The long-run effects of health aid in low-income countries

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Abstract

Background. Whether health aid has a positive, negative, or no effect on the health status of recipient countries is controversial.

Objective. The current paper examines the long-run effect of health aid on health status in low-income countries.

Methods. The long-run health function was estimated using infant mortality as a proxy for health status and panel data constructed from 34 low-income countries from 2000 to 2017. For the estimation, fixed effect, random effect, and Hausman-Taylor estimators were employed.

Results. The estimation results indicate that health aid has a beneficial and statistically significant long-run effect on the health status of low-income countries. Doubling health aid saves the lives of 44 infants per 1000 live births in the long run.

Conclusion. This study shows that health aid could be one of the best interim tools with which the health status of low-income groups could get improved and helps meet the target of universal health coverage. Despite the favorable effect of health aid observed in this study, recipient countries need to find ways of promoting surrogate domestic health financing systems, as external assistance cannot be an everlasting means of improving population health.

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Introduction

While low-income countries have been major recipients of health aid for decades, they exhibit poor health outcomes.[1,2] According to World Bank, in 2000, the life of 88 per 1000 live births passed before they celebrated their first birthday in low-income countries.[3] Though it is expected that health aid will improve health outcomes in recipient countries, there is no consensus as to whether health aid has a beneficial effect on the health status of the population in low-income countries. Several researchers hold the view that health-specific aid leads to improved health outcomes in low-income countries by relaxing resource constraints and directly improving health service delivery.[4-6]

However, others like Williamson and Wilson disagree with the effectiveness of health aid and argue that there is no as such reliable empirical evidence supporting the claimed positive effect of health aid on health outcomes.[2,7] According to Petterson, the reason behind the ineffectiveness of aid is that it is diverted to other sectors or purposes instead of being injected into the sector it was targeted.[8] Others maintain that the aid adversely affects a country's competitiveness, encourages dependency and reduces incentives to adopt good policies, overwhelms the management capacity of governments, or is used inefficiently to benefit the political elite.[9,10]

One likely root of this controversy is methodological deficiencies in empirical studies, specifically misspecification problems in health estimating equations. The extent to which measurement errors have been controlled and the degree to which the appropriate sample was selected could also be the causes of the controversy.

Besides, the distinction of long-run health aid effects is rarely emphasized, particularly in low-income countries, while the size and significance of the estimated marginal effects are strongly dependent on such periods. Therefore, the current study aims to examine the long-run effect of health-targeted aid in low-income countries.

Materials and Methods

Study design and country sample

The study used cross-section and annual time series data from 2000 to 2017 for 34 low-income countries: Afghanistan, Benin, Burkina Faso, Burundi, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Democratic People's Republic of Korea, Liberia, Madagascar, Malawi, Mali, Mozambique, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Somalia, South Sudan, Syrian Arab Republic, Tajikistan, Tanzania, Togo, Uganda, Yemen, Zimbabwe.

Low-income countries were included because if one includes high-income countries with low infant mortality rate (IMR) in the sample economies, the result would likely be statistically insignificant. Hence in this paper, low-income countries were treated separately instead of pooling high-income and low-income groups together.

Variables, data sources and estimation methods

To estimate the long-run health equation given in Eq. 14, eight variables were chosen following past studies: namely, the infant mortality rate (IMR), Health development aid (HDA), gross domestic product *per capita* (GDPP), human capital (HC), adolescent fertility rate (AFERT), elderly dependency rate (EDEP), worldwide governance indicator (INST) and cereal yield (yield).

IMR, which was taken from the World Bank (2018), is defined as the number of infants dying before reaching one year of age, per 1000 live births in a given year.[3] This indicator was used as a health status measure for the fact that it is more sensitive to changes in health and other socioeconomic conditions of low-income economies. The relationship between IMR, and health aid, is expected to follow a downward sloping curve to the right as aid has no or little effect at a very low level of IMR.

HDA data was taken from the World Bank (2018) which defined it as an external source of health expenditure in a recipient country, measured in constant 2010 USD. External sources compose of direct foreign transfers and foreign transfers distributed by the government encompassing all financial inflows into the national health system from outside the country.[3] External sources either flow through the government scheme or are channeled through non-governmental organizations or other schemes. Aggregate aid's effect instead of health sector-specific aid is very likely to be biased downward or its standard error could be upward biased. To take care of this issue as well, this study considered health sector targeted aid instead of aid in general.

GDPP was also taken from the World Bank (2018) and it is defined as the gross domestic product, in constant 2010 USD dollars, divided by midyear population.[3] This variable is considered to be related to health status since a higher level of income favors the consumption of quality goods and services, better nutrition, housing, and the ability to pay for medical care services.

HC index was taken from Feenstra *et al*. The source indicated HC was based on years of schooling and returns to education.[11]

AFERT data was taken from the World Bank (2018) which defined it as the number of births per 1000 women aged 15-19. The rates are based on data on registered live births from vital registration systems or, in the absence of such systems, from censuses or sample surveys.[3] The estimated rates are generally considered reliable measures of fertility in the recent past. Where no empirical information on age-specific fertility rates is available, a model is used to estimate the share of births to adolescents. For countries without vital registration systems fertility rates are generally based on extrapolations from trends observed in censuses or surveys from earlier years.

