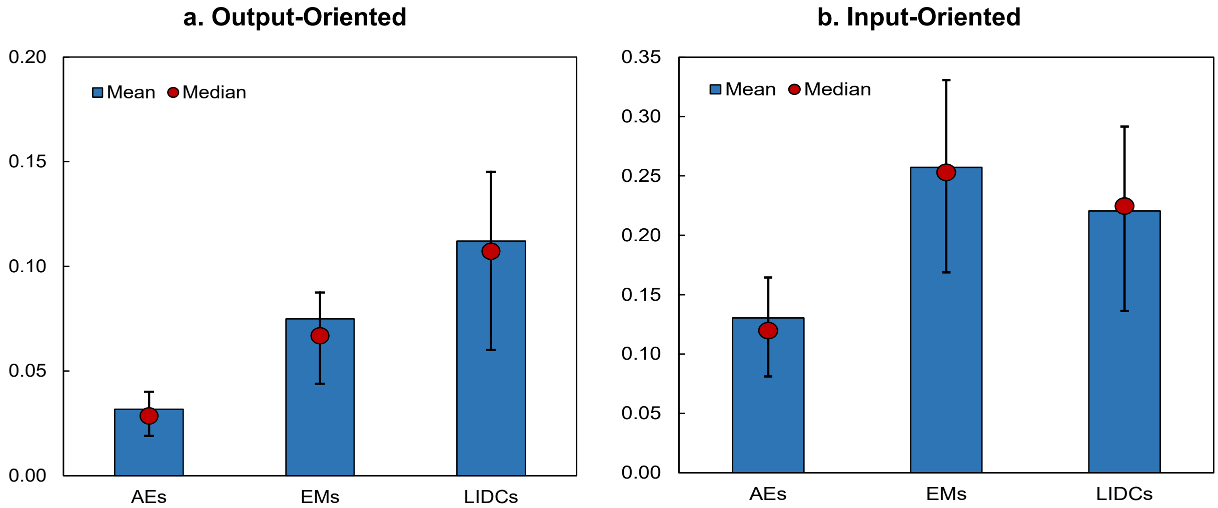
[9] The implicit assumption in our analysis is the existence of a common production function across countries, in the same vein as model specifications in cross-country regressions.

[10] We use 200 bootstrap samples.

[11] HALE indicates the average number of years that a person can live in full health, i.e. accounting for years lived in less than full health due to disease or injury. The composite health index is constructed with 8 different health indicators (maternal mortality rate, neonatal mortality rate, under-5 mortality rate, incidence of tuberculosis, HIV incidence, cardiovascular/cancer incidence, adolescent fertility rate, and HALE) and captures the multi-dimensional aspect of health outcomes.

Figure 6. Health Spending Efficiency, 2017

(Inefficiency Scores)



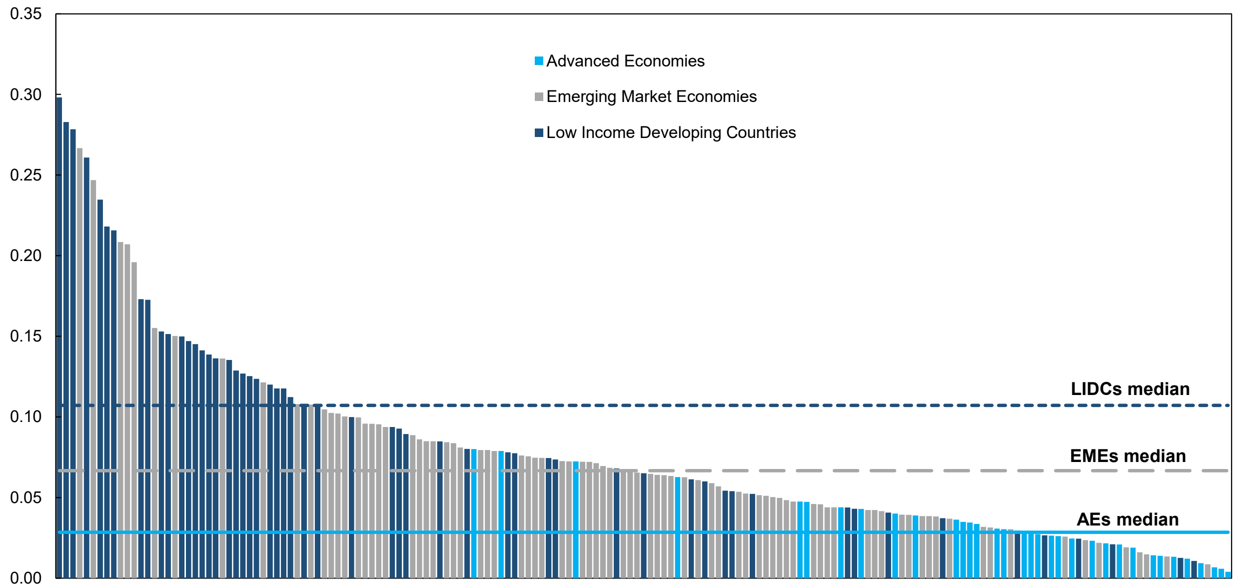
Source: IMF staff calculations.
Note: Bias-corrected (bootstrapped) DEA scores for life expectancy in 2017 using as input total per capita health expenditure (PPP) averaged over 2013 to 2017. Black lines denote the inter-quantile range.

considering input-oriented efficiency—i.e. the ability of countries to achieve a certain outcome (e.g. here, life expectancy) with a given amount of resources (Figure 6.b). However, LIDCs are found to be modestly more input-efficient than EMs. At this point it is useful to remind ourselves that efficiency measures are a distinctly different concept from measuring outcomes: Figure 2 had shown that EMs have clearly higher life expectancy than LIDCs, but Figure 6.b indicates that this does not necessarily translate into higher input efficiency. Also, the comparison of income groups in Figures 6.a and 6.b are an illustration that input- and output-orientation do in fact measure different aspects of efficiency, as was discussed in Section III. Appendix II, Figure AII.1 and Appendix III, Figure AII.1 show the equivalent results considering health-adjusted life expectancy (HALE) and a composite health index as alternative ways of capturing health outcomes, and we come to very similar conclusions.[12]

Underlying this aggregate picture is, however, a lot of variation within income groups. For example, while half of LIDCs have output-inefficiency scores above 0.1, there is a wide dispersion among LIDCs, with some reaching scores similar to the highest-performing EMs and AEs (Figure 7). Similarly, EMs' inefficiency scores span nearly the full range of all countries. In contrast, there is much less variation among AEs, of which only three countries have inefficiency scores above that of EMs' median.

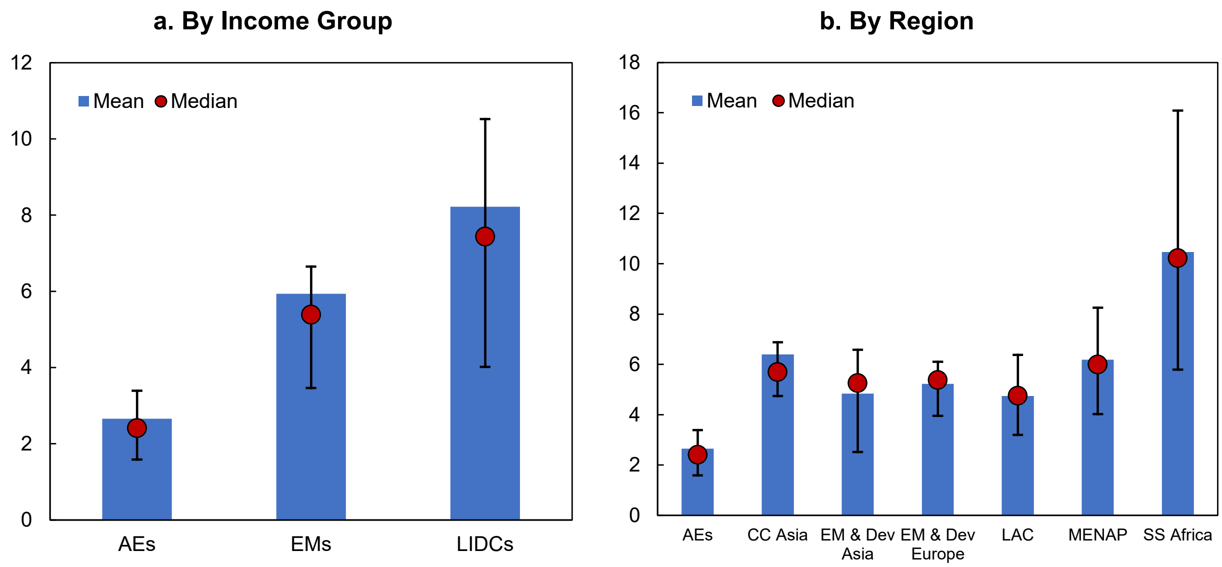
[12] The robustness of the results using alternative outputs is consistent with a very high positive correlation of the corresponding efficiency scores. The correlation of output-oriented efficiency scores across countries when output is life expectancy and when it is health adjusted life expectancy is 0.94, and the analogous correlation for input-oriented efficiency scores is 0.88. Similarly, the correlation between output-oriented efficiency scores using life expectancy and the composite health index as outcome variables is 0.92, and the analogue for input-efficiency scores is 0.87.

Figure 7. Cross-country Variation in Health Spending Efficiency, 2017
(Inefficiency Scores)



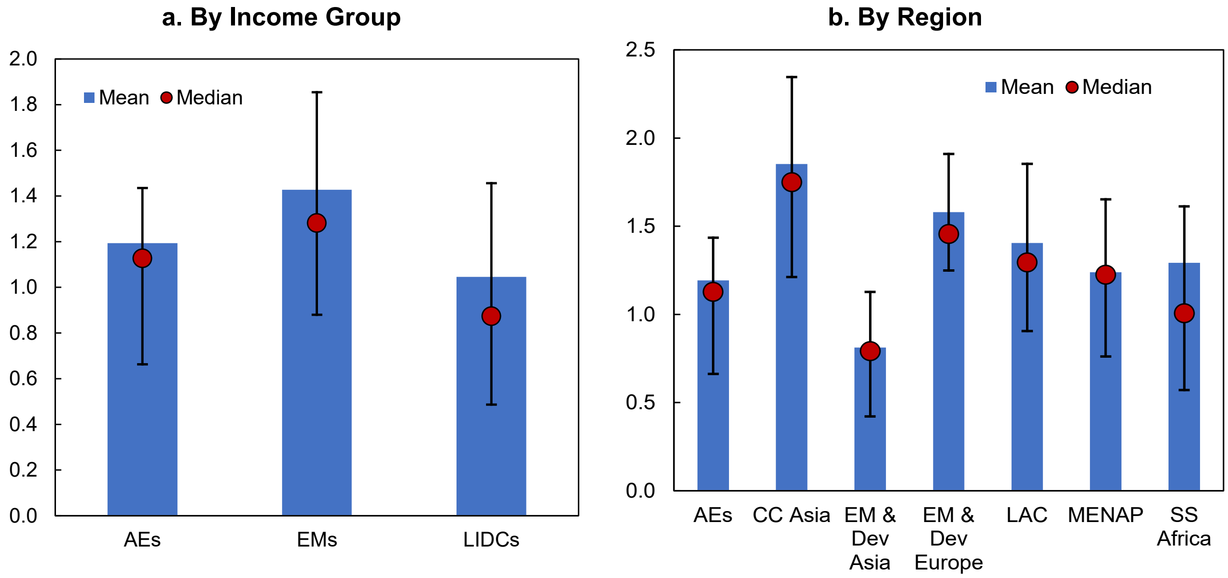
Source: IMF staff calculations.
Note: Output-oriented inefficiency scores for life expectancy in 2017 using as input total (public and private) per capita health expenditure (PPP) averaged over 2013 to 2017.

