The short-run effects of health aid in low-income countries: evidence from panel data analysis

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Abstract

The effectiveness of health-targeted aid in improving health outcomes in developing countries remains a subject of debate. This paper investigates the short-run impact of health aid on health status in low-income countries globally. A panel dataset was constructed from 34 low-income countries spanning 2000 to 2017, with Infant Mortality Rate (IMR) serving as the primary proxy for health status. To estimate the short-run effect, First Difference GMM and System GMM estimators were employed, with a preference for System GMM due to its robustness against weak instrument problems in dynamic panel data models. The model incorporated log transformations for Health Development Aid (HDA), GDP per capita, and cereal yield, while exponential transformations were applied to human capital and governance indices, alongside adolescent fertility rate and elderly dependency rate. The System GMM estimation revealed a statistically significant and beneficial short-run effect of health aid on health status. Specifically, a doubling of health aid is associated with a reduction of 2 infant deaths per 1,000 live births. Other significant findings include the positive impact of GDP per capita, human capital, and governance, and the negative impact of adolescent fertility rate and elderly dependency rate on infant mortality. The Sargan test confirmed the validity of the over-identifying restrictions (p=0.2279), and the Arellano-Bond test for AR(2) indicated no serial correlation in the idiosyncratic errors (p=0.158). The findings strongly suggest that health aid serves as a potent instrument for narrowing the health status gap between high and low-income countries, thereby contributing to the achievement of Universal Health Coverage. However, recipient countries should also prioritize fostering domestic factors that positively influence the health sector to reduce persistent reliance on external resources.

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Introduction

Low-income countries grapple with a dual burden of disease: the persistent challenge of communicable diseases and a rapidly escalating prevalence of Non-Communicable Diseases (NCDs), such as common diseases found in all income groups, including heart disease, stroke, cancer, diabetes, and chronic lung diseases.[1] This epidemiological complexity is exacerbated by healthcare financing mechanisms heavily reliant on Out-Of-Pocket (OOP) payments.[2] Such payments impose significant financial hardship, pushing approximately 100 million individuals into poverty and subjecting 150 million to catastrophic health expenditures annually, perpetuating a vicious cycle of poverty and ill health.[3] In this context, a critical question emerges: can avoidable infant mortality be averted in the foreseeable future, and what policy instruments can most efficiently achieve this?

Globally, Universal Health Coverage (UHC) has been recognized as a cornerstone of sustainable development. The United Nations General Assembly enshrined UHC within the Sustainable Development Goals (SDGs) as Goal 3.8, aiming to "Achieve universal health coverage, including financial risk protection, access to quality essential health care services and access to safe, effective, quality, and affordable essential medicines and vaccines for all" by 2030. A key pathway to achieving this goal involves increased health aid, particularly that channeled through public spending on health, which is expected to enhance financial protection. In low-income countries, health aid currently accounts for an average of 30% of health expenditure and has been increasing in absolute terms over time.[2] While this raises numerous questions, this paper specifically investigates the effect of health aid in low-income countries on the achievement of the aforementioned UHC goal, particularly regarding infant mortality.

The existing literature on the impact of health-specific aid on recipient countries' health status presents a notable divergence, contrasting with the more extensively studied effects of aggregate aid on national growth. This section synthesizes the arguments for and against the effectiveness of health aid, highlighting key findings and the methodological nuances that contribute to the ongoing debate.

A significant body of research suggests that health-targeted aid demonstrably improves health outcomes in low-income countries by augmenting resource availability for health service delivery. Proponents argue that health is a sector where aid's impact is particularly discernible due to the direct link between health programs and desired outcomes. For instance, Levine and Kinder[3] posits that health programs like communicable disease prevention and control (through safe water, sanitation, immunizations, and improved nutrition) are directly linked to positive health outcomes. Easterly,[4] similarly, contends that with appropriate accountability, external aid can significantly decrease infant mortality.

Empirical support for this perspective is robust. Mishra and Newhouse[5] provide strong evidence using donor commitment data from 118 countries (1973-2004), finding that a 1% increase in per capita health aid is associated with a 2% improvement in infant mortality rate. Likewise, Chauvet *et al.*[6] utilizing a panel data of 109 developing countries (1987-2004), reported significant effects of health aid on health improvement. Similar findings are reported by Ebeke and Drabo,[7] Mishra and Newhouse,[8] and Chauvet and Guillaumont,[9] all suggesting a substantial positive impact of health aid on health outcomes in the developing world. These studies often emphasize the heightened effectiveness of health-targeted aid in low-income settings.

Furthermore, some scholars argue that the impact of aggregate aid on health status is also evident in low-income countries. Gormanee *et al.*[10] assert that aggregate aid bridges resource gaps, leading to remarkable changes through direct public health projects such as communicable disease prevention and control, improved water supplies and sanitation, malaria control, and immunization programs. This positive effect of aggregate aid on health status has been corroborated by other studies.[11,12]

Conversely, another group of scholars argues that there is insufficient evidence to conclusively claim that health aid consistently improves health outcomes in recipient countries. This skepticism often stems from concerns about aid fungibility and potential negative externalities.

