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Do efficiency and equity move together? Cross-dynamics of Health System performance and Universal Health Coverage

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Efficiency within the health system is well recognised as key for achieving Universal Health Coverage (UHC). However, achieving equity and efficiency simultaneously is often seen as a conflicting effort. Using 12 years of data (2003–2014) from the selection of a number of low- and lower middle-income countries (Afghanistan, Bangladesh, Burkina Faso, Ghana, Indonesia, Mongolia, Mozambique, Tajikistan, Togo, Uzbekistan and Yemen Republic), we compute an index of Universal health coverage (UHC), measure the health system's performance (HSp) and, finally, investigate the cross-dynamics of the resulting HSp and the UHC previously obtained. We find that, with the few exceptions over the statistical sample, the causality between performances of the national health system and the universal health coverage is typically bidirectional. From an empirical standpoint, our findings challenge the idea from economic orthodoxy that efficiency must precede equity in healthcare services. Rather, our findings support the view of simultaneous efforts to improve expansion of the coverage and efficiency of the health system, directing attention towards the importance of organisation of the health system in the country context.

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Introduction

Sustainable development goals (SDGs) 3 aspires to ensure healthy lives and promote wellbeing for all at all ages. SDG target 3.8 is explicit about Universal Health Coverage (UHC) and is also for realising the goals of any health system. The World Health Report (2010) acknowledges the importance of an efficient health system for achieving the UHC—an appropriate balance between extending coverage to more people, offering more services, and/or covering more of the cost of care in the country context. In this article, we attempt to find the linkage between these two public policy objectives—achieving equity and promoting efficiency—and to examine empirically the question: can equity and efficiency move together?

Promoting equity and achieving efficiency simultaneously are generally seen as conflicting, because giving access to health protection to new social groups of the population, and diverse group of sick persons, is not easy in resource-poor countries and often demands mobilising a considerable amount of resources for a not-so-visible incremental result. The problems of inefficiency in the health system are well recognised as the barrier to UHC (Hurst, 2010; Gilson et al., 2003). Several authors have argued that a fundamental reform of health systems in low -and lower middle-income countries should include improving service delivery first, at the primary care level (Hurst, 2010; WHO, 2008; Laokri et al., 2018). Among other reasons, improved efficiency is an essential source of fiscal space for the health system to perform and, therefore, is often advocated as a precondition for widening coverage (Heller, 2006; Hernandez de Cos and Moral-Benito, 2011). This is recognised as the "prudent" prescription from the viewpoint of economic orthodoxy. However, this statement, "does a health system's performance indeed precede advancement in equitable access to healthcare?" has not yet been empirically validated in the context of any country.

In this paper, our objective is to establish the empirical relationship between the health system's performance and progress towards the UHC for low -and lower middle-income countries. Focussing on the mortality of children (age under 5; U5) as the criterion for assessing efficiency, this study empirically examines the direction of causality between the UHC and the health system's efficiency. We also provide an insight into the trends in the UHC and the health systems' performance over the period of 12 years (2003–2014) in 12 economies (low -and lower middle-income) of the world.

Data and methods

We used the data from the World Bank (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups); the World Health Organisation (http://apps.who.int/nha/database and http://apps.who.int/ghodata/) and the United Nations (http://data.un.org/). The paucity of the data availability confined this study to seven low-income countries (LICs) and five lower middle-income countries (LMICs) for 12 years (2003–2014)—Afghanistan, Bangladesh, Burkina Faso, Ghana, Indonesia, Mongolia, Mozambique, Tajikistan, Togo, Uzbekistan and Yemen Republic.

The inequality in U5 mortality is well documented in our study countries. Despite variations in U5 mortality rates between the provinces, and between wealth quintiles within the provinces, the overall patterns of U5 mortality trends show remarkable consistency: there is a clear rank order, with higher mortality in the poorest quintiles (UNFPA—Afghanistan, 2015). Similar trend is observed across the regions in Guinea, Tajikistan, Togo, Uzbekistan and Yemen Republic (Chao et al., 2018). Children from the worse-off households are having on an average 1.17 times higher mortality rate than those from the better-off households (Chowdhury et al., 2017). Coverage of immunisation, skilled birth attendants (SBAs), and post-natal visits are found to be associated with the geographical differences in U5 mortality in Burkina Faso (Millogo et al., 2019). Although the U5 mortality has decreased in all the districts, the distributional differences of U5 mortality across the districts have increased in Ghana between the period of 2000 and 2010 (Arku et al., 2016). The widened relative and absolute inequalities in U5 mortality by geography in Indonesia between 1980 and 2011 is attributed to the low density of healthcare workers with limited access to the health facilities and the healthcare services (Hodge et al., 2014). The situation is no different in Mongolia (Joshi et al., 2017). Income distribution and population density, distribution of the basic infrastructure including provision of the healthcare services, climatic and ecologic factors are suggested to have confounding effects on U5 mortality and so, the observed difference in U5 mortality across regions in Mozambique (Macassa et al., 2012).