Figure 8. Years of Life Lost due to Inefficient Health Spending
(Years)



Source: IMF staff calculations.
Note: Efficiency scores underlying these calculations use as output life expectancy in 2017 and as input total per capita health expenditure (PPP) averaged over 2013 to 2017. Black lines denote the inter-quantile range.

Figure 9. Wasted Resources due to Inefficient Health Spending
(Percent of GDP)



Source: IMF staff calculations.
Note: Efficiency scores underlying these calculations use as output life expectancy in 2017 and as input total per capita health expenditure (PPP) averaged over 2013 to 2017. Black lines denote the inter-quantile range.

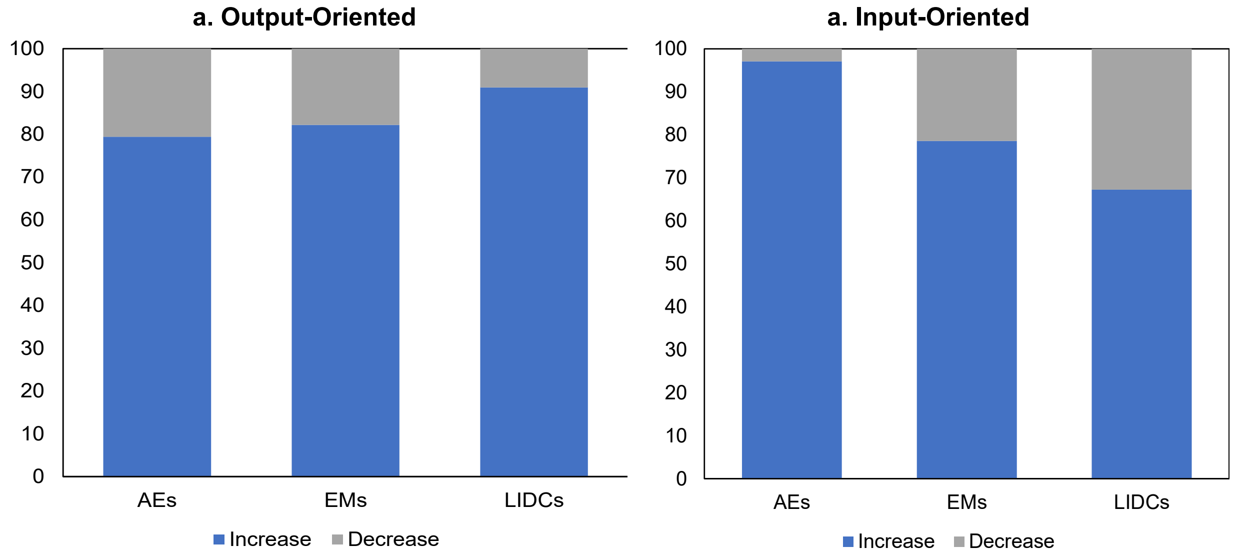
The estimation of input-oriented efficiency affords an analysis of the resources wasted as a result of inefficient spending. As a reminder, input-efficiency scores measure the gap between the resources employed by a given country and that of the most efficient countries that achieve a similar output. EMs have the most to gain from closing the input-efficiency gap, as they could save 1.4 percent of GDP on average, while AEs could prevent a waste of 1.2 percent of GDP in health expenditures (Figure 9.a). LIDCs' resources lost due to inefficiency are the lowest of the three income groups, at 1.0 percent of GDP, in part reflecting that health spending levels per capita are considerably lower than that of AEs or EMs (Figure 1). The regional disaggregation of resources wasted due to inefficiencies reveals Emerging and Developing Asia to be region with the smallest waste (0.8 percent of GDP) followed by AEs (1.2 percent of GDP) (Figure 9.b). Caucasus and Central Asia (1.9) and Emerging and Developing Europe (1.6) perform most poorly. Results are similar when examining the resources lost to inefficiency in using inputs to bring about health-adjusted life expectancy, except that AEs' resources lost are more sizeable (1.8 percent of GDP) and larger than those of EMs' (Appendix III, Table AIII.1).

V. Evolution of Health Spending Efficiency Over Time

In order to assess how health spending efficiency has evolved over time, we conduct the same analysis for 2007 as carried out for 2017, then derive the share of countries within each income group for which efficiency improved over time. It is evident from the results displayed in Figure 10 that more countries showed improvements in efficiency over the span of the decade than fell behind (when using health-adjusted life efficiency as an output, however, only a quarter of AEs showed output-efficiency improvements over time; see Appendix II, Table AII.4). In total, 146 (136) countries became more output (input) efficient over time, compared

Figure 10. Change in Health Spending Efficiency by Income Group, 2007–17

(Percent of Countries in Income Group)



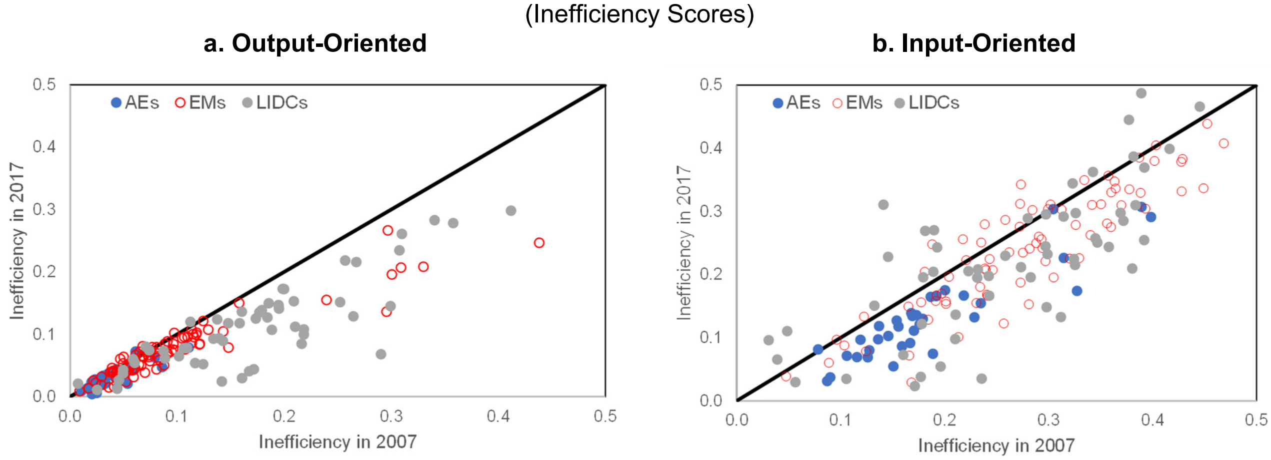
Source: IMF staff calculations.
Note: Efficiency scores for 2007 [2017] use as output life expectancy in 2007 [2017] and as input total per capita health expenditure (PPP) averaged over 2003 to 2007 [2013 to 2017].

to 27 (37) that saw a deterioration. As with the cross-sectional results, the findings on evolution also highlight the importance of considering both input- and output-orientation in interpreting how efficiency varies by country groups. The share of countries becoming more output-efficient over time is greater for EMs than AEs, and for LIDCs than EMs (Figure 10.a). In contrast, the lower the income status of the group, the lower the share of its countries that see an improvement in input-efficiency over the span of the decade (Figure 10.b).

Figure 11 reveals further granularity underlying these trends over time both by showing individual country dispersion in the cross-temporal efficiency space, as well as by enabling a visualization of the magnitude of improvements (patterns in HALE-based efficiency change are very similar, see Appendix II, Figure AII.5).

Figure 11. Evolution of Spending Efficiency, 2007–17

(Inefficiency Scores)

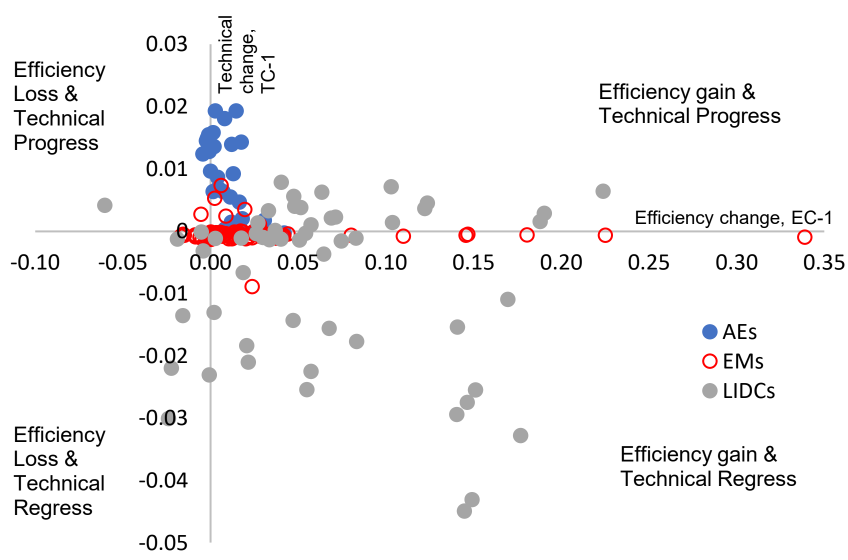


Source: IMF staff calculations.
Note: The diagonal is the 45º line indicating no change in efficiency between the two periods.