For example, Williamson,[13] examining the impact of foreign aid commitments on the health sector across 208 developed and developing countries (1973-2004), found an insignificant effect. Similarly, Wilson's[14] empirical analysis of a panel data from 96 high-mortality countries (1975-2005) indicated no significant effect of health aid on recipient countries' infant mortality rate.

The primary argument for the ineffectiveness of health-targeted aid centers on the concept of "fungibility," where recipient countries may divert aid resources to non-targeted expenditures instead of channeling them into the health sector as intended. Pettersson[15] highlights that such non-targeted expenditures, sourced from all development assistance, can be as high as 70%. Beyond fungibility, critics also argue that aid can negatively impact the competitiveness of aid-receiving countries, foster dependency, disincentivize the adoption of sound domestic policies, and exacerbate corruption.[16,17]

The contrasting findings presented above create a significant dilemma for policymakers: should health aid be considered a complementary tool for achieving UHC, or should the focus be exclusively shifted to domestic factors? One root of this persistent controversy lies in methodological deficiencies within existing empirical studies. Specifically, issues such as misspecification problems, encompassing both weak functional forms and omitted variables, are prevalent in health estimating equations. The literature also rarely emphasizes separate short-run health aid effects, despite the fact that the size and significance of estimated marginal effects are strongly dependent on such time spans.

Therefore, this research endeavors to address these critical gaps by employing a better-specified estimation equation that is consistent with a sound theoretical framework grounded in utility-maximizing human behavior.[18-21] This will involve a rigorous examination of functional forms and the inclusion of relevant control variables to mitigate omitted variable bias.

Investigating the short-run effects of health aid on health outcomes in low-income countries, a dimension often overlooked in existing analyses, which predominantly focus on long-term impacts. This will provide more nuanced insights into the immediate responsiveness of health indicators to aid inflows. By addressing these methodological shortcomings, this paper aims to provide a more robust and reliable assessment of the effect of health aid on achieving UHC goals in low-income countries, offering clearer guidance for policy formulation.

Materials and Methods

Framework of the study

Grossman's health production model specifies a vector of inputs, where the variables of the vector include: nutrition, education, consumption of public goods, income, initial individual endowments like genetic makeup, time devoted to health-related procedures, and community endowments such as the environment.[20] Following this approach, let the implicit function that relates these factors $W_1(t), W_2(t), \ldots W_k(t), \ldots W_n(t)$ to health outcome $H(t)$ as

$$\mathrm{H}(t) = f\left(W_1(t), W_2(t), \ldots W_k(t), \ldots W_n(t)\right) \quad [1]$$

where $W_j(t)$ the input $j>t$ variables are unobserved or not measured, H(t) represents the health outcome at time t. In constructing health capital model, Grossman suggested the application of utility maximization constrained with resources which may require application of optimal control analysis.[20] 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. The common and very important solution from such utility maximization problem is the constancy of marginal effects of the input variable. That is after taking total derivative of equation [1]

$$\mathrm{dH}(t) = f_1 dW_1(t) + f_2 dW_2(t) + \ldots, f_k dW_k(t), \ldots f_n dW_n(t) \quad [2]$$

The marginal effects f_j are constants. Based on the constancy of marginal effects, one can integrate equation [2] to get

$$\mathrm{H}(t)^* = f_1 W_1(t) + f_2 W_2(t) + \ldots, f_k W_k(t), \ldots f_n W_n(t) + A \quad [3]$$

Where A is some constant. In fact, in empirical analysis, to maintain the result of optimal control analysis, *i.e.* constancy of the marginal effects, the input variables have to undergo some mathematical transformations, like log transformation, exponential transformation, depending on the measure of the input variable, otherwise the estimation equation will face a misspecification problem arising from the wrong functional form. In the specification of the health estimating equation, besides the wrong functional form, one may face the omitted variable problem, the case where a part of the input variables is unobservable, or the 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, here it is assumed that the omitted variables follow autoregressive of order two, which can be expressed as a Second Order Difference Equation whose particular solution and complementary function together form a function of time, *i.e.,* for omitted variable

The estimated Auto regressive of order two for $W_j(t)$ can be written as

$$W_j(t)=a_j+b_{1j}W_j(t-1)+b_{2j}W_j(t-2)$$

whose complementary function and particular solution will be

$$X_j(t)=X_{cj}(t)+X_{pj}(t)$$

where complementary function

$$W_{cj}(t)=A_1r_1^t+A_2r_2^t \text{ where } A_1 \text{ and } A_2 \text{ are arbitrary constants } r_1 \text{ and } r_2 \text{ are characteristic roots}$$

$$\text{and particular solution } W_{pj}(t)=\frac{a_j}{1-b_{1j}-b_{2j}} \quad \text{for } b_{1j}+b_{2j}\neq 1;\ W_{pj}(t)=\frac{a_j t}{2-b_1} \quad \text{for } b_{1j}\neq 2;$$

$$X_{pj}(t)=\frac{a_j t^2}{2} \quad \text{for } b_{1j}=2 \text{ and } b_{1j}+b_{2j}=1$$

$$W_j(t),\ j>k$$

we have

$$W_j(t)=f(t)$$

Taking the total derivative of the variable and divide through by $W_j(t)$ to get

$$\frac{dW_j(t)}{W_j(t)}=\eta_j\frac{dt}{t} \qquad \text{where } \eta_j\equiv\frac{f'(t)t}{W_j(t)} \quad [4]$$