Variables used and descriptions

Variables	Definition
Under-five mortality rate [U5 Mortality per 1000 live births]	Probability of dying between birth and exactly 5 years of age expressed per 1000 live births.
Total population	Total population counts all residents regardless of legal status or citizenship. The values used are midyear estimates.
Fertility rate [total births per woman]	Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year.
Percentage of population having access to basic drinking water services	The percentage of people using at least basic water services. This indicator encompasses both people using basic water services, as well as those using safely managed water services. Basic drinking water services is defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tube wells, protected dug wells, protected springs, and packaged or delivered water.
Percentage of population using at least basic sanitation services	The percentage of people using at least basic sanitation services, that is, improved sanitation facilities that are not shared with other households. This indicator encompasses both people using basic sanitation services, as well as those using safely managed sanitation services. Improved sanitation facilities include flush/pour flush to piped sewer systems,

	septic tanks or pit latrines; ventilated improved pit latrines, compositing toilets or pit latrines with slabs.
Percentage of population living below poverty line	National poverty headcount ratio is the percentage of the population living below the national poverty lines. National estimates are based on population-weighted subgroup estimates from household surveys.
High-burden country	Country with T.B./HIV/Malaria.
Density [other health workers, nurse/midwives and physician]	Number per 1000 population.
Prenatal service coverage	Pregnant women receiving prenatal care are the percentage of women attended at least once during pregnancy by skilled health personnel for reasons related to pregnancy.
TT coverage women	Percentage of pregnant women received Tetanus toxoid vaccines.
Coverage BCG, DPT and Measles	Percentage of children up to 23 months received BCG, DPT, Measles (1st and 2nd dose).
Percentage of births attended by SBAs.	The percentage of deliveries attended by personnel trained to give the necessary supervision, care, and advice to women during pregnancy, labour, and the postpartum period; to conduct deliveries on their own; and to care for new-borns.
Pooling effect of community (public finance) on the health system.	[1 – (OOP/HCE)], OOP = out-of-pocket health expenditure and HCE = total health expenditure.

A glance of the methods: a 3-step approach. Establishing relationship between the health system's performance and progress towards the Universal health coverage (UHC) implies examining the direction of causality between these two measures. So, we apply a 3-step approach—Step 1 and Step 2 derive two aggregate measures of the UHC and the health system's performance respectively. From the methodological standpoint, Step 1 calculates an index of the UHC, inspired by the "mashup" index (Wagstaff et al., 2016), to monitor UHC progress across time and space in the 3 dimensions of the UHC cube (WHO, 2010). Step 2 applies a stochastic frontier analysis (SFA) model to derive time and country-specific health system's performance indicator (HSp). Finally, having the "efficiency (HSp)" on one side and the "UHC indicator" on the other side, step 3 investigates the cross-dynamics of the resulting HSp and the UHC for the 12 countries (a mix of LICs and LMICs), using Granger non-causality test.

Step 1. UHC progress index. SDG indicator 3.8.1 is for coverage of essential health services, defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, new-born and child health, infectious diseases and non-communicable diseases, and service capacity, and access among the general and the most disadvantaged population (UN, 2017). The core of UHC to SDG agenda and country contexts are having implications on reproductive, maternal and child health. The core defines the scope of services and population coverage, and the contexts represents the strength of the health system (Boerma et al., 2018). A single, interpretable UHC metric for coverage of essential health services will inevitably be imperfect, especially given the vast array of indicators (Fullman and Lozano, 2018). Although coverage rates of immunisation are high compared to other maternal and child health interventions, many children still die from easily preventable diseases, including pneumonia and diarrhoea (Walker et al., 2013). High rates of malnutrition underlie more than 45% of all deaths in children younger than 5 years. For those children who survive, malnutrition jeopardises their potential for optimum growth and development, with important consequences later in life (Bhutta et al., 2013; Black et al., 2013).