But do efficiency changes drive all the observed changes in life expectancy? In other words, what is the role of technological change? Progress over time in life expectancy may materialize either due to spending efficiency changes, or due to technological advance, or both. Efficiency change (*EC*) captures how much closer to the frontier a unit gets between two periods, and is calculated as $EC_h = \frac{\theta_h^{22}}{\theta_h^{11}}$ where θ_h^{11} denotes country *h*'s efficiency score in period 1 as we have derived it heretofore, i.e. using as a reference the technology of year 1. θ^{22} is the analogous score in period 2. The second component, technical change (*TC*), captures the frontier shift: how much the global frontier shifts between the two time periods at each country's observed input mix. It thus gives the degree of progress arising from the innovations occurring between the two periods, and is measured as $TC_h = \sqrt{\frac{\theta_h^{11}}{\theta_h^{12}} \cdot \frac{\theta_h^{21}}{\theta_h^{22}}}$, where θ_h^{12} evaluates country *h*'s period-1 input-output combinations with respect to period-2's technology frontier (and vice versa for θ_h^{21}). It is then apparent from the expression for technical change that, for given input-output mixes that *h* has in periods 1 and 2, if the frontier shifts upward from period 1 to period 2, then TC_h rises, i.e. there is positive technical change. The Malmquist index measures the change in productivity of a unit from one point in time to another. The index M_h is derived as the multiplication of the efficiency change index with the technical change:

$$M_h = EC_h \cdot TC_h = \frac{\theta_h^{22}}{\theta_h^{11}} \cdot \sqrt{\frac{\theta_h^{11}}{\theta_h^{12}} \cdot \frac{\theta_h^{21}}{\theta_h^{22}}} \quad (3)$$

Figure 12. Change in Life Expectancy Driven by Efficiency and Technology, 2007–17
(Malmquist Sub-indexes)



Source: IMF staff calculations.
Note: Output-oriented decomposition of Malmquist Index.

While Figure 11 showed the changes in efficiency over time, Figure 12 plots both efficiency change (along the horizontal axis) as well as technical change (along the vertical axis). It shows that between periods not only efficiency improvements, but also technological progress, have been responsible for greater productivity in using resources to enhance life expectancy. Most of the countries are located on the upper-right-hand quadrant, meaning that countries improved both in terms of efficiency and technology. Fewer countries are seen under the horizontal line, and among these, especially several LIDCs and EMs suffered a relative technological regress while experiencing relative efficiency gains.[13] This implies that the frontier for these countries shifts proportionally less than their peers, but they got closer to the frontier over the sample period. If the frontier had shifted at the same rate, overall efficiency gains would have been larger for these LIDCs and EMs.[14]

VI. Determinants of Efficiency

Section IV had revealed interesting patterns in efficiency across income groups, regions, and time, and the fiscal and years-of-life losses due to how health resources are spent. These patterns provoke the question of what the drivers of health expenditure inefficiency may be. We explore the following three factors given the implications for policymakers: universal health coverage with essential services, income distribution, and corruption.

Coverage of the population with essential health care, consisting of a minimum, core package including prevention, treatment and rehabilitation services that can be progressively expanded, can be highly cost-effective in addressing the most significant causes of illness and death. As such, allocating a relatively larger share of medical resources to such essential coverage may contribute to achieving greater life expectancy for a given envelope of total health expenditures. We thus consider this a potential explanatory factor of health spending efficiency, and use the index developed by the WHO of universal health coverage (UHC). This index is based on 14 tracer indicators across four essential service areas: infectious diseases; reproductive, maternal, newborn and child health; non-communicable diseases; and service capacity and access (WHO, 2019). To reflect the extent to which countries allocate a greater or lesser amount of their health resources to such essential services, our analysis also includes as a control variable the country's total amount of health spending.

A broader phenomenon, economic inequality, may also inhibit the effective conversion of financial resources allocated to the health sector into higher life expectancy. Ravallion (2003) remarks on the plausibility of the variation in income distribution mattering for countries' social outcomes. Income inequality may work against health spending efficiency given that (holding average income constant) more unequal distribution translates to a greater share of poor people, and the livelihood, residential, and other options of poorer populations may make them more susceptible to illness, injury, and shortened lives. This motivates inclusion of the Gini coefficient in our second stage regression.

There is vast evidence on the corrosive effects of poor governance and corruption on efficiency in service provision, which in turn hampers growth and development (Bardhan, 1997). In the health sector in particular, an estimated US$455 billion of health care expenditures worldwide are lost globally each year to corruption (NASEM, 2018). The complexity of health systems, diversity of actors involved, and various points of asymmetric information increase multiple types of corruptive opportunities in health care. Special interests may, legally or illegally, provide public actors rewards for redirecting public health care funds in ways that contravene both equitable and efficient allocation of health resources. As the poor are less able to pay bribes to get needed

[13] When a country evidences a technical regress in this decomposition analysis, it does not imply that the absolute technology of converting spending to years of life expectancy decays over time.

[14] This result is explained by low levels of spending in mostly Sub-Sahara African economies, i.e. where marginal returns of spending are larger due to the concavity of the production function. Future work is needed to explore the determinants of these changes in efficiency over time.

treatments, affordable care is more likely to go unprovided to disadvantaged groups when corruption is widespread. Arising from these insights, our examination of the determinants of health spending efficiency incorporates a measure of corruption as an explanatory variable, drawn from the Worldwide Governance Indicators (Kauffman et al., 2010).

Also included as potential explanatory variables are factors stated in the literature as potentially influencing the efficiency of health resources. Higher education can enhance the attainment of health outcomes with lower levels of spending, as greater human capital may enable health-supportive individual behaviors, including through the consumption of more preventive care services (Fletcher and Frisvold, 2009) that would reduce the incidence of disease (for example, Grigoli and Kapsoli (2018) assess education as an explanatory factor of health spending efficiency).[15] Also, policy discussions as well as academic assessments of the relative efficiency of private versus public healthcare spending has a long history. A meta-analysis finds suggestive (albeit non-conclusive) evidence that public healthcare delivery may be more efficient (Hollingsworth, 2008). To enable an assessment of this factor, we include in our second-stage regression the share of public in total health expenditures.

Finally, countries' GDP per capita is included as a control variable given the many variables that are correlated with income levels and that could have an impact on efficiency, such as water safety and sanitation.

We include these potential determinants of health spending efficiency as explanatory variables in a cross-sectional regression. The basic model is as follows:

$$\begin{aligned} Eff_i = \ & \alpha + \beta_1 UHC_i + \beta_2 \ln(Gini_i) + \beta_3 Corr_i + \gamma_1 \ln(GDPPC_i) + \gamma_2\, ln\,(Ed_i) \\ & + \gamma_3\, ln\,(HXPC_i) + \gamma_4\, SPHX_i + \varepsilon_c \end{aligned} \tag{4}$$

where Eff_i is the life expectancy efficiency score in 2017 for country *i*, and *UHC*, *Gini* and *Corr* correspond to the primary factors of interest: the Universal Health Care index, the Gini coefficient, and the index for the control of corruption averaged over 2013–17,[16] respectively. As mentioned, it is useful to control for total health expenditures per capita (*HXPC*) in order to derive insights from UHC on the allocation of resources to essential health services versus other health provision. *Ed*, *SPHX*, and *GDPPC* refer to the primary school enrollment rate, the share of public health expenditure in total health spending, and GDP per capita averaged over 2013–17, respectively. We employ a two-stage-least-squares estimation approach, in which the right-hand-side variables are instrumented with their five-year lags.[17],[18]

We first examine the distribution of the key explanatory variables. LIDCs' Universal Health Coverage indexes are highly dispersed around a low median of 44.5, while EMs' and AEs' indexes have both higher medians (at 69.8 and 81.5, respectively) as well as are more concentrated (Figure 13). AEs also have a more equitable within-country income distribution, with a median Gini coefficient of 0.30, while LIDCs' and EMs' median Ginis

[15] However, higher education in a country may also manifest, on average, in a higher-skilled health workforce, and affect efficiency through this channel.

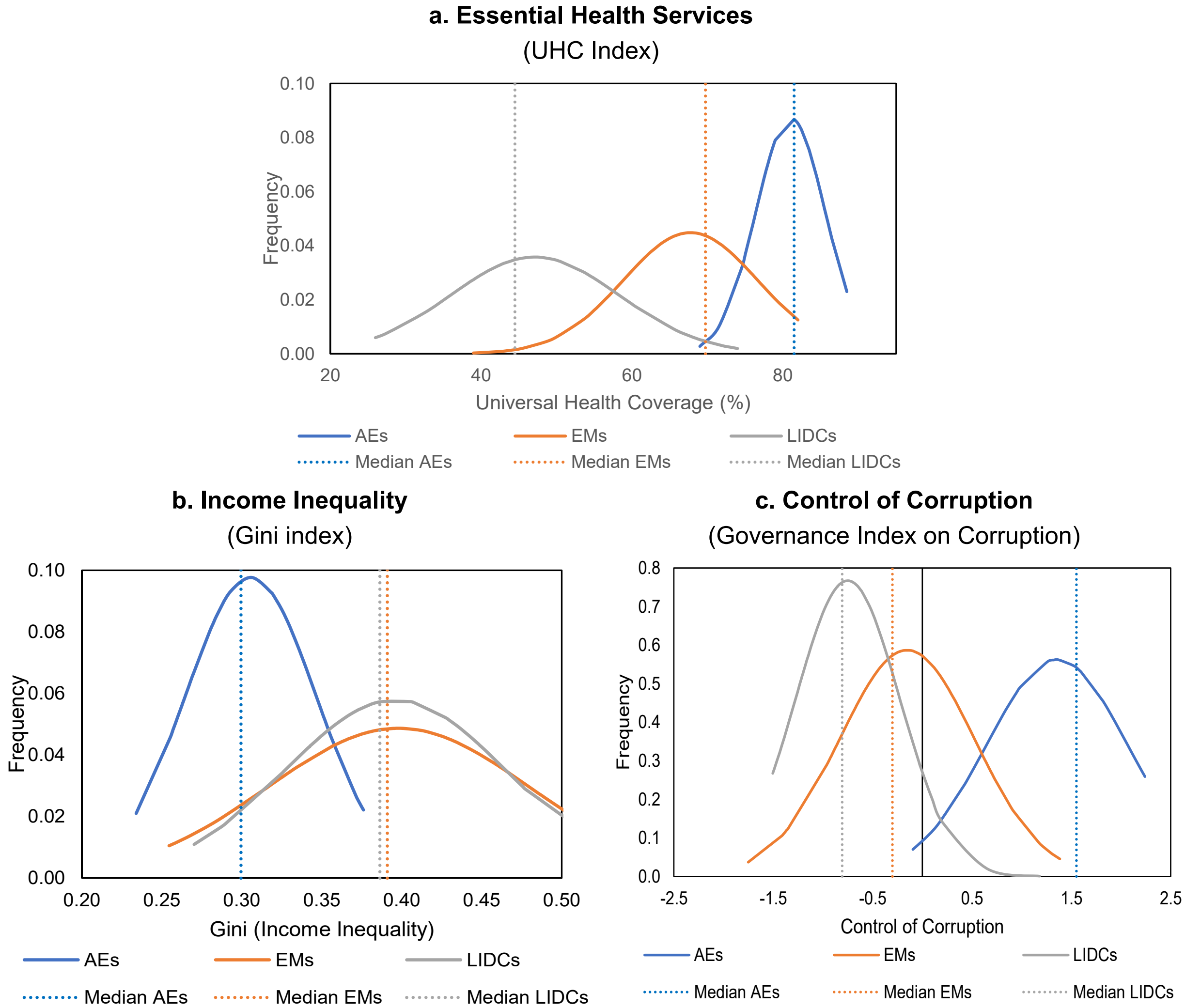
[16] Where these variables did not have observations for one or more of the five years, we averaged over the years with available data.