EDEP data were taken from the World Bank (2018). EDEP is defined as the ratio of elderly dependents, people older than 64, to the working-age population, those aged 15-64. Data are shown as the proportion of dependents per 100 working-age population.[3]

INST is a composite index of governance and was computed from 6 dimensions of governance using principal component analysis, a statistical technique used for data reduction, and based on the 6 aggregate dimensions of governance: rule of law, control of corruption, political stability, government effectiveness, regulatory quality, voice, and accountability. The indices for the dimension were taken from the World Bank (2018).[12] The dimension indices range from -2.5 (the lowest performance) to 2.5 (the highest performance).

Yield was taken from the World Bank (2018) and it is defined as kg per hectare, here converted to quintal per hectare, of harvested land, which includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains. Production data on cereals relate to crops harvested for dry grain only.[3]

To estimate the parameters of interest fixed effect and random effect, Hausman-Taylor estimators were employed. The last estimator was selected to control the likely biases that arise from endogeneity. As the name indicates, the parameters in the long-run health function measure the effects of all past levels as well as the present level of input variables on the present time health indicator. As a result, one expects much higher coefficient estimates in the long-run function as compared to the estimates from the short-run health function we have in the literature.

To deal with the problem of omitted variables, it is assumed that the omitted variables follow auto regressive order two, which is equivalent to assuming that they follow second-order difference equations, whose solution will be a function of time. On this ground instead of just assuming the variables away, log time is used as a control variable representing all omitted variables in the long-run health equations.

Framework

Grossman, assuming health as a durable capital stock and considering that individuals inherit an initial stock of health that depreciates with age but can be increased by investment, constructed a theoretical model of health production. The model specifies a vector of inputs to the health production function, where the elements of the vector include: nutrient intake, income, consumption of public goods, education, time devoted to health-related procedures, initial individual endowments like genetic makeup, and community endowments such as the environment.[13] Mosley and Chen's conceptual framework grouped these variables as socioeconomic factors that appear at individual, household and community level.[14] Following this approach let the implicit function that relates these factors $X_1(t), X_2(t),\ldots X_n(t)$, some of which indeed are unobservable or not measurable, to health outcomes $Y(t)^*$ as in Eq.1.

$$Y(t)^*=f(X_1(t), X_2(t),\ldots X_n(t)) \quad [1]$$

where $X_j(t)$ are input variables and, for $j>k$, they are unobserved or not measured variables.

In essence, $Y(t)^*$ is a long-run specification since actually, it is affected by past levels of the input variables; however, these past input levels were not included explicitly. The underlying assumption for omission is that the input variables are on their equilibrium path and hence are some constant proportion of their present levels, which holds in the long run. Under this assumption, the distributed lags of each input variable can be replaced by their respective present level that appears in the implicit function. In the attempt to state the function explicitly, just like other human capital models, Grossman suggested the application of utility maximization constrained with resources which may require the application of optimal control analysis.[13]

Supporting this approach, Berman *et al*. suggest that individuals tacitly undertake utility maximization constrained by resources.[15] They stress the fact that health function represents a dynamic behavioral process through which households combine their knowledge, resources, and behavioral norms and patterns with available technologies, services, information, and skills to restore, maintain, and promote the health of their members.[15] Building on these views it is assumed here that households derive satisfaction from their health status and they strive to maximize their utility constrained by socioeconomic and demographic factors that appear at individual household and community level. The common and very important solution to such a utility maximization problem is the constancy of marginal effects of the input variable. That is in Eq. 2:

$$dY(t)^*=f_1dX_1(T)+f_2sX_2(T)+\ldots f_ndX_n(t) \quad [2]$$

which one could get after taking the total derivative of both sides of Eq. 1 the f_j's are constants. Based on the constancy of marginal effects one can integrate Eq. 2 to get Eq. 3:

$$Y(t)^*= f_1dX_1(T)+f_2sX_2(T)+\ldots f_ndX_n(t)+A \quad [3]$$

where A is some constant. Let $Y(t)_j^*$ be components of $Y(t)^*$ generated by $X_j(t)$ such that

$Y(t)^*=\sum_{j=1}^{n}Y(t)_j^*$ and $dY(t)^*=\sum_{j=1}^{n}dY(t)_j^*$, then we have Eq. 4:

$$dY(t)_j^*=f_jdX_j(t) \quad [4]$$

This informs that in the long-run period that allows individuals to maximize their utility which results in the constancy of the marginal effects of the inputs, the level of health status is just the sum of the portions of the health status caused linearly by the inputs. In fact, usually, the linearity is maintained after the transformation of the inputs and outputs using a logarithmic function. However, in the current case, the constancy of the marginal effects holds only when the health indicator and the measures of the input variables show co-movement in the long run. But here the health indicator, be it life expectancy or infant mortality, is constrained both from below and from above; while some of the input variables exhibit constant growth, others though constrained from above exhibit variable growth rate and others behave just like the health status indicator. As a result, unlike the results from the optimal control analysis, in practice, one may observe increasing or decreasing marginal effects besides the indicated constant marginal effects. To be consistent with the result of optimal control analysis, *i.e.* constancy of the input marginal effects - the input variables have to undergo some mathematical transformations. For these purposes, the set of input variables was classified into 3 subsets following the pattern of their likely marginal effects.