Computation of UHC index. Using the framework of the "mashup" index we develop an index of the UHC for U5 mortality.

UHC index focussing U5 mortality rate included

A. Service coverage indicators [SC]
   1. Density of nurses/midwives
   2. Density of physician
   3. Density of other health workers.

B. Population coverage indicators [PC]
   4. Prenatal service coverage
   5. Tetanus Toxoid coverage
   6. Vaccination coverage BCG
   7. Vaccination coverage DPT
   8. Vaccination coverage Measles
   9. Percentage of births attended by skilled birth attendants (SBAs).

C. Indicator of Financial protection [FP]
   Pooling effect of community (public finances) on the health system.

The UHC index was computed in two steps for each country i (12 countries) at year t (2003, ……, 2014). The first level calculated integrated values for SC (group A) and PC (group B) of indicators using,

$$\mathrm{SC}_t^i = \sum_{j=1}^{3} \left(x_{jt}^i\right)' \quad (1)$$

$$\mathrm{PC}_t^i = \sum_{j=4}^{9} \left(x_{jt}^i\right)' \quad (2)$$

where $\left(x_{jt}^i\right)'$ denotes standardised indicator value $j =$ {1,2,3,4,5,6,7,8,9} for country i at time t; j represents all nine indicators used.

The second level computed index of the UHC. This index is a multidimensional weighted average of SC, PC and FP;

Equation 1. $UHC_t^i = SC_t^i \cdot d_{SC} + PC_t^i \cdot d_{PC} + FP_t^i . d_{FP}$, where "$d_j$" are the weights for each group of indicators. We allocated weights as 0.3, 0.3, 0.4, respectively. The higher the index score [0 < UHC < 1], the better is the coverage.

Step 2. Measuring efficiency: performance of the health systems. Considering multidimensional (levels and distribution) goals of the national health system quantifying the efficiency remains a challenge. Under-5 mortality (Table 1) is acknowledged as one of the high priority health indicators of SDGs (You et al., 2015). Focussing on U5 mortality as the outcome of interest, we identified the main inputs variables of this outcome, for examining efficiency of the health system. We applied Stochastic Frontier

Table 1 U5 Mortality per 1000 live births.

	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Afghanistan	76.0	79.2	82.6	86.2	90.0	93.9	97.9	102.0	106.1	110.1	114.1	117.9
Bangladesh	38.6	41.0	43.6	46.3	49.2	52.3	55.6	58.9	62.5	66.2	70.1	74.1
Burkina Faso	92.6	97.5	103.2	109.4	116.1	123.3	130.8	138.6	146.5	154.1	161.1	167.1
Ghana	58.0	61.5	65.2	68.9	72.4	75.9	78.9	81.5	83.7	85.7	87.8	90.1
Guinea	94.9	98.2	101.6	105.1	108.8	112.7	116.8	121.3	126.1	131.4	137.1	143.5
Indonesia	28.3	29.4	30.6	31.8	33.2	34.8	36.3	37.9	39.7	41.4	49.3	45.3
Mongolia	19.8	21.0	22.4	24.2	26.3	28.8	31.6	34.7	38.0	41.7	45.6	49.8
Mozambique	83.2	87.2	92.2	97.6	103.1	107.6	113.9	120.5	127.3	133.6	140.0	146.7
Tajikistan	37.0	38.2	39.5	41.0	42.8	44.8	47.3	50.2	53.6	57.7	62.5	68.1
Togo	80.1	82.6	85.1	87.7	90.4	93.1	95.9	98.7	101.7	104.6	107.7	110.8
Uzbekistan	27.5	29.5	31.6	33.8	36.2	38.6	41.1	43.7	46.3	49.0	51.7	54.4
Yemen, Rep.	55.4	55.4	55.4	55.5	56.4	58.4	61.3	64.9	68.7	72.7	76.9	81.3

Analysis (SFA) model to estimate performance of the health system (Aigner et al., 1977; Greene, 2005). The SFA is often preferred over a non-parametric approach, i.e., data envelopment analysis (DEA), which is limited in the number of allowable inputs and does not separate out "noise" from the inefficiency term.