[17] As the efficiency scores that constitute the outcome variables are not created through a censoring data generated process, but rather are a form of fractional (or proportional) data, the Tobit estimation method is not called for (McDonald, 2009).

[18] The two-stage-least-squares is used to control for the simultaneity bias that may result from health output (life expectancy) being jointly determined with the explanatory variables included in the analysis, such as GDP per capita and income inequality.

are higher and nearly equal to one another (0.39), with the EMs' Gini showing somewhat greater variation across countries. Finally, LIDCs have distinctly poorer corruption indicators (median of -0.81) than EMs (0.30) and AEs (1.55).

Figure 13. Distribution of Variables by Country Income Group



Source: IMF staff calculations.

Table 1 presents the results on the estimated determinants of health spending efficiency for the total sample of countries and by income group. Table 1 shows that when controlling for total health expenditures, higher allocation to provide essential health care services (UHC) is associated with greater input- as well as output-efficiency when analyzing all countries, as well as for the subsample of EMDEs. This association becomes statistically insignificant in the subsample for AEs, possibly driven by the fact that these countries already have to a great extent achieved universal health coverage of essential services, and thus, additional gains in the UHC index do not make health spending allocation more efficient. AEs are furthermore a small sample, which makes it harder to detect any underlying statistical significance.

Table 1. Determinants of Health Spending Efficiency

	Output Oriented			Input Oriented		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
	All	EMDEs	AEs	All	EMDEs	AEs
Universal Health Care Coverage (UHC)	**0.005****	**0.004****	**-0.001**	**0.009***	**0.010****	**-0.000**
	(0.002)	(0.002)	(0.006)	(0.005)	(0.004)	(0.022)
ln Gini (income)	**-0.097*****	**-0.122*****	**-0.006**	**-0.213*****	**-0.184****	**-0.025**
	(0.031)	(0.038)	(0.058)	(0.072)	(0.083)	(0.216)
Control of Corruption	**0.014***	**0.028****	**-0.003**	**0.067*****	**0.077****	**-0.003**
	(0.008)	(0.013)	(0.012)	(0.020)	(0.034)	(0.042)
ln (GDP per capita)	0.013	0.012	0.035	-0.036	-0.029	0.064
	(0.022)	(0.024)	(0.030)	(0.049)	(0.052)	(0.102)
ln (Health Expenditure per capita PPP)	-0.053**	-0.047*	-0.007	-0.088	-0.112*	-0.028
	(0.025)	(0.025)	(0.045)	(0.058)	(0.059)	(0.161)
ln (Primary School Enrollment)	0.034	0.059	0.262	0.011	-0.009	0.707
	(0.073)	(0.078)	(0.320)	(0.134)	(0.125)	(1.246)
ln (Share of Public Health Expenditure)	-0.000	-0.000	-0.000	-0.001	-0.001	0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Constant	1.005***	1.011**	-0.478	1.841***	1.861***	-2.786
	(0.389)	(0.393)	(1.598)	(0.705)	(0.644)	(6.231)
Observations	108	77	31	108	77	31
Kleibergen-Paap rk LM statistic	9.487	11.99	1.055	9.487	11.99	1.055
F -Overidentificatoin Restriction (p-value)	0.955	0.870	0.147	0.579	0.878	0.092

Source: IMF staff calculations.
Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

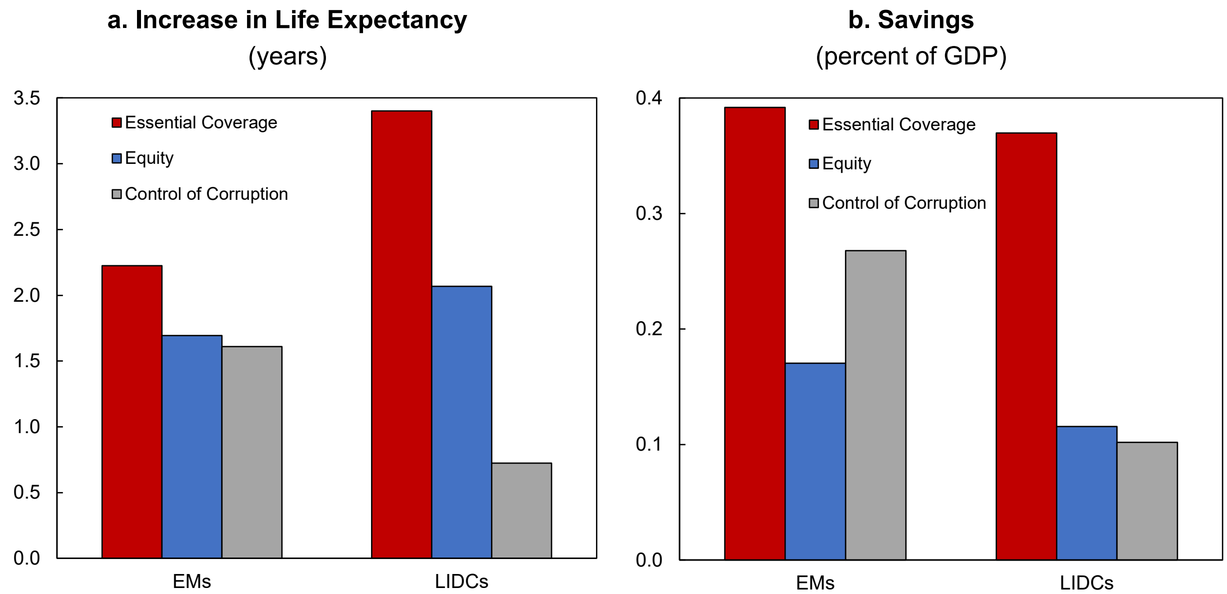
The results also point to greater income inequality undermining overall health outcomes in an economy. The negative relationship of the Gini index with the outcome variable is more pronounced for EMDEs than for the full sample (with results for AEs alone being again statistically insignificant), suggesting that reducing EMDEs' particularly high levels of inequality would yield important gains in the use of funds in the provision of health services. It is also apparent that input-oriented efficiency is more strongly impacted by inequality, that is, the waste of health sector resources to achieve existing life expectancy outcomes can be stemmed if income were more equitably distributed. The results also have policy implications for the allocation of health expenditures. The fact that the variable income inequality is statistically significant for health outcomes in EMDEs comes to show that there is room to improve health expenditures equity for instance by reducing the gaps in the quality of access to health services between rich and poor.

Corruption also bears on health resource efficiency. Greater corruption (a lower value for the control-of-corruption index) is associated with more inefficient health spending. This finding is particularly important for EMDEs, which suffer from lower corruption control (Figure 13.c), compared to AEs, which do not exhibit a statistically significant relationship between corruption and efficiency (columns 3 and 6). The main thrust of these results are consistent with those of other studies that explored corruption as a determinant of health care efficiency (e.g. Cavalieri et al. 2017) or of aggregate efficiency (e.g. Méon and Weill, 2010).[19] Grigoli and Kapsoli (2018) find that governance variables do not seem to have a systematic relationship with health system efficiency; these authors consider governance indicators from the same data source as our corruption indicator (in particular, voice and accountability, political stability, and government effectiveness), but they do not include the corruption indicator.

To give an idea of the quantitative relevance of the three determinants on health spending efficiency, we compute by how much life expectancy and savings would increase if each country were to achieve, for each policy variable, the 75th percentile of its income group (while the top 25 percent of countries retain their actual level). For example, Figure 14.a. shows that if the bottom 75 percent of LIDCs in terms of their indicator for essential health care coverage services were to reach the UHC index of LIDCs' 75th percentile, LIDCs would on average benefit from an increase of 3.4 years of life. Similarly, EMs would gain 2.2 life years from an analogous improvement in their UHC index. This enhancement of essential health services would, alternatively, enable EMs and LIDCs to benefit from 0.39 and 0.37 percent of GDP in savings while maintaining their respective levels of life expectancy (Figure 14.b).

Figure 14. Second Stage: Gains from Policy Actions

(Actions for each policy are defined as reaching the 75th percentile of each income group)



Source: IMF staff calculations.
Note: Second stage estimated coefficients are used to measure change in health spending efficiency and derived from the latter the potential increase in years of life, or the potential savings in health spending.

The gains derived from analogous reductions in income inequality and improvements in the control of corruption to the levels of the 75th percentile within each income group (where the 100th percentile corresponds to the income group's most equal or least corrupt country) are lower but still substantial. A more equitable distribution of income can increase life expectancy by 1.7 and 2.1 years, or bring in savings of 0.17 and 0.12 percent of GDP, for EMs and LIDCs, respectively. Gaining better control of corruption is particularly

[19] This cross-country study finds that greater corruption is associated with greater inefficiency and that other forms of good governance indicators elevate efficiency levels.

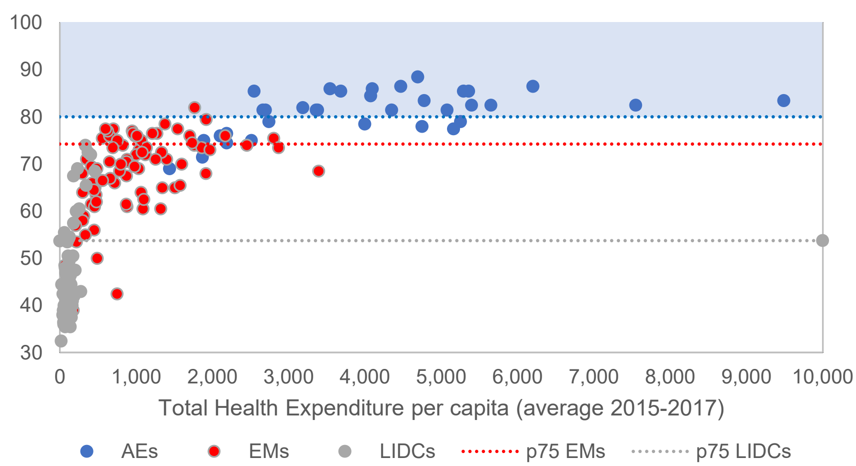
important for EMs, which can benefit from an additional 1.6 years of life expectancy or avoid the waste of 0.27 percent of GDP in health spending.