The first subset includes variables that exhibit decreasing marginal effects with increasing previous levels of the input variables and that leave the level of health status unchanging asymptotically. In other words, in the long run, due to the inelasticity of health outcomes, the level of health status remains unchanging. Health aid and GDP *per capita* could be examples of this subset. In this case, the marginal effects were specified in Eq. 5:

$$\frac{\partial Y(t)^*}{\partial X_{1j}(t)}=\frac{\alpha_{1j}}{X_{1j}(t)}$$

where α_{1j} are some constants.

Substituting Eq. 5 in Eq. 4, one gets,

$$dY(t)_j^*=\alpha_{1j}\frac{dX_j(t)}{X_{1j}(t)},$$

which after integration would give Eq. 6:

$$Y(t)_j^*= \alpha_{1j}ln(X_{1j}(t)) \quad [6]$$

Eq. 6 suggests that in this sub-group, the health indicator forms co-movement with $ln(X_{1j}(t))$, which means the input variables in the subset of decreasing marginal effect need logarithmic transformation $X_{1j}^L(t)\equiv ln(X_{1j}(t))$.

The second subset includes input variables with increasing marginal effects. In this case, we consider the case of knowledge of skill or institutional quality which, unlike other resources, are non-subtractable in their employment. In the portion of health status determined by knowledge, skills, or institutional quality, the change in this portion of health status would be the same level as the previous portion level, since knowledge is non-subtractable and can be reused without depletion after employment.

That is theoretically, $dY(t)_h^*=Y(t)_h^*$ or $\frac{dY(t)_h^*}{Y(t)_h^*}=1$

where $Y(t)_h^*$ is the portion of health determined by knowledge and skill. Integrating both sides and taking the exponential of both sides one gets $Y(t)_h^*=wexpX(t)$. Taking the derivatives of both sides, one gets

$$\frac{dY(t)_h^*}{dX_{2j}(t)}=\omega expX_{2j}(t).$$

$$\frac{\partial Y(t)^*}{\partial X_{2j}(t)}=\alpha_{2j}expX_{2j}(t) \quad [7]$$

$$dY(t)_j^*=\alpha_{2j}expX_{2j}(t)dX(t)_{2j}^* \text{ or } \frac{dY(t)_j^*}{dX(t)_{2j}^*}=\alpha_{2j}expX_{2j}(t)$$

Eq.7 is based on the maximizing behaviors of individuals the portion of health status determined by knowledge and skills are expected to be constant, *i.e.* $\frac{Y(t)'}{Y(t)}\equiv\hbar$ where $\hbar$ is some constant.

Hence $\alpha_{2j}=\frac{\omega}{\hbar}$.

Integrating both sides of equation, one gets Eq. 8:

$$Y(t)_j^*=\alpha_{2j}expX_{2j}(t) \quad [8]$$

where α_{2j} are some constants.

Eq. 8 suggests that in this sub-group health indicator forms co-movement with $exp(X_j(t))$, which implies the input variables in the subset of increasing marginal effect need exponential transformation, *i.e.* $X_{2j}^E(t)\equiv exp(X_{2j}(t))$.

Thus in the cases of knowledge, skills, and institutional qualities, marginal effects were considered to rise exponentially with the previous levels of the input variables. Input variables in these subsets fulfill the requirements of constant marginal effects when the input variables are transformed using the exponential function as $X_{2j}^E(t)\equiv exp(X_{1j}(t))$. Even if it seems that inputs in this subset may lead to a very large level of health status, it is good to keep in mind that further accumulation of knowledge or human capital gets difficult as its previous level gets larger. Hence just like the preceding subset this group also leads to some constant level of health status asymptotically due to the likely input side constraint.

The third subset includes those variables which fulfill the condition of the implied constancy of the marginal effects without transformation. Such cases hold when the measures of the input variables are ratios of variables just like IMR. Demographic variables like fertility rate dependency rates can be seen as good examples. In this case, there is no need for transformation of the input variable as it fulfills the indicated requirement.

$$\frac{\partial Y(t)^*}{\partial X_{3j}(t)}=\alpha_{3j} \qquad [9]$$

where α_{3j} are some constants.

Substituting Eq. 9 in Eq. 4, one gets $dY(t)_j^*=\alpha_{3j}dX_{3j}(t)$, which after integration would give:

$$Y(t)j^*=\alpha_{3j}X_{3j}(t) \qquad [10]$$

Eq. 10 suggests that the input variables in the subset of constant marginal effects need no transformation as they form comovement as they are.

Substituting Eq. 6, Eq. 8, and Eq. 10 in Eq. 3, one gets Eq. 11:

$$Y(t)^*=\sum_{j=1}^{s}\alpha_{1j}X(t)_{1j}^{L}+\sum_{j=s+1}^{m}\alpha_{2j}X(t)_{2j}^{E}+\sum_{j=m+1}^{n}\alpha_{3j}X(t)_{3j}+A \qquad [11]$$

where $j=1,2,\ldots s$ represents input variables with decreasing marginal effects, $j=s+1,s+2,\ldots m$ represents input variables with increasing marginal effects, and $j=m+1,m+2,\ldots n$ represents input variables with constant marginal effects.