Empirical model. Equation 2. $\ln(y_{it}) = \beta_i + \beta_2 \ln x_{i(t-1)} + \sum_k \beta_k \ln c_{i(t-1)k} + \gamma \ln z_{i(t-1)} + v_{it} - u_{it}$, where y_{it} = U5 mortality for each country at each time period;

$x_{i(t-1)}$ indicates the ratio of total per capita health expenditure/total per capita GDP at $t-1$;

$c_{i(t-1)k}$ are vectors for each k covariate for list of the confounding factors at period of time $[t-1]$,

- total population;
- population level factor that takes into account, i.e., total fertility rate;
- percentage of population having access to basic drinking water services;
- percentage of population using at least basic sanitation services;
- percentage of population living below poverty line.

$z_{i(t-1)j}$ represents the vector for country's disease burden [0 = country without any high-burden disease; 1 = country with one high-burden disease; 2 = country with combination of any two high-burden diseases; 3 = country with all high-burden diseases]. β_i is the country fixed-effect that defines the country-specific intercept of the health production frontier. v_{it} is the random error of the model, assumed to be independent and identically distributed $\mathcal{N}(0, \sigma_v^2)$. u_{it} is the inefficiency component assumed to be non-negative, independent and identically distributed. This term follows an exponential distribution. This set of assumptions are done to obtain parameter estimates in SFA modelling.

Our model, "True fixed effects—SFA model" allowed us to disentangle time-varying inefficiency (u_{it}) from country-specific time-invariant unobservable heterogeneity (β_i). We assumed an exponential distribution for inefficiency, rather than half/truncated normal distribution, to ensure that the mean and the variance of the technical inefficiencies are strictly positive. The rationale for such an assumption is that the countries in the sample are heterogeneous, not only by their health production frontier (through the intercept β_i), but also by their inefficiency (u_{it}) and there is no reason that the distribution of these inefficiencies u_{it} follow any (reduced or centred) normal law. The model was estimated using maximum likelihood estimator (MLE) (Aigner et al., 1977). The Wald-test and the log-likelihood ratio validate data fitness with the model used.

Step 3. Causality between the UHC and efficiency of the health system. It is assumed that performance of the health system (HS_p) is having some explanatory power on the UHC and vice-versa. We applied Granger non-causality test for heterogeneous panel data model. This approach accounts both dimensions of the heterogeneity—the heterogeneity of causal relationship and the heterogeneity of data generating process (Hurlin and Venet, 2011).

For each country $i \in [1, N]$, two covariance stationaries denoted by *x and y*, observed on T periods. The variable x_{it} is causing y_{it}, if we are better able to predict y_{it} using all available information, than if the information apart from x_{it} had been used. In practice, it is not possible to use optimum predictors completely, so, we estimate the model of vector autoregression (VAR) coefficients for panel data. For each cross-section unit i and time period t, the model is

Equation 3. $y_{it} = \sum_{k-1}^{p} \beta_k y_{i,t-k} + \sum_{k=0}^{p} \theta_k x_{i,t-k} + u_{it}$, u is normally distributed with $u_{it} = \alpha_i + \varepsilon_{it}$, p is the number of lags and ε_{it} are independently, identically and normally distributed and free from heteroscedasticity and autocorrelation $(0, \sigma^2)$.

Assumptions are the autoregressive coefficients β_k are identical for all individual countries, while, θ_k captures country-specific dimension. Since θ_k differed among countries, we tested heterogeneous non-causality hypothesis (HENC), i.e.,

$$H_0 : \theta_i^k = 0 \, \forall i \in [1, N], \, \forall k \in [0, p]$$

$$H_1 : \theta_i^k \neq \theta_k^j \, \forall i \in [1, N], \, \forall k \in [0, p].$$

We tested HENC hypothesis with the following statistics $F_{\mathrm{HENC}} = \frac{(\mathrm{SSR}_r - \mathrm{SSR}_u)/p}{\mathrm{SSR}_u / [\mathrm{NT} - N(1+2p) + p]}$, where SSR_u denotes the sum of squared residuals for the model (Eq. 3) and SSR_r, squared residuals found in Eq. 3 when the nullity of the k coefficients are imposed. If the country effects, α_i, are assumed to be fixed, SSR_u and SSR_r are SSR obtained from the maximum likelihood (ML) estimation that corresponds to the fixed-effect estimator (FE). We estimated these two models for each of the 12 countries, Eqs. 4 and 5,

$$\Delta UHC_{it} = \sum_{k=1}^{p} \beta_k \Delta UHC_{it-k} + \sum_{k=0}^{p} \theta_k \Delta \mathrm{HSp}_{it-k} + u_{it}$$

$$\Delta HSp_{it} = \sum_{k=1}^{p} \beta_k \Delta HSp_{it-k} + \sum_{k=0}^{p} \theta_k \Delta UHC_{it-k} + u_{it}.$$

Covariance of the error terms were not correlated across the equations. We selected the number of lag using Akaike Information Criterion (AIC), Hannan–Quinn information Criterion (HQIC) and Schwarz Bayesian information Criterion (SBIC). We choose the lag that was significant for at least two of these three criteria. Adoption of such an approach for selecting lag exerted an impact with objectivity in the conclusion of the test.