is the elasticity of $W_j(t)$ with respect to time. Assuming this elasticity to be constant (this assumption is derived from the belief that the growth of the input variables declines over time so that in the long run the variables exhibit stability. This stability, together with the constancy of marginal effects, would imply stability of the portion of health status generated by these variables) and integrating both sides of equation [4], one gets

$$\ln W_j(t)=\eta_j\ln t \quad [5]$$

Substituting equation [5] in equation [3] one gets the long run health function as

$$\mathrm{H}(t)^*=\sum_{j=1}^{\kappa}\alpha_j\mathrm{W}(t)_j+\gamma\ln t+\varphi \qquad \text{where} \quad \gamma\equiv\sum_{j=k+1}^{n}\alpha_j\eta_j \quad \text{and} \quad \alpha_j\equiv f_j \quad [6]$$

Essentially, equation [6] is a long-run health equation since it is grounded on the constancy of marginal effects of the input variables, which holds true in the long run.

To drive the short-run health function from equation [6], the Partial Adjustment Model (PAM) is adopted. Intuitively, it is clear that the possibility that the coefficients in the health status estimating equation [6] could be related to the level of change in health status before the input variables change. That is, keeping all other things equal, a one percent change in an explanatory variable in a population with a lower level of health status could have a higher effect than when a similar change takes place in another population with a higher level of health status. When the interest is to know the short-run effect, this phenomenon demands us to control for the previous level of health status. The PAM specifies the observed level of a given dependent variable as a weighted average of its level that existed in the previous time period and its equilibrium level at the present time, as

$$\mathrm{H}(t)=(1-\lambda)\mathrm{H}(t)+\lambda\mathrm{H}(t)^* \quad [7]$$

where λ such that $0<\lambda\leq 1$ is known as coefficient of adjustment. The PAM postulates that the actual change in the health status indicator in any given time period t, is some fraction λ the expected change for that period. If $\lambda=1$ it means the actual health status is equal to its long-run level. That is, the observed health status adjusts to its long-run level instantaneously. However, if $\lambda=0$ it means that the health status is not changing at all. Substituting equation [6] in equation [7], we get

$$\mathrm{H}(t)=(1-\lambda)\mathrm{H}(t)+\sum_{j=1}^{k}\lambda\alpha_j\mathrm{W}(t)_j+\lambda\gamma\ln t+\lambda\varphi \quad [8]$$

Equation [8] represents the short run health function since the past effects of the input variables are excluded from the coefficients. Negeri and Haile[22] showed that consideration of lagged health status level in the equation is comparable with including all past lagged effects of the input variables under some mathematical restrictions or as a distributed lag of all input variables. Notice that if the system is already on its equilibrium path, the regression assigns one to λ, which makes the transition path dynamics have no effect in determining the level of $H(t)$. But if the system is in transition to equilibrium fully, the regression assigns zero to λ, which makes the equilibrium path dynamics have no effect in determining the level of $H(t)$. In actual cases, λ is expected to lie between these two extremes and hence the observed level of $H(t)$ will be the weighted average of both dynamics as postulated in PAM. Besides this, the specification, while retaining most of the useful properties of the usual dynamic log-linear specification, avoids the implausible prediction that the latter specification makes in the cases of extreme levels of health status. Moreover, it takes care of the problems of unknown variables instead of just assuming their absence, which makes the coefficient estimates biased. Furthermore, it accommodates both transition path dynamics and equilibrium path dynamics together. That is, once we estimate the short-run function properly, it is possible to drive the estimate of the long-run health function by dividing the coefficients of the input variables by the estimate of the coefficient of the lagged health indicator.

Variables, definitions and data sources

To estimate the short-run effect of health aid on health status, eight variables were chosen following past studies.[5,22] These are; 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 was considered a dependent variable of the current study. Though life expectancy is another alternative proxy variable for health status, IMR was preferred in this study; first, it is more sensitive to economic changes of the population than life expectancy, implying that it is a better measure of improvement in low-income groups of society.[5,28] seconds, infant mortality explains substantial improvements in life expectancy itself in poor countries. Third, past studies indicate that in developing countries, improvement in infant mortality shows better access to medical care, safe water and better sanitation, improved maternal and infant nutrition, literacy status especially that of female and increased per capita GDP and economic equality.[22] Fourth, data on infant mortality are available for a large set of countries and are more reliable than life expectancy. On these grounds this study considers IMR as a good proxy for health status.[13]

According to World Bank (WB), IMR is defined as the number of infants dying before reaching one year of age, per 1,000 live births in a given year and the data was taken from WB.[29]

HDA, the main variable of interest here, is defined as an external source of health expenditure in a recipient country, measured in constant 2010 USD. External sources consist of direct foreign transfers and foreign transfers distributed by the government, encompassing all financial inflows into the national health system from outside the country. External sources either flow through the government scheme or are channeled through non-governmental organizations or other schemes, data for this variable was taken from WB.[29]

GDPP was also taken from the World Bank[29,] and the source defined it as "gross domestic product, in constant 2010 USD dollars, divided by midyear population". It is obvious that a higher level of income favors consumption of quality goods and services, better nutrition, housing, and the ability to pay for medical care services. Therefore, GDPP is considered to be an explanatory variable of the health status of the population under study.