Using HALE as the output in efficiency scores yield highly consistent results, with the exception of a weaker relationship of corruption to efficiency; see Appendix II, Table AII.7. Additional analysis to further test the robustness of the results was conducted using a third, alternative, health output variable. This variable consisted in creating a health index using the following eight variables: maternal mortality rate, neonatal mortality rate, under-5 mortality rate, incidence of tuberculosis, HIV, cardiovascular or cancer disease, adolescent fertility rate and health-adjusted life expectancy. The results are presented in Appendix III and do not alter the thrust of the paper's findings.

Another main take away is that there is a limit in terms of outcomes to what can be achieved via efficiency within the current budget envelope since adequacy is also crucial. Of the three determinants of efficiency of primary interest examined in this paper, one, UHC, has marked fiscal implications on the level of health expenditures. Covering all, or even most, of the population with essential health services cannot be easily achieved through reallocations from other medical provision if total health expenditures are low to begin with. Figure 15 illustrates that nearly only AEs undertake actual total health spending consistent with reaching a threshold UHC index of 80, which is still far from truly universal coverage and is lower than AEs' 75th percentile of 85.5. This suggests that improving the efficiency of health spending through increases in the UHC variable above a certain threshold in EMDEs is only feasible through increases in spending adequacy.

Figure 15. Relationship between Health Spending and UHC, by Income Group

(UHC Index, Average of 2015 and 2017)



Source: IMF staff calculations.

VII. Conclusion

COVID-19 has challenged countries across the world to step up health care spending, not only to weather the storm of the current crisis, but also to ensure progress toward the SDGs in the area of health. But constrained fiscal space in many countries, in particular those with high debt levels and large financing needs, as well as the limited extent to which budgets can be reallocated away from other sectors towards health, highlights the importance of improving health spending efficiency.

We document large dispersion on health inefficiencies across countries and within income groups. The scope for efficiency gains are the largest among LIDCs and EMs, but we also find efficiency gains for AEs that can translate into years of life lost (up to 10 years in Sub-Saharan countries) and between 1 and 2 percent of GDP on wasted resources. Over the last decades, inefficiency in health spending has reduced, but some LIDCs and EMs had a regress. Finally, we highlight that policymakers can improve spending efficiency by increasing the allocation of spending towards essential health coverage, reducing income inequality, and fighting corruption—with the understanding that especially the latter two are broad and ambitious agendas. This study serves as an analysis of the “macro-efficiency” of healthcare spending, and there remains a need for analyses of micro-efficiency that look into specific aspects of health systems, such as hospitals, pharmaceutical procurement, public financial management, medical human resources, etc., to produce more actionable interventions. In this sense, while our macro-efficiency assessment provides an entry point for policy discussions on health system efficiency, it should be followed up by research that extends the existing literature that pursues a more micro approach to derive more fine-grained policy measures.

Appendix I. Description and Source of Data

Appendix Table AI.1 Sources for and Descriptions of Data and Variables

Variables	Use	Source	Description
Life expectancy	Output in efficiency analysis	World Bank, "World Development Indicators, at: https://data.worldbank. Org/indicator/ SP.DYN.LE00.IN (accessed August 2020)	Life expectancy at birth, in years. Indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
Per capita health spending	Input in efficiency analysis	WHO Global Health Expenditure database, at: https://apps.who.int/nha/database/Select/Indicators/en	Total (public and private) per capita health expenditure, in purchasing-power parity dollars, calculated as domestic general government health expenditure per capita, PPP (SH.XPD.GHED.PP.CD), plus domestic private health expenditure per capita, PPP (SH.XPD.PVTD.PP.CD).
Universal Health Coverage (UHC) index	Explanatory variable in second-stage regression	WHO, "UHC Service Coverage Index", at: https://www.who.int/ data/gho/indicator-metadata- registry/imr-details/4834) (accessed August 2020)	Coverage of the population with essential health services, computed as the geometric mean of 14 tracer indicators and normalized to a 0–100 scale. The 14 indicators relate to family planning, pregnancy and delivery, child immunization, child treatment, tuberculosis, HIV/AIDS, malaria, water & sanitation, hypertension, diabetes, tobacco, hospital access, health workforce, and health security. Metadata can be found at https://www.who.int/healthinfo/universal_health_coverage/UHC_Tracer_Indicators_Metadata.pdf .
Share of public in total health spending	Explanatory variable in second-stage regression	WHO Global Health Expenditure database	Share of public health expenditure in total health expenditures (public / (public + private)).
School enrollment, primary (% gross)	Explanatory variable in second-stage regression	World Bank, "World Development Indicators, at: https://data.worldbank.org/indicator/SE.PRM.ENRR (accessed August 2020)	Gross enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Primary education provides children with basic

Variables	Use	Source	Description
			reading, writing, and mathematics skills along with an elementary understanding of such subjects as history, geography, natural science, social science, art, and music (SE.PRM.ENRR).
GDP per capita	Control variable in second-stage regression	World Bank, "World Development Indicators, at: https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD	Gross domestic product in PPP dollars, divided by the population size (NY.GDP.PCAP.PP.CD)
Gini coefficient	Explanatory variable in second-stage regression	IMF staff calculations, using data from the Luxembourg Income Study; the Organisation for Economic Co-operation and Development's Income Distribution Database; Eurostat Income Inequality Statistics; the Socio-Economic Database for Latin America and the Caribbean; and PovcalNet.	Measure of the degree of income inequality in a country, ranging from 0 (all individuals have the same income) to 1 (one individual has all income).
Control of Corruption	Explanatory variable in second-stage regression	World Bank, "Worldwide Governance Indicators" (Kauffman et al., 2010), at: https://info. Worldbank.org/ governance/wgi/	Perception of extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. The index ranges from -2.5 to 2.5 (worst and best possible outcome, respectively).
Maternal mortality rate (per 100,000 live births)	Component of Own Index Output in efficiency analysis	World Bank, "World Development Indicators", at: http://data.worldbank.org/indicator/SH.STA.MMRT	The estimated number of women, between the age of 15–49, who die from pregnancy-related causes while pregnant or within 42 days of termination of pregnancy, per 100,000 live births.
Neonatal mortality rate (per 1,000 live births)	Component of Own Index Output in efficiency analysis	World Bank, "World Development Indicators", at: http://data.worldbank.org/indicator/SH.DYN.NMRT	The number of newborn infants (neonates) who die before reaching 28 days of age, per 1,000 live births.

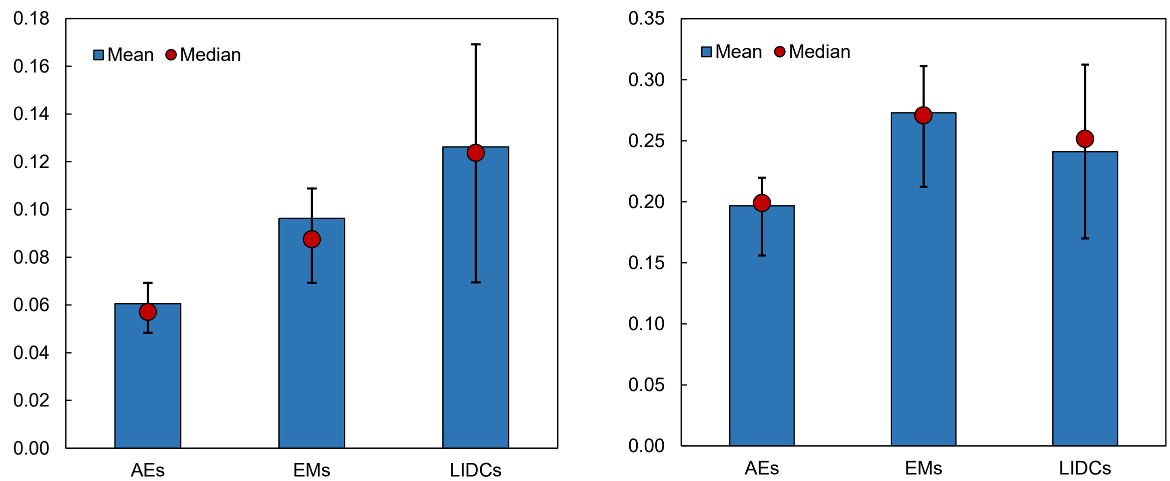
Variables	Use	Source	Description
Under-5 mortality rate (per 1,000 live births)	Component of Own Index Output in efficiency analysis	World Bank, "World Development Indicators", at: http://data.worldbank.org/indicator/SH.DYN.MORT	The probability that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year, per 1,000 live births.
Tuberculosis incidence (per 100,000 population)	Component of Own Index Output in efficiency analysis	World Bank, "World Development Indicators", at: http://data.worldbank.org/indicator/SH.TBS.INCD	The estimated rate of new and relapse cases of tuberculosis in a given year, expressed per 100,000 people. All forms of tuberculosis are included, including cases of people living with HIV.
HIV incidence (per 1,000 uninfected population)	Component of Own Index Output in efficiency analysis	UNAIDS (2020), at: http://aidsinfo.unaids.org?did=55da49cd64e925b94e70b0ce&r=world&t=2018&tb=d&bt=dnli&ts=0,0&tr=world&aid=5970eccef7341ed11f26de5d&sav=Population:%20All%20ages&tl=2	Number of people newly infected with HIV per 1,000 uninfected population.
Cardiovascular or cancer incidence	Component of Own Index Output in efficiency analysis	WHO (2018), at: https://unstats.un.org/sdgs/indicators/database/?indicator=3.4.1	The probability of dying between the ages of 30 and 70 years from cardiovascular diseases, cancer, diabetes or chronic respiratory diseases, defined as the percent of 30-year-old-people who would die before their 70th birthday from these diseases, assuming current mortality rates at every age and that individuals would not die from any other cause of death (e.g. injuries or HIV/AIDS).
Adolescent fertility rate (births per 1,000 adolescent females aged 15 to 19)	Component of Own Index Output in efficiency analysis	World Bank, "World Development Indicators", at: http://data.worldbank.org/indicator/SP.ADO.TFRT	The number of births per 1,000 women between the age of 15 to 19.
Healthy-adjusted life expectancy	Output in efficiency analysis	World Health Organization, "Global Health Observatory", at: https://www.who.int/data/gho/indicator-metadata-registry/imr-details/66	Average number of years that a person can expect to live in "full health" by taking into account years lived in less than full health due to disease and/or injury.