Table 2 UHC index.

	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003
Afghanistan	0.93	0.64	0.45	0.52	0.49	0.43	0.31	0.28	0.28	0.24	0.28	0.27
Bangladesh	0.63	0.54	0.53	0.52	0.44	0.42	0.39	0.41	0.60	0.59	0.54	0.52
Burkina Faso	0.68	0.53	0.54	0.57	0.46	0.50	0.65	0.49	0.32	0.34	0.34	0.28
Ghana	0.82	0.77	0.78	0.77	0.61	0.55	0.50	0.30	0.45	0.47	0.62	0.52
Guinea	0.43	0.54	0.65	0.77	0.75	0.77	0.88	0.75	0.73	0.69	0.46	0.52
Indonesia	0.68	0.91	0.94	0.89	0.82	0.47	0.46	0.37	0.47	0.52	0.45	0.49
Mongolia	0.53	0.54	0.92	0.62	0.57	0.28	0.29	0.56	0.60	0.58	0.60	0.69
Mozambique	0.88	0.88	0.83	0.80	0.43	0.49	0.35	0.58	0.61	0.53	0.39	0.39
Tajikistan	0.24	0.25	0.26	0.29	0.28	0.42	0.53	0.75	0.42	0.38	0.55	0.59
Togo	0.47	0.40	0.40	0.41	0.47	0.53	0.58	0.48	0.43	0.39	0.50	0.63
Uzbekistan	0.70	0.41	0.65	0.68	0.47	0.53	0.58	0.53	0.62	0.57	0.74	0.76
Yemen, Rep.	0.79	0.85	0.67	0.62	0.61	0.50	0.28	0.29	0.32	0.26	0.35	0.31

Table 3 MLE estimation of SFA || Dependent variable: lnU5 mortality rate.

Variables	Coefficient	Standard error
lnRatio of total per capita health expenditure/Total per capita GDP	−0.353***	0.082
lnFertility rate	1.082**	0.354
lnPercentage of population have access to basic drinking water	−0.184	0.436
lnPercentage of population using basic sanitation services	−0.138	0.097
lnPercentage of population living below national poverty line	0.267	0.222
lnTotal population	0.095	0.082
High burden country [TB/Malaria/HIV]		
TB/Malaria/HIV	−0.006	0.051
Combination of any two	−0.028	0.057
Combination of all three	−0.216*	0.112
σ_u	0.124***	0.026
σ_v	0.040***	0.010
λ	3.080***	0.033
Log-Likelihood	106.8197	
Wald (χ^2)	21223.00	
Probability (χ^2)	0.000	
N	132	

ln = log transformed. ***, **, * ⇒ Significance at 1%, 5%, 10% level.

Results

Table 2 presents the UHC attainment for the U5 mortality. A cluster of countries, namely, Afghanistan, Burkina Faso, Mozambique and Yemen Republic registered a substantial progress while we found setback in Guinea, Mongolia, Tajikistan, Togo and Uzbekistan over the period of 12 years. However, the coverage exhibited a fluctuating trend for all the countries during the study period (Table 2).

Table 3 presents the MLE of parameters of the stochastic frontier production function. A significant negative effect of the ratio between per capita health expenditure and total per capita GDP, and the total fertility rate emerged as the important drivers of the U5 mortality reduction.

Further, the coefficients with negative sign (the statistical significance at 10% level) of the high-burden country (combination of all three of T.B./HIV/Malaria) in SFA output captured intuitively the efforts to combat the problem not the prevalence affecting the performance of the health system.