HC index was taken from Feenstra *et al.* The source indicated that the HC was based on years of schooling and returns to education.[30]

AFERT data was taken from the World Bank World Development indicators[29] and it is defined as the number of births per 1,000 women aged between 15 and 19 years. 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. 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. EDEP data were taken from the World Bank[29] and the Bank defined the variable as the ratio of elderly dependents—people older than 64—to the working-age population—those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population.

INST is a composite index of governance and was computed from six dimensions of governance using Principal Component Analysis, a statistical technique used for data reduction, and based on the six aggregate dimensions of governance- Rule of Law (rula), Control of Corruption (ccorr), Political Stability (psav), Government Effectiveness (goeff), Regulatory Quality (requ), Voice and Accountability (voac). The indices for the dimension were taken from World Bank (31). The dimension indices range from -2.5 (the lowest performance) to 2.5 (the higher performance) Composite Index was computed as

$$inst = 0.207845 rula + 0.169909 ccorr + 0.120478\, psav + 0.181561 goeff + 0.181732 requ + 0.138458\, voac$$

where the coefficients of each variable were obtained from the square of the principal component that adds up to unity.

Governance was considered because its quality affects health systems by shaping resource allocation, policy implementation, and service delivery. Effective governance ensures transparent funding, equitable healthcare access, and accountability, minimizing corruption and inefficiencies. Political stability further safeguards health infrastructure from disruptions due to conflict or instability.

Yield was taken from the World Bank, and the source defined it as kilograms per hectare, but 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. The study used cross-sectional and annual time series data from 2000 to 2017 for 34 low-income countries. Agricultural productivity, measured by cereal yield, directly impacts food security and nutrition. Higher yields increase food availability, improve dietary quality, and reduce malnutrition-related health risks. Economic benefits of strong agricultural output also enhance household income, enabling better access to healthcare and improved living conditions.[29]

Estimation methods

To estimate the short-run health function given in equation [8] econometric methods were applied to panel data. The method considers multiple cross-section measures over multiple time series data together to get more reliable parameter estimates than what cross-section or time series approach alone cannot address. Following the specification given in 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 relation 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 to the function without transformation.

Under the assumption of equation [8], the econometric specification that relates health status to a vector of explanatory variables is given as

$$H(i,t) = \beta_0 H(i,t-1) + \beta_1 \ln \mathrm{W}_1(i,t) + \beta_2 \ln W_2(i,t) + \beta_3 \ln W_3(i,t) + \beta_4 \exp W_4(i,t)$$
$$\beta_5\, exp W_5 + \beta_6 W_6(i,t) + \beta_7 W_7(i,t) + \beta_8 \ln W_8(i,t) + \mu_0 + \mu_1(i) + \mu_2(t) + \varepsilon(i,t)$$

where $W(i,t)$, is Infant mortality rate, $W(i,t\text{-}1)$ one period lagged infant mortality, $\ln W(i,t)$ is log-health development assistance for health, $\ln W_2(i,t)$ is log-GDP per capita, $\ln W_3(i,t)$ is log yield $\exp W_4(i,t)$ is exponential of human capital index, $\exp W_5(i,t)$ is exponential of governance index, $W_6(i,t)$ is adolescent fertility rate, $W_7(i,t)$ 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 $\text{var}[e(i,t)]=(s_e)^2$; m_0 is constant term; and $m_2(t)$ are country and time specific effects respectively.

To estimate equation [9] the first difference Generalized Method of Moments (GMM) developed by Arellano and Bond[23] is suitable. Furthermore, based on the nature of the error terms, system GMM developed by Blundell and Bond depending is recommended.[24] First-Difference GMM (Arellano & Bond) removes individual-specific effects and addresses endogeneity by using lagged variables as instruments. System GMM (Blundell & Bond) enhances efficiency by combining level and differenced equations, reducing bias and strengthening weak instruments, making it more ideal for persistent health variables.

Therefore, in the cases of a weak instrument problem in a dynamic panel data model like equation [9], the first differenced GMM estimator has been found to have poor precision.[25] Therefore, the system GMM estimator is recommended to provide a more accurate estimate in the current IMR equation (5, 8, 26, and 27). However, for comparison purposes, estimation results from both estimators will be considered in the current study. At the same time, the conventionally derived variance estimator for GMM estimation is employed for the standard error, the Variance-Covariance Estimator using GMM.

To deal with omitted variables, it is assumed that the omitted variables follow an autoregressive process of order one, which is equivalent to assuming that they follow first-order differential 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 both short-run and long-run health equations.

Results

Table 1 reports that during the study period 2000-2017, in low-income countries, the estimated average infant mortality per 1000 live births was 65. According to the dataset, it was as high as 114 in Sierra Leone and 103 in the Central African Republic per 1000 live births. Good health performance was observed in Syria (16.0) and the Democratic People's Republic of Korea (26.0). Besides this, the table indicates that during the indicated period, the average per capita HDA and GDP 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 per capita were Niger (2.70 USD), Senegal (2.98 USD), Togo (2.69 USD), Yemen, Rep. (2.00 USD), whereas Zimbabwe (19.41 USD), Tanzania (23.0 USD), and Haiti (25.30 USD) were receiving relatively higher amounts. Countries with low per capita GDP were Burundi (227.85 USD) and the Congo, the Democratic Republic of the Congo (334.80USD), whereas countries with relatively higher per capita GDP were Yemen, the Republic (1106.76 USD) and Senegal (983.78 USD).