Eq. 11 can be treated as the long-run health function for it does not explicitly considers the effects of the past level of input variables but assumes the input variables are on their equilibrium path which holds only in the long run. Consequently, the coefficient α_{ij} represents the cumulative marginal effects of all the past marginal effects as well as the present input variables, for the details see Negeri G and Haile Mariam D.[16]

Besides the considered misspecification arising from functional form, in practical analysis, a part of the input variables are unobservable or their data may not be available. From introductory econometrics, we understand that ignoring these variables will make the coefficient estimates of the known variables unbiased. To deal with this issue let's assume that input variables $X_j(t)$ for $j>k$ are unobservable or their data may not be available. Without loss of generality let's assume that these omitted variables follow some auto regressive of order two, which can be expressed as second order difference equation whose particular solution and complementary function[1] will be a function of time. *i.e.* $X_j(t)=f(t)$. Taking total derivative, dividing through by $X_j(t)$, and rearranging one gets

Eq.12 $\frac{dX_j(t)}{X_j(t)}=\left(\frac{dX_j(t)t}{dtX_j(t)}\right)\frac{dt}{t}$.

[1]The estimated auto regressive of order two for $X_j(t)$ can be written as $X_j(t)=a_j+b_{1j}X_j(t-1)+b_{2j}X_j(t-2)$ whose complementary function and particular solution will be $X_j(t)=X_{cj}(t)+X_{pj}(t)$ where complementary function $X_{cj}(t)=A_1r_1^t+A_2r_2^t$ where A_1 and A_2 are arbitrary constants r_1 and r_2 are characteristic roots and particular solution $X_{pj}(t)=\frac{a_j}{1-b_{1j}-b_{2j}}$ for $b_{1j}+b_{2j}\neq 1$; $X_{pj}(t)=\frac{a_jt}{2-b_j}$ for $b_{1j}\neq 2$; $X_{pj}(t)=\frac{a_jt^2}{2}$ for $b_{1j}=2$ and $b_{1j}+b_{2j}=1$

To make a plausible assumption about the term in the bracket, *i.e.* the elasticity of $X_j(t)$ with respect to time, consider the portion of health status determined by the omitted variable $X_j(t)$ separately. In the long run, this portion is expected to be constant just like the entire health indicator. At the same time from Eq. 4, one understands that it is determined as the product of some constant marginal effects and the input omitted variable. Hence in the long run we expect that the levels of the omitted variables are constant as well, which implies the growth rate of each omitted variable is expected to decay over time. This pattern can be expressed as

$\frac{dX_j(t)}{X_j(t)dt}=\frac{\eta_j}{t}$ for some constant h_j. After rearranging one gets.

$$\frac{dX_j(t)}{X_j(t)}=\frac{\eta_j dt}{t}.$$

On this ground, it is possible to assume the constancy of the elasticity under consideration. Integrating both sides of this equation one gets Eq.13:

$$lnX_j(t)=h_j lnt \qquad [13]$$

Substituting Eq. 13 in Eq. 11 one gets the long-run health function as

$$Y(t)^*=\sum_{j=1}^{s'}\alpha_{1j}X(t)_{1j}^{L}+\sum_{j=s+1}^{m'}\alpha_{2j}X(t)_{2j}^{E}+\sum_{j=m+1}^{n'}\alpha_{3j}X(t)_{3j}+\gamma lnt+\varphi \qquad [14]$$

$$\text{where } s'<s,\ m'<m,\ n'<n \text{ and } s'+m'+n'=k;\ \gamma=\sum_{j=k+1}^{n}\alpha_{ij}\eta_j\ \ i=1,2,3$$

Eq. 14 lessens the problems arising from the wrong functional form as well as omitted variables as it limits subjective choices in the attempt to circumvent the problem. Direct estimation of the equation using observed values of health status as point estimates $Y(t)^*$ is expected to give estimates of the long-run coefficient which includes the past role of the input variables.

Results and Discussion

Descriptive results

In the empirical analysis, the initial health condition of the sample countries is required. The average IMR for 2000-2002 were considered as an indicator of initial health status (IMR0). Table 1 reports that in the sample countries, IMR0 per 1000 live birth was 84.27 infants. It was high in Sierra Leone (139.43), Liberia (117.93) and was low in Syria (19.03) and the Democratic People's Republic of Korea (39.26). During the study period 2000-2017, the estimated average infant mortality per 1000 live births was 66. According to the dataset, it was as high as 114 in Sierra Leone and 103 in Central Africa per 1000 live births. During the study period, good health performance was observed in Syria (16.0) and the Democratic Republic of Korea (26.0). The product of CHEP and GDPP may give the estimate of the annual average health expenditure of a representative person in the sample countries. During the covered period of study, this estimate was 34.74 USD, but the WHO (2014) estimates that a minimum of US$ 44 is needed per person per year to provide basic, life-saving health services.[17] Besides, the table indicates that during the indicated period the average *per capita* HDA and GDPP were 8.38 and 574.00, respectively, both in constant 2010 USD dollars. The average growth in these variables was 7.47% and 1.45% per year, respectively.