As expected, the mean and the variance of u_{it} are both strictly positive. This confirms, for the countries in our sample, presence of technical inefficiency, and that the differences between the observed (actual) and the frontier (potential) output were caused by a systematic decay (not the chance alone). Furthermore, the rejection of the null hypothesis (Wald-test) confirmed model appropriateness that included inefficiency term to explain the health system's performance. The post-estimation test did not validate the normality of residual v_{it}; this is possibly attributed to the limited number of data points in our study.

However, as the partition of the whole variability $(v_{it} + u_{it})$ between v_{it} and u_{it} is predetermined by the SFA modelling, the inferences on u_{it} and the tests made on u_{it} remain valid—which is the main purpose of the SFA application.

Figure 1 illustrates the trends of the health system's performance (inefficiency) and the UHC, and cross-dynamics between the health system's performance (i.e., HS_p) and the UHC. A consistent progress of the UHC attainment was only in Afghanistan, Ghana, and Yemen Republic albeit with fluctuations. The UHC score was decreasing at a relatively fast pace between 2003 and 2005, and between 2009 and 2013 in Tajikistan, Togo and Guinea (towards the end of the study period), such observation could be attributable to the country-specific random effect, that was indeed substantial (Fig. 1).

The index of inefficiency was almost at the same level in Afghanistan, Bangladesh, Guinea, Togo and Yemen Republic during the study period. We observed a steep increase of the health system's inefficiency for Mongolia compared to the score of the UHC (Fig. 1).

The Granger non-causality test for the heterogeneous panel data model revealed (Table 4) causality from HSp ⇒ UHC for Burkina Faso, Indonesia and Mozambique, and from UHC ⇒ HSp for Bangladesh only. The bidirectional causality HSp ⇔ UHC was found in Ghana, Mongolia, Tajikistan, Togo, Uzbekistan and Yemen Republic. Our result could not find any causality between the HSp and the UHC or vice-versa for Afghanistan and Guinea. All the causality effects were at 1% (probability of rejecting HENC hypothesis) level of statistical significance. We noted that the signs of the "betas" were not homogeneous across the countries (column 4); for instance, when a causality was for HSp ⇒ UHC (unidirectional and bidirectional), the sign was negative in four cases, and positive in five cases; when a causality was for UHC ⇒ HSp (unidirectional and bidirectional), the sign was negative in five cases, and positive in two cases.

Discussion

This study attempted to examine direction of causality between the Universal Health Coverage and the performance of the health