Besides this, Figure 1 suggests that the IMR-HDA forms a downward-sloping curve, or there is a negative semi-log linear relation between the two variables, indicating that an increase in HDA could lead to a decline in IMR. On the other hand, Figure 2, which plots IMR against lnHDA, indicates that the curve is more or less straight at least for lnHDA>0 or HDA>1.0 USD, and downward sloping to the right. The linearity of the curve in turn implies that the sought constancy of the marginal effect of the lnHDA is confirmed, *i.e.*, the log transformation of the HDA is appropriate in estimating the health function. 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.

Moreover, Table 1 informs that the average human capital index was 1.60. The least index was observed in Burkina Faso (1.14), whereas the highest index was observed in Tajikistan (3.14). The table also reports that for the income group, the average adolescent fertility was 107.30 births per 1,000 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, the table 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 high-

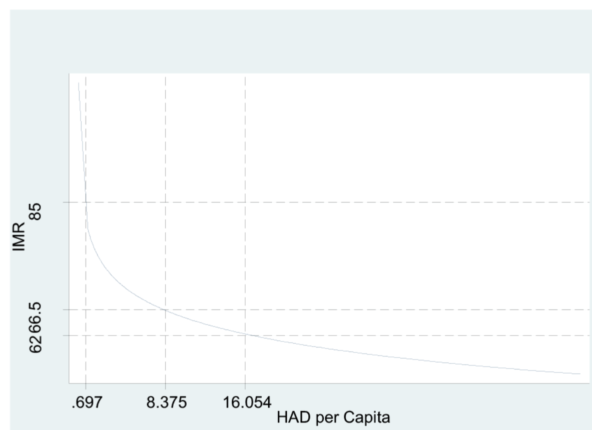

Figure 1. Plot of IMR *vs* HDA per capita. Fractional Polynomial Fit [2000-2017].

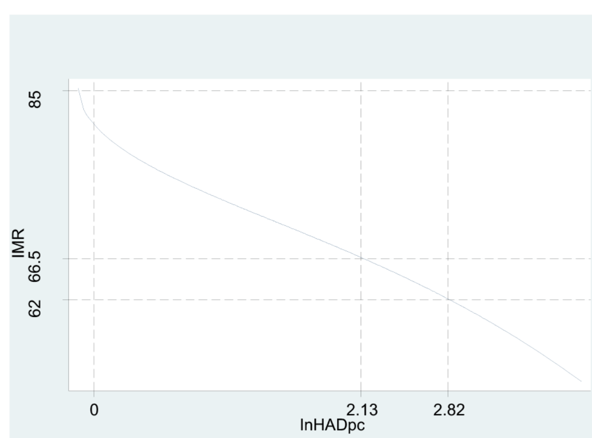

Figure 2. Plot of IMR *vs* lnHDApc. Fractional Polynimial Fit [2000-2017].

est in the Democratic People's Republic of Korea (11.96%).

Furthermore, Table 1 shows that during the covered years of study, 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% Conf. Interval] of (-.0163, -.0013) *i.e.* institutional qualities are worsening substantially rather than improving during the covered period of study.

Finally, the table reports that in the indicated time period the average cereal yield was 13.59 quintal 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).

Considering an estimate of the effect of health-targeted aid on health status measure (IMR), whilst first difference GMM estimator result is shown for comparison purposes only as indicated on Table 2, the system GMM estimator was considered for a detail description of the results for the reason argued earlier.[5,8,26,27]

Consequently, like all GMM estimators, system GMM can produce consistent estimates only if the moment conditions used are valid. To test the validity of the over-identified restriction, the Sargan test is employed for it, unlike the Hansen test, which can be weakened by many instruments, but is not weakened by many instruments. In fact, Arellano and Bond show that the one-step Sargan test over-rejects in the presence of heteroskedasticity.[23] In the case of the current study, the null hypothesis that the overidentifying restrictions are valid is not rejected. In its second half, Table 2 reports that the Sargan test of over-identifying restrictions accepts the null hypothesis that states the over-identifying restrictions are valid, χ^2 *(102)=112.388, P=0.2279.* Accepting this null hypothesis implies that the current study model or instruments need not be reconsidered. Hence, the test confirms the hypothesis that the instrumental variables should not be correlated with the residuals, and hence they are acceptable. Moreover, the table informs that for these countries the Wald test rejects the null hypothesis that states all the coefficients except the constant term are zero in both estimators.

The table also reports that the coefficient of the lagged IMR is 0.5458 and is statistically significant, z=11.27, P=0.0000, confirming the need for controlling for past effects of the independent variables when the interest is in getting their short-term effects. In its robust version, the Arellano-Bond test for AR(2) in the first difference accepts the null hypothesis of no serial correlation in the idiosyncratic errors, which implies the instrumental variables are acceptable, z =1.411, P=0.1580. Besides, the table also informs that for the measured variables, the Wald test rejects the null hypothesis that states all the coefficients except the constant term are zero, Wald χ^2 (9)=2890.76, P=0.0000 (Table 2). Moreover, as shown in Table 2, the coefficient estimate of log-HDA was -1.9818, and this was statistically significant (P=0.0000). Similarly, a statistically significant estimate was observed for the log-GDPP coefficient, -9.6007 (P=0.0000). In the same way, the estimator gives -as a coefficient of expINST, 7.8092 (P=0.0160). The estimator also gives -0.8945 as a coefficient estimate of expHC, which is statistically significant at 10% level of significance (P=0.051).