The recipients of a low amount of HDA were Niger (2.70 USD), Senegal (2.98 USD), Togo (2.69 USD), Republic of Yemen (2.00 USD), whereas Zimbabwe (19.41 USD), Tanzania (23.0 USD), and Haiti (25.30 USD) were receiving a relatively higher amount. Countries with low *per capita* GDPP were Burundi (227.85 USD) and the Democratic Republic of Congo (334.80 USD) whereas countries with relatively higher *per capita* GDPP were the Republic of Yemen (1106.76 USD), and Senegal (983.78 USD).

Figure 1A suggests that the IMR-HDA forms a downward-sloping curve or there is a negative semi-log linear relation between the two variables forming an increase in HDA that could lead to a decline in IMR. On the other hand, Figure 1B suggests that for GDPP greater than 270, the IMR-GDPP is a downward-sloping to the right at a decreasing rate. The decreasing rate can be seen as lesser demand (change in IMR) for the rising price. Grossman notes that such a downward-sloping demand curve is the most fundamental law in economics; the quantity demanded should be negatively correlated with its shadow price.[13] This figure also suggests that during the covered period of study for the sample countries there was a maximum IMR which was 83.5 infants per 1000 live births. Countries with GDPP lower than 270 USD were Burundi, the Democratic Republic of Congo, Ethiopia, Liberia, Mozambique, and Sierra Leone. In these economies, the figure suggests that an increase in income induces IMR to rise.

Moreover, Table 1 reports that the average human capital index was 1.60. The lowest index was observed in Burkina Faso (1.14) whereas the highest index was observed in Tajikistan (3.14). Table 1 also reports that for the income group, average adolescent fertility was 107.30 births per 1000 women aged 15-19. The indicator was the highest in Niger (208) and the lowest in the Democratic People's Republic of Korea. (0.61). In fact, the data indicates that this indicator is falling over time at an average decline of -1.9 births per year. Moreover, Table 1 informs that the elderly dependency rate was 5.88 per 100 working-age population. The indicator was the lowest in Sierra Leone (4.53%) and the highest in the Democratic People's Republic of Korea (11.96%).

Furthermore, Table 1 shows that during the study period, in the considered income group the mean composite index of governance was below zero (-0.96). It was below -2.0 in Somalia (-2.17) and South Sudan (-1.75), whereas it was above -0.3 in Senegal (-0.19) and Benin (-0.304).

A look at the overall trend of the index reflects that it was declining, at an annual average of -0.0088 with 95% CI=-.0163, -.0013, *i.e.*, institutional qualities are worsening substantially rather than improving during the study period. Finally, Table 1 reports that in the indicated time period the average cereal yield was 13.59 quintals per hectare of harvested land. It was below 5qt/hr in Eritrea (4.70qt/hr) and Niger (4.34qt/hr) and above 25qt/hr in the Democratic People's Republic of Korea (35.05qt/hr) and Madagascar (28.76qt/hr).

Table 1. Health-related indicators across low-income countries (2000-2017).

Variable	Obs	Mean	SD	Min	Max
IMR0	612	84.27	24.1	19.03	139.43
IMR	612	65.25	24.16	13.80	142.00
CHEP	473	6.05	2.39	1.44	19.73
HDA	440	8.38	7.68	0.00	48.38
GDPP	531	574.00	223.95	193.87	1309.23
HC	375	1.60	0.44	1.07	3.17
AFERT	578	107.30	48.08	0.29	217.16
EDEP	606	5.88	1.37	4.33	14.03
INST	568	-0.96	0.50	-2.43	0.06
YIELD	566	1359.09	715.33	158.20	4439.90

IMR0, initial infant mortality rate; IMR, infant mortality rate; CHEP, …; HDA, health aid; GDPP, gross domestic product *per capita*; HC, human capital, AFERT, adolescent fertility rate; EDEP, elderly dependency rate; INST, worldwide governance indicator; YIELD, cereal yield; Obs, …; SD, standard deviation; Min, minimum; Max, maximum.

Table 2. Estimate of the effect of health aid on the infant mortality rate (2000-2017).

Variable	Fixed effect				Random effect-gls			
	Coef.	Robust std. err.	T	P>|t|	Coef.	Robust std. err	T	P>|t|
lnHDA	-4.5225	0.7602	-5.9500	0.0000	-4.4239	0.7448	-5.9400	0.0000
lnGDPP	-14.1275	3.2899	-4.2900	0.0000	-14.0541	2.9310	-4.7900	0.0000
lnYIELD	-5.2368	1.6559	-3.1600	0.0020	-5.3121	1.6096	-3.3000	0.0010
expHC	-1.9871	1.0026	-1.9800	0.0480	-1.3670	0.6747	-2.0300	0.0430
expINST	-18.3411	3.5645	-5.1500	0.0000	-18.9318	3.3474	-5.6600	0.0000
AFERT	0.1941	0.0672	2.8900	0.0040	0.1943	0.0510	3.8100	0.0000
EDEP	4.9441	1.0522	4.7000	0.0000	4.6549	1.0156	4.5800	0.0000
lnTIME	-7.8187	0.7636	-10.2400	0.0000	-8.1324	0.7132	-11.4000	0.0000
_cons	162.2681	27.9444	5.8100	0.0000	161.0608	23.0750	6.9800	0.0000
corr(u_i, Xb)=-0.3375 F(8,274)=273.82 Prob>F=0.0000					Wald chi2(11)=2273.64,Prob>chi2=0.0000			

Coef, coefficient; std. err, standard error; HDA, health aid; GDPP, gross domestic product *per capita*; YIELD, cereal yield; HC, human capital, INST, worldwide governance indicator; AFERT, adolescent fertility rate; EDEP, elderly dependency rate.