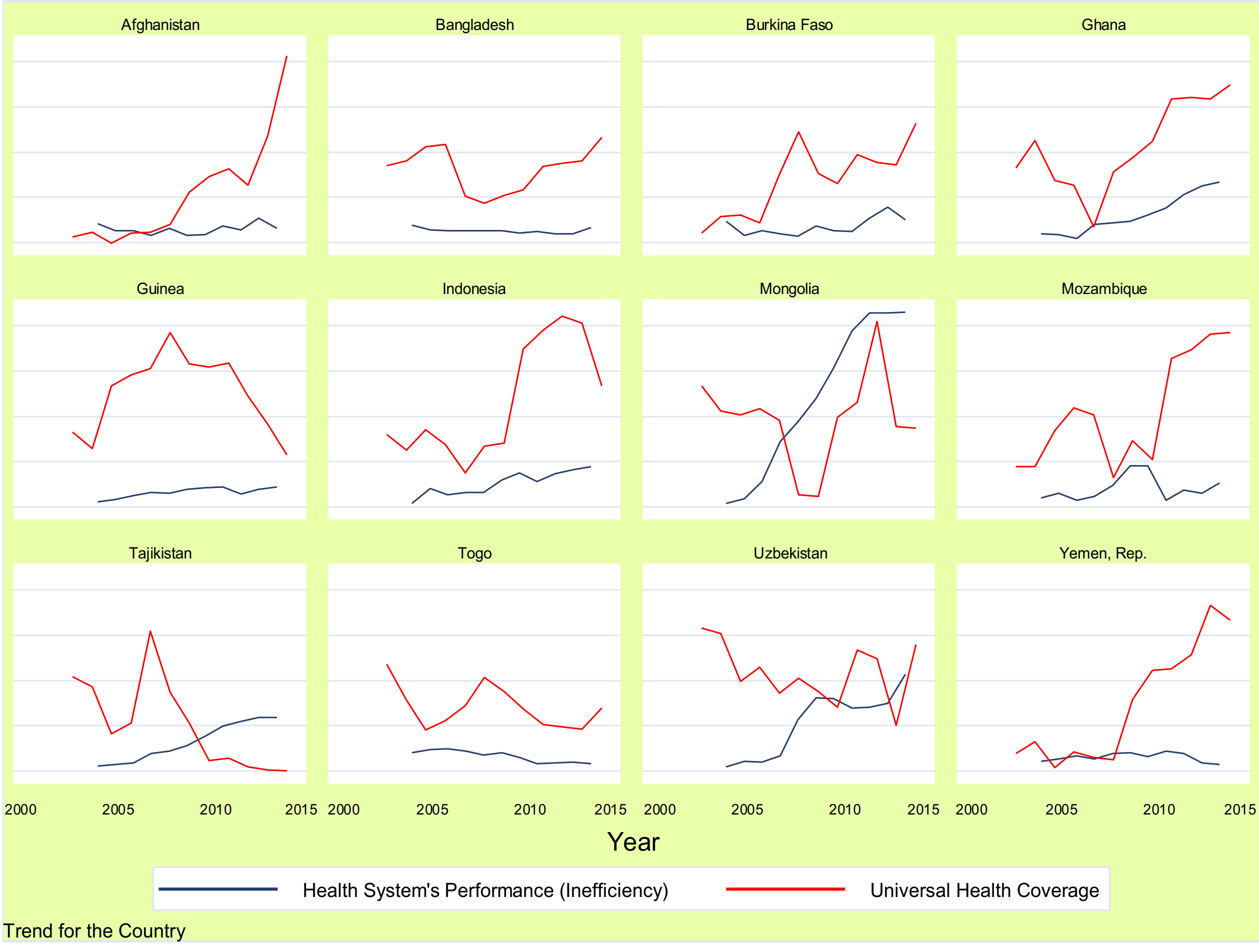

Fig. 1 Cross-dynamics: The health system's performance (inefficiency) and the Universal Health Coverage.

system for U5 mortality in seven LICs and five LMICs over the period of 12 years (2003–2014). Coverage of essential health services for child health are established as one of the tracer indicators to track the UHC. Inspired from the approach of "mashup" index, we first developed the UHC index for U5 mortality in the framework of the UHC cube (where we have allocated weights as 30% for each of the service coverage and the population coverage, and 40% weight for the financial protection). We applied a 3-step approach—first, we derived the UHC index for seven LICs and five LMICs showing levels of the UHC attainment, and changes and trends therein. Second, using SFA methods, we generated scores of efficiencies for the 12 countries under this study and obtained the result of extent of inefficiency in the performance of the national health system. Finally, we applied Granger non-causality test to a heterogeneous panel data model with fixed coefficients to ascertain the direction of causality between the UHC and the HS_p.

A bidirectional causality HSp ⇔ UHC was found for six of the twelve countries in our sample, but with the mix of a negative sign (3 countries), and a positive sign (3 countries). Togo and Yemen reflected that the efficiency and the equity can evolve simultaneously, rather than in any opposite direction. The conventional view that efficiency and equity contradict each other were found to be true in three cases: Ghana, Tajikistan and Uzbekistan. "Inefficiency" also affects the coverage without any discrimination or selectivity. In Mongolia, although increased efficiency of the health system was associated with the improved UHC, the reverse was not true, i.e., an improved UHC was not associated with a better performing national health system. The scenario that the efficiency indeed precedes the equity was found only in two countries (unidirectional, HSp ⇒ UHC), i.e., in Burkina Faso and Indonesia). Lastly, the negative unidirectional causality relationship for Bangladesh (UHC ⇒ HSp), implied that the equity efforts were not without the expense of the efficiency (WHO, 2000).

Such a mixed findings implied that the context matters to conclude the existence of a "rivalry effect" between equity and efficiency. The findings from Togo and Yemen established the importance of examining combined effects of interactions between and within determinants to achieve health policy goals. From an empirical standpoint, the statistical findings critically challenged the idea, driven by the economic orthodoxy, that efficiency must precede equity in healthcare services. Rather, our findings mostly supported the view of simultaneous efforts for improvement in the expansion of coverage and the health system's efficiency, directing attention towards the importance of organisation of the health system in the country context. Quantifying multidimensional goals of the national health system is always a challenge and so, this study has demonstrated an approach to overcome such a challenge using an illustration with U5 mortality.

We have presented a framework to examine and monitor cross-dynamicity of the health system's performance and the universal health coverage, and thereby, this study objectively contributes to the debates and the contestation in decision making for public health development. With this effort to have

Table 4 Results from the Granger non-causality test (heterogeneous non-causality hypothesis).