Sometimes the short run relative importance of the selected input variables together with their flexibility in policy decisions may be point of interest. Table 3 reports the shares of effects of the chosen variables' effect in declining IMR from the annual average. In calculating the shares of the effects of the input variables, the previous level of IMR is unchanging for it has already been realized. Hence what determine the change in IMR from previous time up to the present time are changes in the input variables. Accordingly, during the covered period of study, in the sample countries, while the annual average change in IMR from the data was -0.9845 infants per 1000 live births the predicted change from the input variables using the chosen estimator was -1.1133 infants per 1000 live births, indicating the estimator predicted very close to what was observed in the short run (Table 3).

The table informs that a decline in adolescent fertility, an increase in health aid, and an increase in per capita income play a major role in reducing infant mortality. In explicit terms, in the observed average annual IMR decline, 13.29 percent (-1.9818x0.0747)/-0.9845) is due to an increase in health aid, 12.54 percent (-9.600x0.0145)/-0.9845) is due to an increase in per capita income and 15.68 percent (0.0921x1.8968)/-0.9845) is due to a decline in adolescent fertility. If left unchecked governance quality and yield were found to play an adverse role in the efforts made to reduce IMR (Table 3). Moreover, from Table 3, it can be understood that 46% of the decline in IMR was due to the selected input variables.

Discussion

In this study, the short-run health function analysis provides important insights for policymakers working to enhance health outcomes in low-income countries, particularly regarding health

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

Variable	Obs	Mean	Std. Dev.	Min	Max
IMR	612	65.25	24.16	13.80	142.00
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

HDA, Health Development 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.

aid allocation and governance reforms. The significant negative coefficient of log-Health Development Assistance (HDA) (-1.9818, p=0.000) underscores the strong positive impact of health aid on reducing Infant Mortality Rate (IMR). Specifically, doubling per capita health aid is associated with saving approximately two infant lives per 1,000 live births. This finding aligns with previous research by Mishra and Newhouse[5] and Negeri and Haile Mariam,[22] reinforcing the argument that properly allocated health aid significantly improves population health in low-income settings. The compelling relationship between health aid and IMR highlights the need for optimizing aid allocation to maximize its effectiveness. Policymakers should prioritize investments in interventions proven to reduce infant mortality, such as maternal and child health programs, immunization campaigns, and improved access to essential healthcare services.[3,2] However, direct aid is most impactful when it strengthens broader health systems. Investments in healthcare infrastructure, professional training, and efficient medical supply chains are necessary to bolster long-term health outcomes.[13] Additionally, aligning health aid with domestic financing mechanisms, such as taxes or health insurance, can mitigate out-of-pocket expenditures, a key factor contributing to financial hardship among vulnerable households.[1] Thoughtfully integrating aid into sustainable financing structures ensures that it complements national efforts rather than replaces them.

Beyond the role of health aid, our findings highlight the significant influence of broader economic and social determinants. The strong negative coefficient of log-GDP per capita (-9.6007, p=0.0000) suggests that economic growth plays a pivotal role in improving population health. This aligns with Pritchett and Summers,[34] who argue that higher income levels facilitate public health improvements through infrastructure expansion—such as improved access to safe water and sanitation—and enhanced

Table 2. Estimate of IMR estimating equation, 2000-2017, one-step GMM results.

Variable	First difference GMM					System GMM				
IMR	Coef.	Std. Err.	z	P value	CI	Coef.	Std. Err.	z	P value	CI
L.IMR	0.6030	0.0541	11.1400	0.0000	(0.50, 0.71)	0.5372	0.0476	11.2700	0.0000	(0.44, 0.63)
LnHDA	-1.6653	0.6891	-2.4200	0.0160	(-3.02, -0.31)	-1.9818	0.4919	-4.0300	0.0000	(-2.95, -1.02)
lnGDPP	-8.8893	3.1900	-2.7900	0.0050	(-15.14, -2.64)	-9.6007	2.2734	-4.2200	0.0000	(-14.06, -5.14)
LnYIELD	0.3882	1.2592	0.3100	0.7580	(-2.08, 2.86)	0.5115	1.1601	0.4400	0.6590	(-1.76, 2.79)
ExpHC	-0.8519	0.7793	-1.0900	0.2740	(-2.38, 0.68)	-0.8945	0.4589	-1.9500	0.0510	(-1.79, 0.00)
ExpINST	-4.7728	4.1800	-1.1400	0.2540	(-12.97, 3.42)	-7.8092	3.2433	-2.4100	0.0160	(-14.17, -1.45)
AFERT	0.0485	0.0617	0.7900	0.4320	(-0.07, 0.17)	0.0921	0.0373	2.4700	0.0130	(0.02, 0.17)
EDEP	1.5025	1.1151	1.3500	0.1780	(-0.68, 3.69)	1.9293	0.9289	2.0800	0.0380	(0.11, 3.75)
LnTIME	-3.5430	1.2644	-2.8000	0.0050	(-6.02, -1.06)	-3.5444	1.0611	-3.3400	0.0010	(-5.62, -1.46)
_cons	82.6748	26.8142	3.0800	0.0020	(30.12,135.23)	86.4150	19.7937	4.3700	0.0000	(47.51, 125.32)
Sargan test of overidentifying restrictions						*Sargan test of over identifying restrictions*				
H0: overidentifying restrictions are valid						*H0: over identifying restrictions are valid*				
χ^2 (89)=86.9263 P=0.5424						*χ^2 (102)=112.388 P=0.2279*				
Arellano-Bond test for AR(1) in first differences: z=-1.2039 P=0.2286						*Arellano-Bond test for AR(1) in first differences: z=-1.247 P=0.2125*				
Arellano-Bond test for AR(2) in first differences: z =1.2937 P=0.1958						*Arellano-Bond test for AR(2) in first differences: z =1.411 P=0.158*				
Wald χ^2 (9)=5121.08 P =0.0000						*Wald χ^2 (9)=2890.76 P=0.0000*				
Number of Instruments 99, Number of Countries 24, Number of Observations 265						*Number of Instruments 112, Number of Countries 24, Number of Observations 289*				