Appendix II. Robustness of the Results using as Output Health-Adjusted Life Expectancy (HALE)

Appendix Figure AII.1. Health Spending Efficiency, 2015

(Inefficiency Scores; Output in Efficiency Score Estimation: HALE)

a. Output-Oriented **b. Input-Oriented**

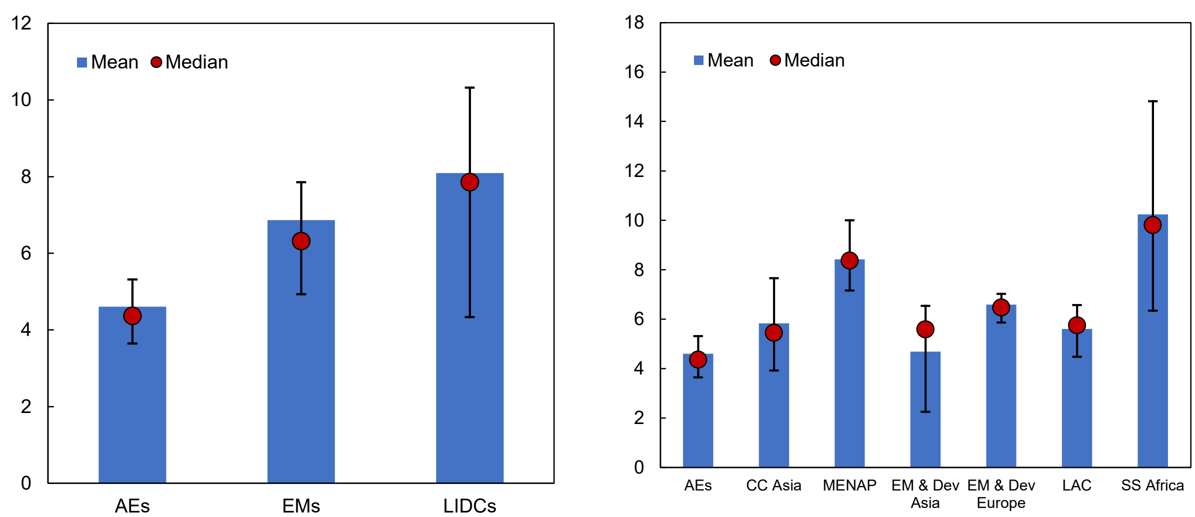


Source: IMF staff calculations.
Note: Bootstrapped DEA scores for health-adjusted life expectancy in 2015 using as input total per capita health expenditure (PPP) averaged over 2011 to 2015. Black vertical lines denote the inter-quantile range.

Appendix Figure AII.2. Years of Health-adjusted Life Years Lost due to Inefficient Health Spending

(Years)

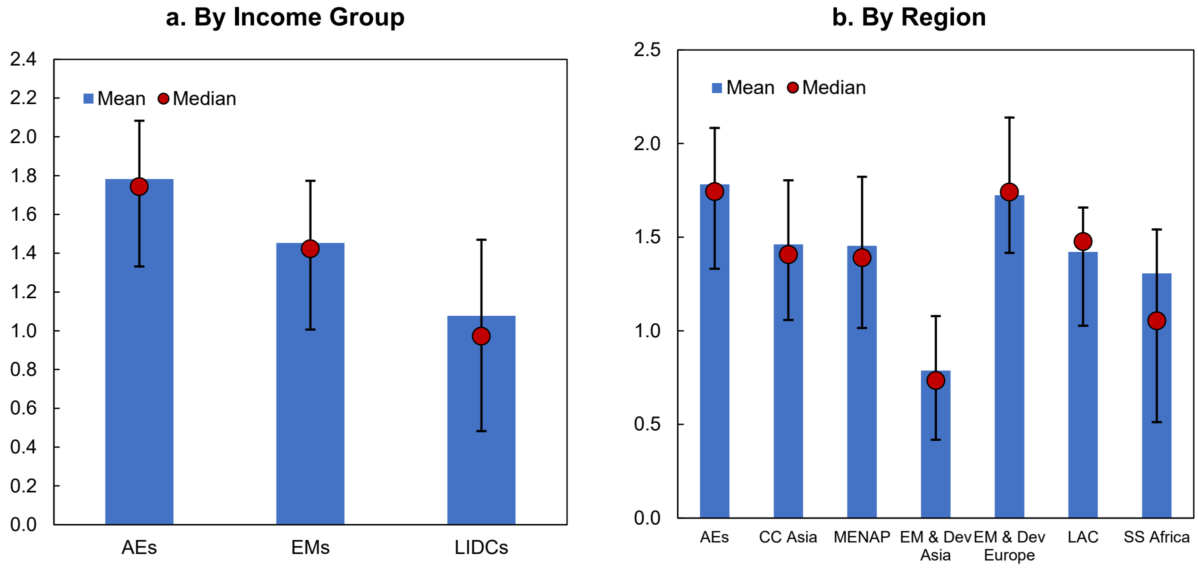
a. By Income Group **b. By Region**



Source: IMF staff calculations.
Note: Efficiency scores underlying these calculations use as output health-adjusted life expectancy in 2015 and as input total per capita health expenditure (PPP) averaged over 2011 to 2015. Black lines denote the inter-quantile range, and red circles the median values.

Appendix Figure AII.3. Wasted Resources due to Inefficient Health Spending

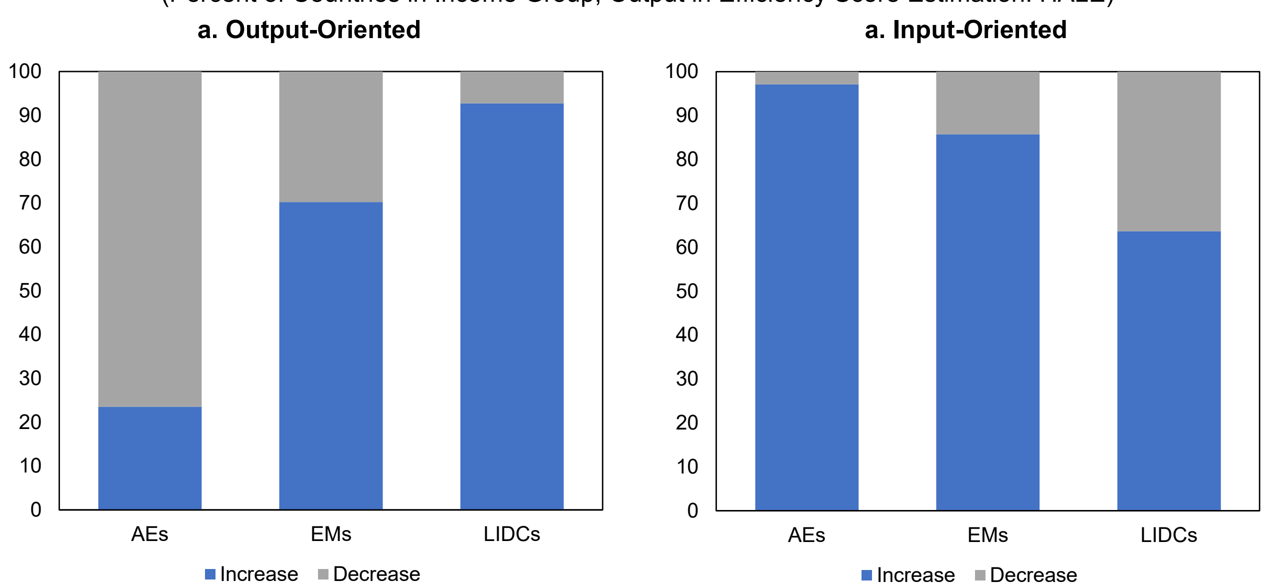
(Percent of GDP; Output in Efficiency Score Estimation: HALE)



Source: IMF staff calculations.
Note: Efficiency scores underlying these calculations use as output health-adjusted life expectancy in 2015 and as input total per capita health expenditure (PPP) averaged over 2011 to 2015. Black lines denote the inter-quantile range.

Appendix Figure AII.4. Change in Spending Efficiency by Income Group, 2005–15

(Percent of Countries in Income Group; Output in Efficiency Score Estimation: HALE)

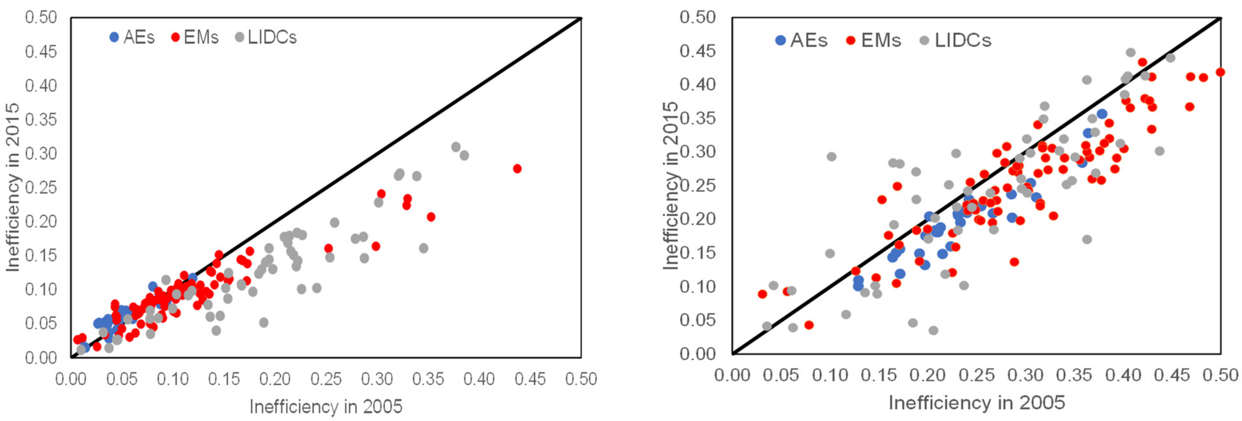


Source: IMF staff calculations.
Note: Efficiency scores underlying these calculations use as output health-adjusted life expectancy in 2005 and 2015, and as input total per capita health expenditure (PPP) averaged over 2001 to 2005 and 2011 to 2015.