Estimation results

To estimate the long-run function of health aid given in Eq. 14, econometric methods were applied to panel data. The method combines cross-section and time series data together to get more reliable parameter estimates than what cross-section or time series approach alone may give. Following the specification given in the equation, the marginal effect of HDA, GDPP, and YIELD were assumed to vary inversely with the previous level of IMR, and hence log transformation of these variables were taken for estimation. On the other hand, the marginal effects of HC and INST were assumed to have exponential relations with the previous level of IMR as these inputs are non-subtractable in their very nature. Hence their exponential transformation was used in the estimation process. The marginal effect of AFERT and EDEP were assumed to be constant since they are indices or ratios. Hence they were entered into the function without transformation.

Under the assumption of Eq. 14, the econometric specification that relates health status to a vector of explanatory variables is given as:

$$IMR(i,t)=\beta_1 lnHDA(i,t)+\beta_2 lnGDPP(i,t)+\beta_3 lnYIELD(i,t)+\beta_4 expHC(i,t)+\beta_5 expINST(i,t)+\beta_6 AFERT(i,t)+\beta_7 EDEP(i,t)+\beta_8 lnTIME(i,t)+\mu(i)+\mu(t)+\varepsilon(i,t) \quad [15]$$

where *IMR(i,t)* is the infant mortality rate, *lnHDA(i,t)* is log-health development assistance, *lnGDPP(i,t)* is log-GDP *per capita*, *lnYIELD(i,t)* is log yield, *expHC(i,t)* is exponential of human capital index, *expINST(i,t)* is exponential of governance index, *AFERT(i,t)* is adolescent fertility rate, *EDEP(i,t)* is elderly dependency rate, in country *i* at time *t* for *i=1,2,…34* (number of countries), *t=1,2,..17* (number of time units), *e(i,t)* is error term with the property $E[e(i,t)]=0$ and $var[e(i,t)]=(\sigma_e)^2$; m_0 is constant term; $\mu_1(i)$ and $\mu_2(t)$ are country and time specific effects respectively.

To estimate Eq. 15, the fixed effect estimator assumes there are constant country-specific effects and the random effects estimator assumes there are random country-specific effects. The one that fits the data better was chosen based on the Hausman specification test. Next to take care of the endogeneity problem, the Hausman-Taylor estimator is employed. Based on instrumental variables, the Hausman-Taylor fits panel-data random-effects models in which some of the covariates are correlated with the unobserved individual-level random effect. The estimator requires the subset of time-invariant variables, that is, constant within the panel. The estimation results from this approach were presented in Tables 2 and 3.

The Hausman test presented at the bottom of Table 2 accepts the null hypothesis that states the error terms are independent of the explanatory variables, which implies that the random effect estimator is preferable to fixed effect, $\chi^2(8)=3.80$, P=0.8747.

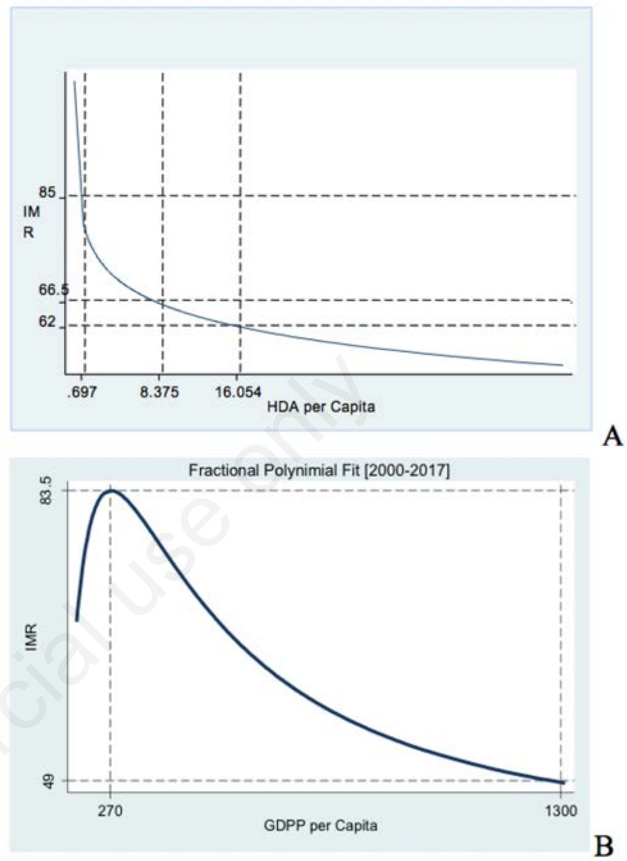

Figure 1. Fractional Polunimial fit (2000-2017). A) Plot of infant mortality rate versus health aid; B) Plot of infant mortality rate versus gross domestic product *per capita*.