HDA, Health Development 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.

Table 3. Estimates of the relative importance of the input variables.

Variable	Coef.	Std. Err.	z	P>|z|	Share in%
_b[lnHDA]*0.0746858	-0.1480	0.0367	-4.0300	0.0000	13.29
_b[lnGDPP]*0.0145404	-0.1396	0.0331	-4.2200	0.0000	12.54
_b[lnYIELD]*0.0146193	0.0075	0.0170	0.4400	0.6590	-0.67
_b[expHC]*0.0784127	-0.0701	0.0360	-1.9500	0.0510	6.30
_b[expINST]*-0.0027128	0.0212	0.0088	2.4100	0.0160	-1.90
_b[AFERT]*-1.8968	-0.1746	0.0707	-2.4700	0.0130	15.68
_b[EDEP]*-0.0036	-0.0069	0.0033	-2.0800	0.0380	0.62
_b[lnTIME]*0.1700219	-0.6026	0.1804	-3.3400	0.0010	54.13
Sum	-1.1133	0.1654	-6.7300	0.0000	100.00
Mean[d.imr]	-0.9845	0.0404	-24.3600	0.0000	

healthcare accessibility. Similarly, the statistically significant negative coefficient of human capital (-0.8945, p=0.051) reinforces the view that human capital accumulation serves as a vital policy instrument.[19,20] Individuals with higher levels of education and skills are better equipped to adopt health-improving technologies and behaviors, while families with stronger human capital can provide more effective primary healthcare.

Although cereal yield was not statistically significant in the short run, extensive literature emphasizes its long-term role in reducing mortality through improved nutrition. Scholars such as Cutler *et al.*[11] and Fogel[37] underscore the essential link between sustained agricultural productivity and health outcomes, supporting the idea that food security remains a key long-term policy consideration in reducing mortality.

One of the most striking findings of our analysis is the pronounced role of governance quality in shaping health aid effectiveness. Institutional quality (expINST) exhibits a significant negative coefficient (-7.8092, p=0.0160), demonstrating that improvements in governance can yield health outcomes comparable to doubling health aid. Raising the governance index to 0.5816 from its current negative and declining average could save two additional infants per 1,000 live births—underscoring the critical importance of robust governance in maximizing the effectiveness of health aid.[31]

To enhance aid effectiveness, policymakers must implement targeted governance reforms. The declining governance index signals an urgent need to combat corruption and improve transparency through rigorous anti-corruption measures, enhanced financial accountability, and robust oversight mechanisms.[4,17] Strengthening rule of law and institutional frameworks is equally crucial, ensuring that health aid is disbursed efficiently and reaches its intended beneficiaries. Public financial management systems must be reinforced, healthcare regulatory structures improved, and judicial independence safeguarded.[9] Participatory governance also plays a crucial role in optimizing aid impact. By engaging local communities and civil society in health policy planning and implementation, governments can foster ownership, ensure resource allocation aligns with local needs, and strengthen accountability in aid delivery.[14,15]

Additionally, capacity building within government agencies is essential to effectively absorb, manage, and monitor health aid. Policymakers should invest in training programs focused on project management, financial oversight, and data-driven decision-making to enhance institutional efficiency and responsiveness.[24,26] Without these governance improvements, aid effectiveness will remain constrained, reducing its long-term impact on population health. While our selected input variables explain 46% of the decline in IMR—leaving room for further policy exploration—the robust effects of health aid, income, human capital, and institutional quality provide clear policy pathways. Prioritizing efficient health aid allocation alongside meaningful governance reforms is not merely a best practice; it is fundamental to maximizing aid effectiveness and ultimately saving lives in low-income countries.