Country	Optimal VAR length (k)	Significance of Granger non-causality test statistic	Sign of coefficient β_k	Direction of causality
Afghanistan	HSp = 1 UHC = 2	$\chi^2 = 0.273$ $\chi^2 = 0.136$		No causality
Bangladesh	HSp = 4 UHC = 0	$\chi^2 = 0.009$	–	UHC => HSp
Burkina Faso	HSp = 2 UHC = 4	$\chi^2 = 0.006$	+	HSp => UHC
Ghana	HSp = 2 UHC = 2	$\chi^2 = 0.000$ $\chi^2 = 0.000$	–	HSp <=> UHC
Guinea	HSp = 4 UHC = 3	$\chi^2 = 0.270$ $\chi^2 = 0.687$		No causality
Indonesia	HSp = 4 UHC = 4	$\chi^2 = 0.009$	+	HSp => UHC
Mongolia	HSp = 1 UHC = 0	$\chi^2 = 0.000$ $\chi^2 = 0.000$	+ –	HSp <=> UHC
Mozambique	HSp = 0 UHC = 0	$\chi^2 = 0.000$	–	HSp => UHC
Tajikistan	HSp = 0 UHC = 4	$\chi^2 = 0.000$ $\chi^2 = 0.000$	–	HSp <=> UHC
Togo	HSp = 0 UHC = 4	$\chi^2 = 0.000$ $\chi^2 = 0.000$	+	HSp <=> UHC
Uzbekistan	HSp = 4 UHC = 2	$\chi^2 = 0.000$ $\chi^2 = 0.000$	–	HSp <=> UHC
Yemen, Rep.	HSp = 4 UHC = 2	$\chi^2 = 0.000$ $\chi^2 = 0.003$	+	HSp <=> UHC

plausible results, this study was limited to the countries where data availability source was common both over time within a country and across countries; this led us to restrict the sample to only 12 countries over 12 years. This short time-horizon was probably the most thwarting limitation in this study, with possible consequences for the confirmation of few technical assumptions (but not for the validation of the model used). Further, the paucity of the consistency in the data availability across the countries did not allow post-natal care coverage to be included in the population coverage of the UHC cube. In addition, the almost similar economic, social and other macro context of the countries studied restricted the generalisability of the findings, although ensured a reasonable comparability.

Despite these limitations, this study has used advanced methodological approaches on the data from multilateral organisations and presents a novel insight for understanding contributions of universal health coverage on under-5 mortality level attainment. In addition, this study has captured the role of determinants for the health systems to be efficient. Our methodological approach for measuring "inefficiency" has picked up all time-invariant effects (e.g., effect of investment in the health system as a ratio between per capita health expenditure and per capita GDP, and fertility rates), as well as possible inter-country unobserved heterogeneity, and thus, the "inefficiency" was estimated as an unstructured time-varying effect.

Conclusions

Besides other mechanisms, the policy coherence for SDGs calls for an adoption of an integrated approach interlinking different sectors. This study demonstrates the relevance of our approach for U5 mortality in the context of the "agenda 2030". To conclude, this study presents the need for SDGs target-specific data generation and more specifically, examining interlinkages and interactions between and within the SDG targets for estimating the combined efficiency/equity effects of interventions in the context of resource-poor countries with consideration of the effect of organisation of the respective health system. Our data can also be used as a starting point to develop an information system for tracking the effect of cross-dynamicity between the health system's performance and the Universal Health Coverage on U5 mortality.

Data availability

Data used in this study are taken from the World Bank (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups); and the World Health Organisation (http://apps.who.int/nha/database and http://apps.who.int/ghodata/); and United Nations (http://data.un.org/).

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Author contributions

PP: concept development; literature review; study design; data acquisition and organisation; data analysis; interpretation of results from the analysis and writing the manuscript. UN: software syntax development. AN: contributed for choosing the right econometric model for examining health systems' performance. NK: construction of mathematical expressions and validation of the models used. BV: conceptualisation of the study; development of the analytical approach; providing critical comments; revising with important intellectual contents and final reviewing of the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

Not applicable. This article does not contain any studies with human participants performed by any of the authors.

Informed consent

Not applicable. This article does not contain any studies with human participants performed by any of the authors. This study uses administrative data with no individual identification identifiable by the user.

Additional information

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