Table 3. Hausman-Taylor estimation results.

Variable	Coef.	Robust std. err.	T	P>|t|
TVexogenous				
expINST	-17.3385	3.4044	-5.0900	0.0000
AFERT	0.1296	0.0543	2.3800	0.0170
EDEP	4.5321	1.0148	4.4700	0.0000
lnTIME	-8.3885	0.7133	-11.7600	0.0000
TVendogenous				
lnHDA	-4.4119	0.7521	-5.8700	0.0000
lnGDPP	-15.8256	3.0887	-5.1200	0.0000
lnYIELD	-5.2401	1.6430	-3.1900	0.0010
expHC	-2.1369	0.8848	-2.4200	0.0160
TIexogenous				
IMR0	0.4254	0.1609	2.6400	0.0080
_cons	146.9241	30.1701	4.8700	0.0000

Wald chi2(9)= 2230.81,Prob>chi2=0.000

sigma_u=15.3591, sigma_e=4.1104, rho=0.9331 (fraction of variance due to of u_i),

Number of obs.306, Number of groups 24

TV, time varying; TI, time invariant; AFERT, adolescent fertility rate; HDA, health aid; GDPP, gross domestic product *per capita;* YIELD, cereal yield; HC, human capital; IMR0, initial infant mortality rate; cons, …; obs, …; Coef, coefficient; Std. Err., standard error.

According to the identified estimator, all explanatory variables have coefficient estimates with the expected sign and were found to be statistically significant. The estimation results indicate that while increases in health aid, *per capita* income, human capital, governance quality, and yield play the role of reducing infant mortality, decreases in adolescent fertility and elderly dependence could play some role in reducing mortality.

Moreover, the estimation results indicate that doubling health aid *per capita* would result in saving the life of 44 infants per 1000 live births. Obviously, this estimate is far larger than the estimates we have seen in the literature. The reason for the discrepancy could be that the estimate reported in Table 2 is from the estimate of the long-run health function where the coefficient estimate includes the effects of the past health aids, whereas the ones seen in the literature are estimates from the short-run health equation since most of them include lagged dependent variables. It could also be because the estimator did not consider the possibility of endogeneity of health aid. That is the case where countries that performed better in health improvement get relatively higher amounts of health aid. Besides this, health status could likely affect the levels of *per capita* income, yield, and human capital in its turn. Moreover, even if the sample countries are restricted to low-income countries the health aid and health status could likely be affected by the initial conditions of a country, *i.e*., health status could be more responsive at a lower level than at a higher level of health status. To explore this, the Hausman-Taylor estimator is employed, and the estimation results are presented in Table 3.

Hausman-Taylor estimation results reported in Table 3 are very close to the ones obtained from random effect-gls and reported in Table 2.

The estimator gives -4.4119 as the coefficient estimate of log-HDA, which is strongly significant, z=-5.8700 Pr>z=0.000, suggesting, that HDA has a strong negative effect on IMR. The estimate indicates that, in the long run, in the considered panel of countries, doubling the health aid saves the life of 43 infants per 10,000 live births. Based on the suitability of IMR as a proxy for health status, this estimation result strongly supports the view that in low-income health aid has a strong effect in improving the health status of the population. If properly injected, HDA could serve not only as a means of reducing death but also as a useful tool by which nations could break the vicious cycle of poverty arising from out-of-pocket payments, particularly if it complements prepayment mechanisms such as taxes or health insurance.

Similarly, Table 2 indicates that the log-GDPP coefficient estimate is -15.8256, which is statistically significant, z=-5.120 Pr>z=0.0000, suggesting that raising *per capita* income growth contributes to the improvement of the health status of low-income countries. The threat that rising economic growth worsens health status through resource allocation away from the sector is not observed in the considered income group. In line with this estimation result, Pritchett and Summers have argued that income is more important than any other factor since higher income makes it easier to provide the infrastructure of public health, such as water and sanitation.[18] Besides this, better income allows access to better medical care which is expected to reduce infant mortality. Preston attributed about half of the gain in life expectancy in developing countries to the combined effects of changes in income, literacy, and the supply of calories.[19] Wang considers income as one of the major input variables of health function.[20]

The long-run effect of cereal yield growth on IMR is also significant. The coefficient estimate is -5.2401, which is statistically significant, z=-3.190 Pr>z=0.0010, suggesting that raising cereal yield growth contributes to the improvement of the health status of low-income countries. In the literature, several writers argued that it has a significant effect on health. For example, Cutler *et al*. argued that improved nutrition resulting from improvements in agricultural yields is one of the main factors that determine a decline in mortality. They argue that better-fed people resist most bacterial diseases better, and recover more rapidly and more often.[21] Fogel, based on historical evidence, also argues that improved nutrition results in mortality decline.[22]

In the same way, the estimator gives -2.1369 as a coefficient estimate of expHC, which again is statistically significant, z=-2.420 Pr>z=0.016, implying that human capital accumulation could serve as one of the useful policy instruments in attempts made to improve the health status of low-income countries. In explaining how human capital improves health status, Link and Phelan note that whenever an improved mechanism or technology exists that enhances people's health, those with higher human capital are well situated to use them for their health. A family with better human capital can serve better as primary health caretakers, and implement behaviors that can improve their children's health. Besides these, it is argued that individuals with higher human capital are less likely to smoke which affects health adversely.[23]

Similarly, the estimator gives -17.3385 as a coefficient of expINST, which is again statistically significant, z=-5.090 Pr>z=0.000. This informs that improvement in institutional quality could serve as a reliable and additional policy measure that low-income countries could play within the attempts made to improve health status. Here it is good to recall that, as it was indicated in the descriptive analysis, the observed average governance index was negative and fell over time.