Appendix Figure AII.5. Evolution of Spending Efficiency, 2005–15

(Inefficiency Scores; Output in Efficiency Score Estimation: HALE)

a. Output-Oriented **b. Input-Oriented**

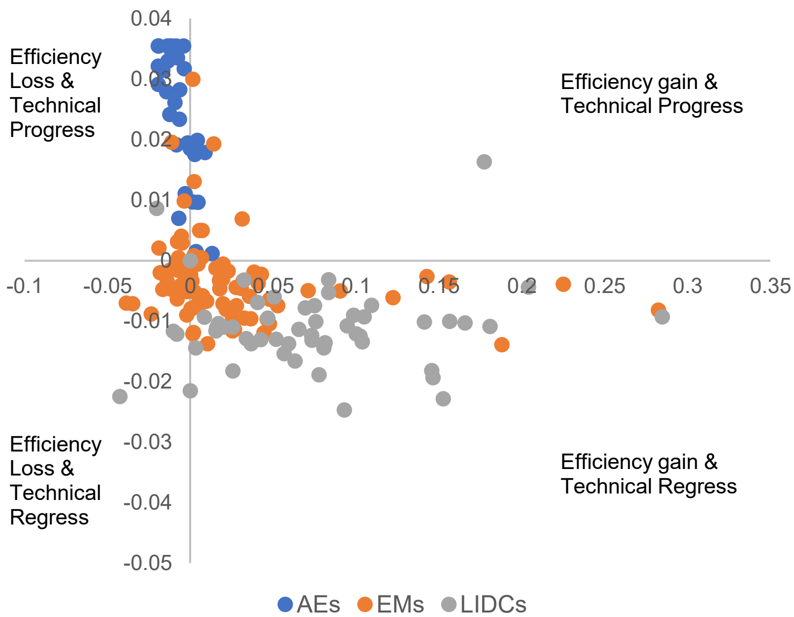


Source: IMF staff calculations.

Note: Bootstrapped DEA scores for health-adjusted life expectancy using as input total per capita health expenditure (PPP). The diagonal is the 45o line indicating no change in efficiency between the two periods.

Appendix Figure AII.6. Change in HALE driven by Efficiency and Technology, 2005–15

(Malmquist Sub-indexes)



Source: IMF staff calculations.

Note: Output-oriented decomposition of Malmquist Index. EC and TC are derived based on variable-returns-to-scale DEA efficiency scores. Efficiency scores underlying these calculations use as output health-adjusted life expectancy in 2005 and 2015, and as input total per capita health expenditure (PPP) averaged over 2001 to 2005 and 2011 to 2015.

Appendix Table AII.1. Determinants of Health Spending Efficiency
(Output in Efficiency Score Estimation: HALE)

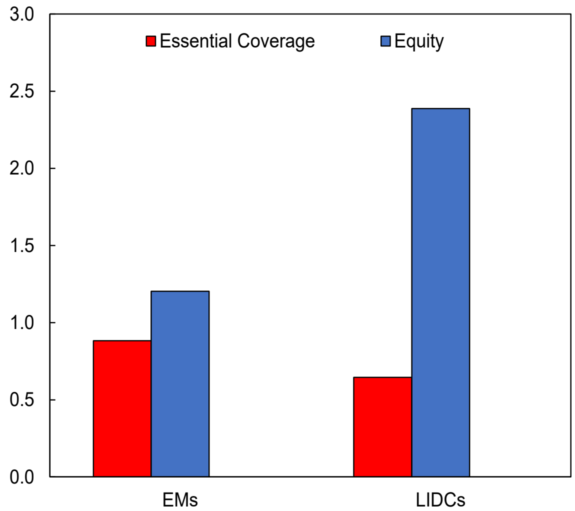
	Output Oriented			Input Oriented		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
	All	EMDEs	AEs	All	EMDEs	AEs
Universal Health Care Coverage (UHC)	**0.005****	**0.004****	**0.004**	**0.008***	**0.008****	**0.020**
	(0.002)	(0.002)	(0.005)	(0.004)	(0.004)	(0.018)
ln Gini (income)	**-0.095*****	**-0.112*****	**-0.033**	**-0.168****	**-0.169****	**-0.148**
	(0.035)	(0.043)	(0.049)	(0.073)	(0.084)	(0.139)
Control of Corruption	**0.008**	**0.014**	**-0.006**	**0.034****	**0.042**	**-0.038**
	(0.007)	(0.014)	(0.009)	(0.015)	(0.027)	(0.036)
ln (GDP per capita)	0.008	0.006	0.058*	-0.042	-0.051	0.120
	(0.024)	(0.026)	(0.031)	(0.044)	(0.047)	(0.080)
ln (Health Expenditure per capita PPP)	-0.048**	-0.040*	-0.049	-0.069	-0.065	-0.208
	(0.023)	(0.024)	(0.054)	(0.048)	(0.048)	(0.157)
ln (Primary School Enrollment)	0.066	0.076	0.037	0.049	0.037	-0.025
	(0.067)	(0.072)	(0.227)	(0.109)	(0.109)	(0.761)
ln (Share of Public Health Expenditure)	0.000	0.000	-0.001	0.000	0.000	-0.002
	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.002)
Constant	0.852**	0.895**	0.376	1.419**	1.555***	0.431
	(0.368)	(0.377)	(1.042)	(0.600)	(0.596)	(3.406)
Observations	110	79	31	110	79	31
Kleibergen-Paap rk LM statistic	11.23	14.50	0.728	11.23	14.50	0.728
F -Overidentificatoin Restriction (p-value)	0.016	0.005	0.225	0.066	0.027	0.291

Source: IMF staff calculations.
Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

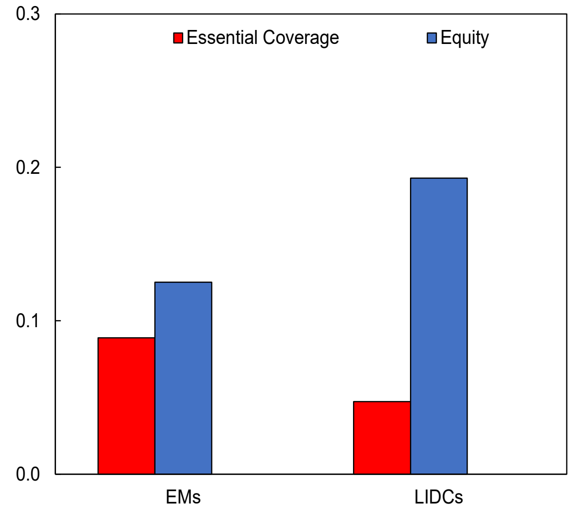
Appendix Figure AII.7. Second Stage: Gains from Policy Actions

(Actions for each policy defined as reaching 75th percentile of each income group;
Output in Efficiency Score Estimation: HALE)

a. Increase in Life Expectancy
(Years)



b. Savings
(Percent of GDP)



Source: IMF staff calculations.
Note: Second-stage estimated coefficients are used to measure change in efficiency and derive from the latter the potential increase in years of life, or the potential savings in health spending. Efficiency scores underlying these Estimations use as output health-adjusted life expectancy in 2015, and as input total per capita health expenditure (PPP) averaged over 2011 to 2015.

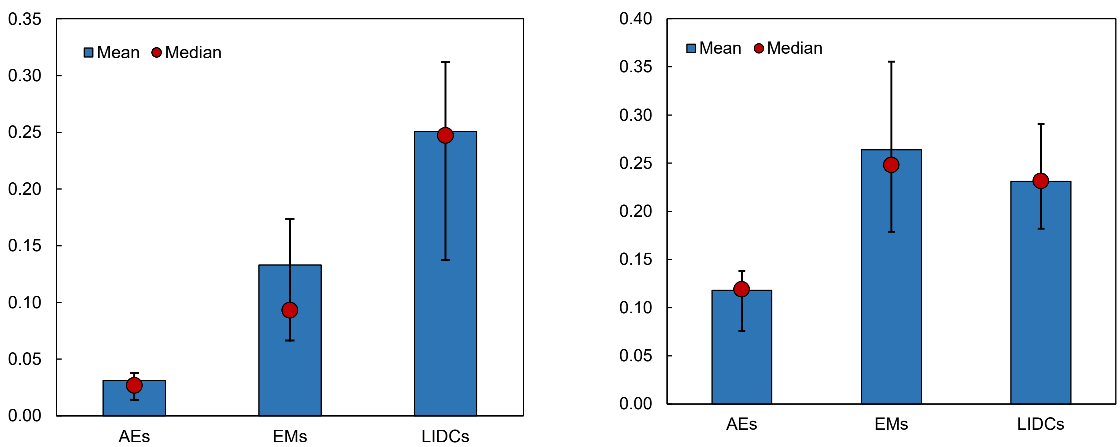
Appendix III. Robustness of the Results using as Output an Index of 8 Key Health Indicators

The output index uses the following variables, averaged over the indicated year ranges: (i) maternal mortality rate (2014–17), (ii) neonatal mortality rate (2015–18), (iii) under-5 mortality rate (2015–18), (iv) incidence of tuberculosis (2015–18), (v) HIV incidence (2015–18), (vi) cardiovascular/cancer incidence (2010–16), (vii) adolescent fertility rate (2014–17), and (viii) HALE (2016) (see Appendix Table AI.1 for a detailed description of and source for these variables)

Appendix Figure AIII.1. Health Spending Efficiency, 2015

(Inefficiency Scores; Output in Efficiency Score Estimation: Health Index)

a. Output-Oriented **b. Input-Oriented**

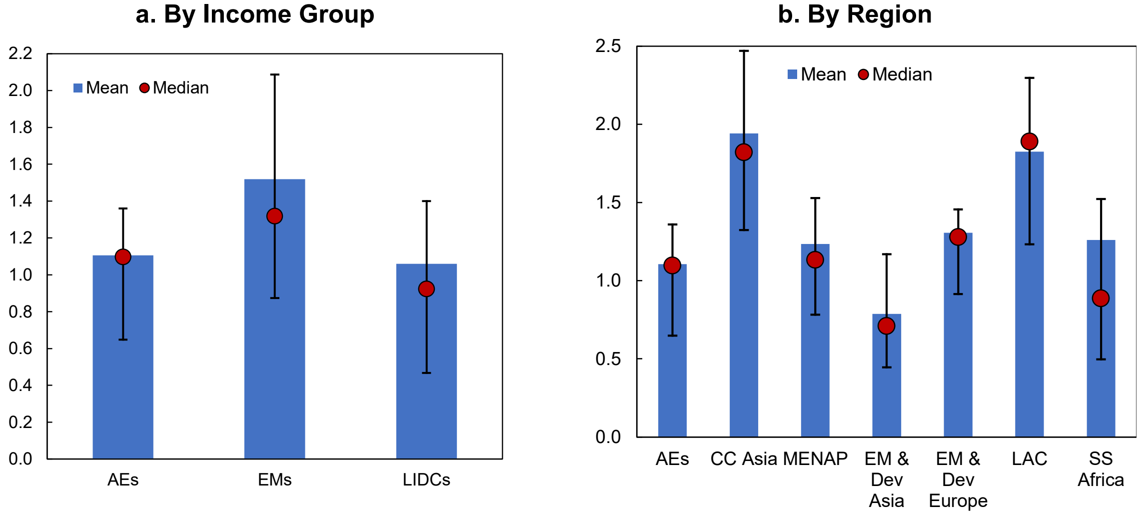


Source: IMF staff calculations.
Note: Bootstrapped DEA scores. Black vertical lines denote the inter-quantile range.