Recommendations

Based on the findings this study, the following recommendations were given for optimizing health financing in low-income countries: i) aligning with WHO guidance, donor funds should increasingly focus on reducing out-of-pocket health expenditures to prevent poverty; ii) low-income countries health policymakers, decision-makers, and all healthcare financing stakeholders should consider private foreign direct investment and workers' remittances as essential complementary sources of health funding; iii) to enhance the effectiveness of aid in health sector, low-income countries should implement strong governance frameworks that ensure transparency, accountability, and efficient resource allocation; iv) health aid recipient low income countries and their policymakers must prioritize the development of alternative domestic mechanisms to pool resources, safeguarding populations from catastrophic health costs and reducing unsustainable dependence on external aid.

References

1. Goryakin Y, Suhrcke M. The prevalence and determinants of catastrophic health expenditures attributable to non-communicable diseases in low- and middle-income countries: a methodological commentary. Int J Equity Health 2014;13:107.
2. WHO. New perspectives on global health spending for universal health coverage. Geneva: World Health Organization; 2018.
3. Levine R, Kinder M. Millions saved: proven successes in global health. Washington: Center for Global Development; 2004.
4. Easterly W. The white man's burden. London: Penguin; 2006.
5. Mishra P, Newhouse D. Health aid and infant mortality. IMF Working Paper WP/07/100. Washington: International Monetary Fund; 2007.
6. Chauvet L, Gubert F, Mesple S. Aid, remittances, medical brain drain and child mortality: evidence using inter and intra-country data. J Dev Stud 2013;49:801-8.
7. Ebeke C, Drabo A. Remittances, public health spending and foreign aid in the access to health care services in developing countries. Etudes Doc CERDI 2011.
8. Mishra P, Newhouse D. Does health aid matter? J Health Econ 2009;28:855-72.
9. Chauvet L, Guillaumont P. Aid, volatility, and growth again: when aid volatility matters and when it does not. Rev Dev Econ 2009;13:452-63.
10. Gormanee K, Girma S, Morrissey O. Aid, public spending and human welfare: evidence from quantile regressions. J Int Dev 2005;17:299-309.
11. Cutler D, Deaton A, Lleras-Muney A. The determinants of health disparities. J Econ Perspect 2006;20:97-120.
12. Leunig I, Dijkstra G, Tuytens P. Health aid and health outcomes in developing countries. Forum Dev Stud 2024;51:45–68.
13. Williamson CR. Foreign aid and human development: the impact of foreign aid to the health sector. South Econ J 2008;75:188-207.
14. Wilson S. Chasing success: health sector aid and mortality. World Dev 2011;39:2032-43.
15. Pettersson J. Child mortality: is aid fungibility in pro-poor expenditure decisive? Rev World Econ 2007;143:673-93.
16. Friedman M. Foreign economic aid. Yale Rev 1958;47:500-16.
17. Rajan R, Subramanian A. What undermines aid's impact on growth? IMF Working Paper 05/126. Washington: International Monetary Fund; 2005.
18. Mushkin SJ. Health as an investment. J Polit Econ 1962;70:129-57.
19. Becker GS. Human capital. New York: Columbia Univ Press; 1964.
20. Grossman M. On the concept of health capital and the demand for health. J Polit Econ 1972;80:223-55.
21. Berman P, Kendall C, Bhattacharyya K. The household pro-

duction of health: integrating social science perspectives on micro-level health determinants. Soc Sci Med 1994;38:205-15.
22. Negeri G, Haile Mariam D. Effect of health development assistance on health status in sub-Saharan Africa. Risk Manag Healthc Policy 2016;9:33.
23. Arellano M, Bond S. Some tests for panel data: Monte Carlo evidence and an application to an employment equation. Rev Econ Stud 1991;58:277-97.
24. Blundell R, Bond S. GMM estimation with persistent panel data: an application to production functions. Econ Rev 2000;19:321-40.
25. Alonso-Borrego C, Arellano M. Symmetrically normalized instrumental variable estimation using panel data. CEMFI Working Paper No. 9612, September; 1996.
26. Blundell R, Bond S. Initial conditions and moment restrictions in dynamic panel data models. J Econom 1998;87:115-43.
27. Yousuf AS. Impact of health aid on infant mortality rate. MPRA Paper No. 4294; 2012.
28. Boone P. Politics and the effectiveness of foreign aid. Eur Econ Rev 1996;40:289-329.
29. World Bank. World development indicators. [Accessed 5 Mar 2018]; 2018a.
30. Feenstra RC, Inklaar R, Timmer MP. The next generation of the Penn World Table. Am Econ Rev 2015;105:3150-82.
31. World Bank. Worldwide governance indicators. [Accessed 5 Mar 2018]. Available from: http://data.worldbank.org/data-catalog/worldwide-governance-indicators; 2018b.
32. WHO. Global health expenditure atlas. Geneva: World Health Organization; 2014.
33. Negeri G. The long-run effects of health aid in low-income countries. J Public Health Afr 2023;14:2219.
34. Pritchett L, Lawrence HS. Wealthier is healthier. J Hum Resour 1996;31:841-68.
35. Preston SH. Causes and consequences of mortality declines in less developed countries during the 20th century. In: Easterlin RA, ed. Population and economic change in developing countries. Chicago: Univ Chicago Press; 1980.
36. Wang L. Determinants of child mortality in LDCs: empirical findings from demographic and health surveys. Health Policy 2002;65:277-99.
37. 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.
38. Link BG, Phelan J. Social conditions as the fundamental causes of disease. J Health Soc Behav 1995;35:80-94.