Conclusions

The effectiveness of health aid on health outcomes was examined using panel data constructed from 34 low-income countries from 2000 to 2017 and infant mortality as a proxy for health outcomes. The estimation results inform that during the period covered by the study, in the considered income, group health aid is effective in reducing infant mortality in the long run. More specifically, doubling health aid saves the lives of more than 44 per 1000 live births.

WHO recommends moving away from direct out-of-pocket payments that push individuals into the vicious cycle of poverty towards using prepaid mechanisms to raise funds. In this line of thought, donor funding should increasingly be injected in a way that reduces out-of-pocket health expenditures.[17] Besides the funds that come from donors, private foreign direct investment and workers' remittances have to get enough attention in making them a complementary source of external health financing. On the recipient side, they need to find ways of promoting domestic factors that have a favorable impact on the health sector as they cannot rely on external resources persistently in improving the health status of their population. Besides this, reduction of adolescent fertility, improvement of income growth, upgrading of human capital accumulation, and improvement of governance quality that may include, but is not necessarily limited to, rule of law, control of corruption, political stability, government effectiveness, regulatory quality voice, and accountability could be potential areas of focus.

From the findings of this paper, it can be concluded that health aid could be used as an interim tool with which the broader health status gap currently observed between high-income and low-income groups could be eliminated and hence the target of universal health coverage is met.

References

1. Gomanee K, Girma S, Morrissey O. Aid, public spending and human welfare: evidence from quantile regressions. J Int Dev 2005;17:299-309.
2. Williamson CR. Foreign aid and human development, the impact of foreign aid to the health sector. Southern Economic Journal 2008;75:188-207.
3. World Bank. World development indicators. Available from: https://databank.worldbank.org/source/world-development-indicators. Accessed: 5 March 2018.
4. Easterly W. The white man's burden: why the west's efforts to aid the rest have done so much ill and so little: why the west's efforts to aid the rest have done so much ill and so little good. London, UK: Penguin Books; 2006.
5. Mishra P, Newhouse D. Does health aid matter? J Health Econ 2009;28:855-72.
6. Chauvet L, Gubert F, Mesplé-Somps S. Aid, remittances, medical brain drain and child mortality. Evidence using inter and intra-country data. J Dev Stud 2013;49:801-18.
7. Wilson S. Chasing success: health sector aid and mortality. World Development 2011;39:2032-43.
8. Pettersson J. Child mortality: is aid fungibility in pro-poor expenditure sectors decisive? Rev World Econ 2007;143:673-93.
9. Friedman M. Foreign economic aid: means and objectives. Standford University: Hoover Institution on War, Revolution, and Peace; 1995.
10. Subramanian A, Rajan R. What undermines aid's impact on growth?. IMF Working Papers. 2005;126. Available from: https://www.imf.org/en/Publications/WP/Issues/2016/12/31/What-Undermines-Aids-Impact-on-Growth-18380.
11. Feenstra RC, Inklaar R, Timmer MP. The next generation of the penn world table. Am Econ Rev 2015;105:3150-82.
12. World Bank. Worldwide governance indicators. Available from: http://data.worldbank.org/data-catalog/worldwide-governance-indicators. Accessed: 5 March 2018.
13. Grossman M. On the concept of health capital and the demand for health. J Polit Econ 1972;80:223-55.
14. Mosley W, Chen L. An analytical framework for the study of child survival in developing countries. Bull World Health Organ 1984;81:140-5.
15. Berman P, Kendall C, Bhattacharyya K. The household production of health: integrating social science perspectives on micro-level health determinants. Soc Sci Med 1994;38:205-15.
16. Negeri G, Haile Mariam D. Effect of health development assistance on health status in sub-Saharan Africa. Risk Management Healthcare Policy 2016;9:33.
17. WHO. Global health expenditure atlas; 2014. Available from: https://apps.who.int/nha/database.
18. Pritchett L, Summers L. Wealthier is healthier. JHR 1996;31:841-68.
19. Easterlin RA. Causes and consequences of mortality declines in less developed countries during the 20th century, in population and economic change in developing countries. 1980, Chicago (IL), USA: University of Chicago Press; 1980.
20. Wang L. Determinants of child mortality in LDCs empirical findings from demographic and health surveys. Health Policy 2003;65:277-99.
21. Cutler D, Deaton A, Lleras-Muney A. The determinants of mortality. J Econ Perspect 2006;20:97-120.
22. Fogel RW. Economic growth, population theory and physiology: the bearing of long term processes on the making of economic policy. Am Econ Rev 1994;84:369-95.
23. Link B, Phelan J. Social conditions as fundamental causes of disease. J Health Soc Behav 1995;35:80-94.