Appendix Figure AIII.2. Wasted Resources due to Inefficient Health Spending

(Percent of GDP)

a. By Income Group **b. By Region**



Source: IMF staff calculations.
Note: Black lines denote the inter-quantile range.

Appendix Table AIII.1. Determinants of Health Spending Efficiency

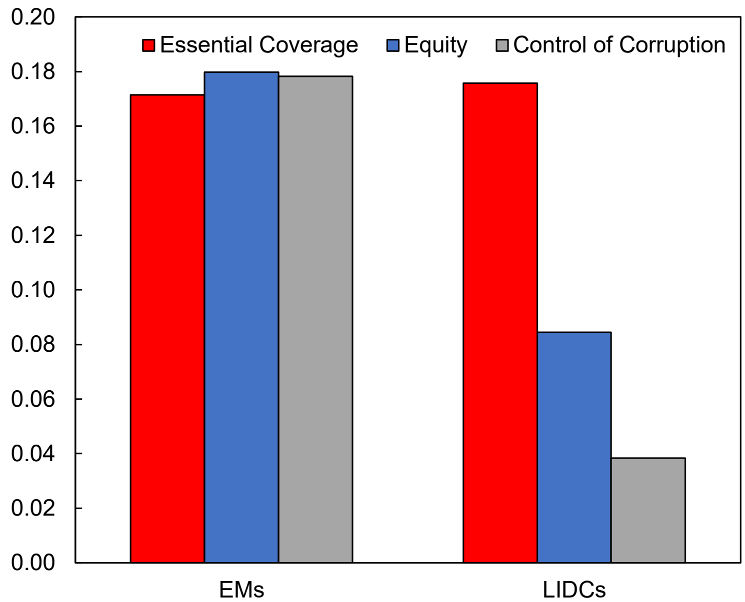
(Output in Efficiency Score Estimation: Health Index)

	Output Oriented			Input Oriented		
Variables	(1)	(2)	(3)	(4)	(5)	(6)
	All	EMDEs	AEs	All	EMDEs	AEs
Universal Health Care Coverage (UHC)	**0.018*** **	**0.014*** **	**-0.005**	**0.009***	**0.009** **	**-0.014**
	(0.006)	(0.005)	(0.008)	(0.005)	(0.004)	(0.023)
ln Gini (income)	**-0.297*** **	**-0.368*** **	**0.016**	**-0.347*** **	**-0.323*** **	**0.065**
	(0.072)	(0.081)	(0.074)	(0.066)	(0.073)	(0.201)
Control of Corruption	**0.029**	**0.064** **	**0.007**	**0.067*** **	**0.071** **	**0.017**
	(0.018)	(0.028)	(0.024)	(0.019)	(0.032)	(0.064)
ln (GDP per capita)	-0.027	-0.040	0.077	-0.061	-0.066	0.162
	(0.056)	(0.054)	(0.055)	(0.053)	(0.055)	(0.135)
ln (Health Expenditure per capita PPP)	-0.122**	-0.081	-0.006	-0.081	-0.088	-0.047
	(0.058)	(0.054)	(0.058)	(0.057)	(0.056)	(0.161)
ln (Primary School Enrollment)	-0.059	0.039	0.696	-0.030	-0.042	1.768
	(0.160)	(0.162)	(0.531)	(0.147)	(0.130)	(1.449)
ln (Share of Public Health Expenditure)	-0.001	-0.000	0.000	-0.000	0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Constant	2.099**	2.027**	-2.705	2.660***	2.715***	-7.832
	(0.879)	(0.820)	(2.515)	(0.796)	(0.714)	(6.865)
Observations	108	77	31	108	77	31
Kleibergen-Paap rk LM statistic	8.955	11.70	1.055	8.955	11.70	1.055
F -Overidentificatoin Restriction (p-value)	0.674	0.594	0.491	0.553	0.803	0.444

Source: IMF staff calculations.
Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix Figure AIII.3. Second Stage: Savings from Improving Policy

(Percent of GDP; improvements defined as reaching 75th percentile of each income group; Output in Efficiency Score Estimation: Health Index)



Source: IMF staff calculations.
Note: Second stage estimated coefficients are used to measure change in efficiency and derive from the latter the potential savings in health spending.

References

Alexander, Christine A., Gary Busch, and Karl Stringer, 2003, "Implementing and Interpreting a Data Envelopment Analysis Model to Assess the Efficiency of Health Systems in Developing Countries," *IMA Journal of Management Mathematics*, Vol. 14 (No. 1), pp. 49–63.

Afonso, António, and Miguel St. Aubyn, 2005, "Non-Parametric Approaches to Education and Health Efficiency in OECD Countries," *Journal of Applied Economics*, Vol. 8 (No. 2), pp. 227–46.

Banker, R. D., A. Charles, and W. W. Cooper, 1984, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis," *Management Science*, Vol. 30 (No. 9), pp. 1078–92.

Bardhan, Pranab, *1997, "*Corruption and Development: A Review of Issues," *Journal of Economic Literature*, Vol. XXXV (September), pp. 1320–46.

Bogetoft, Peter, and Lars Otto, 2011, *Benchmarking with DEA, SFA, and R*, (New York: Springer).

Cavalieri, Marina, Calogero Guccio, Ilde Rizzo, 2017, "On the Role of Environmental Corruption in Health Care Infrastructures: An Empirical Assessment for Italy using DEA with Truncated Regression Approach," *Health Policy*, Vol. 121 (No. 5), pp. 515–24.

Fletcher, Jason M. and David E. Frisvold, 2009, "Higher Education and Health Investments: Does More Schooling Affect Preventive Health Care Use?," *Journal of Human Capital*, Vol. 3 (No. 2), pp. 144–76.

Gaspar, Vitor, David Amaglobeli, Mercedes Garcia-Escribano, Delphine Prady, and Mauricio Soto, 2019, "Fiscal Policy and Development: Human, Social, and Physical Investment for the SDGs," IMF Staff Discussion Note SDN/19/03 (Washington: International Monetary Fund).

Greene, William, 2004, "Distinguishing Between Heterogeneity and Inefficiency: Stochastic Frontier Analysis of the World Health Organization's Panel Data on National Health Care Systems," *Health Economics*, Vol. 13 (No. 10), pp. 959–80.

Grigoli, Francesco, and Javier Kapsoli, 2018, "Waste Not, Want Not: The Efficiency of Health Expenditure in Emerging and Developing Economies," *Review of Development Economics*, Vol. 22 (No. 1), pp. 384–403.

Gupta, Sanjeev, and Marijn Verhoeven, 2001, "The Efficiency of Government Expenditure: Experiences from Africa," *Journal of Policy Modeling*, Vol. 23 (No. 4), pp. 433–67.

Hollingsworth, Bruce, 2008, "The Measurement of Efficiency and Productivity of Health Care Delivery" *Health Economics*, Vol. 17, (No. 10), pp. 1107–28.

______, Anthony Harris, and Elena Gospodarevskaya, 2002, "The Efficiency of Immunization of Infants by Local Government", *Applied Economics*, Vol. 34 (No. 18), pp. 2341–45.

Hou, Xiaohui, Gerard Abou Jaoude, Lara Goscé, Shepherd Shamu, Chenjerai N. Sisimayi, Laurence Lannes, Thomas David Wilkinson, Cliff Kerr, Hassan Haghparast-Bidgoli, and Jolene Skordis, 2021, *Improving Allocative Efficiency in Zimbabwe's Health Sector: Results from the Health Interventions Prioritization Tool*, (Washington: The World Bank Group).

Kathuria, Vinish, and Deepa Sankar, 2005, "Inter-State Disparities in Health Outcomes in Rural India: An Analysis Using a Stochastic Production Frontier Approach," *Development Policy Review*, Vol. 23 (No. 2), pp. 145–63.

Kaufmann, Daniel, Kraay, Aart, and Mastruzzi, Massimo, 2010, "The Worldwide Governance Indicators: A Summary of Methodology, Data and Analytical Issues," Policy Research Working Paper No. 5430 (Washington: The World Bank Group).

Medeiros, João, & Schwierz, Christoph, 2015, "Efficiency Estimates of Health Care Systems", No. 549, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

McDonald, John, 2009, "Using Least Squares and Tobit in Second Stage DEA Efficiency Analyses," *European Journal of Operational Research*, Vol. 197 (No. 2), pp. 792–98.

Méon, Pierre-Guillaume, and Laurent Weill, 2010, "Is Corruption an Efficient Grease?," *World Development*, Vol. 38 (No. 3), pp. 244–59.

National Academies of Sciences, Engineering, and Medicine (NASEM), 2018, *Crossing the Global Quality Chasm: Improving Health Care Worldwide*, National Academies of Sciences, Engineering, and Medicine, (Washington: The National Academies Press).

Pérez-Cárceles, María Concepción, Juan Cándido Gómez-Gallego, and María Gómez-Gallego, 2018, "Environmental Factors Affecting European and Central Asian Health-Systems' Bias-Corrected Efficiency," *Applied Economics*, Vol. 50 (No. 32), pp.3432–40.

Puig-Junoy, Jaume, 2000, "Partitioning Input Cost Efficiency into its Allocative and Technical Components: An Empirical DEA Application to Hospitals," *Socio-Economic Planning Sciences*, Vol. 34 (No. 3), pp. 199–218.

Ravallion, Martin, 2003, "On Measuring Aggregate 'Social Efficiency," Policy Research Working Paper No. 3166 (Washington: The World Bank Group).

Samut, Pınar Kaya, and Reyhan Cafrı, 2016, "Analysis of the Efficiency Determinants of Health Systems in OECD Countries by DEA and Panel Tobit," *Social Indicators Research*, Vol. 129, pp. 113–32.

Savedoff, William D., 2011, "Governance in the Health Sector: A Strategy for Measuring Determinants and Performance," Policy Research Working Paper No. 5655 (Washington; The World Bank Group).

Simar, Léopold and Paul W. Wilson, 2007, "Estimation and Inference in Two-Stage, Semi-Parametric Models of Production Processes," *Journal of Econometrics*, Vol. 136 (No. 1), pp. 31–64.

Teo, Hui Sin and Dao Lan Huong, 2020, *Improving Efficiency in the Health Sector: An Assessment of Vietnam's Readiness for Integration of Care*, Health, Nutrition and Population Global Practice (Washington: The World Bank Group).

World Development Indicators (WDI), 2020, http://publications.worldbank.org/WDI/, accessed August 2020 (Washington: The World Bank Group).

World Health Organization (WHO), 2019, "Primary Health Care on the Road to Universal Health Coverage," Global Monitoring Report, Conference Edition (Geneva: World Health Organization).

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