

The Short Run Effects of Health Aid in Low Income Countries: Evidence from Panel Data Analysis

Keneni Gutema Negeri (✉ kenenigut2000@yahoo.com)

Research article

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Abstract

Background The effect of health targeted aid in developing countries is debatable. This paper examines the short run effect of health aid on health status in low income countries of the world. **Method** The study estimates the short run effect of health aid on health status in low income countries. Infant mortality rate was used as a proxy for health status and a panel data was constructed from 34 countries for the period between 2000 and 2017. For the estimation, first difference GMM and System GMM were employed. **Results** The estimation results confirm the argument that health aid has a beneficial and statistically significant short run effect on the health status of low income countries: doubling health aid saves the lives of 20 infants per 10,000 live births. **Conclusion** From the findings of this paper it can be concluded that health aid could be one of the best tools 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. However, recipient countries need to find ways of promoting domestic factors that have favorable impact on health sector as they cannot persistently rely up on external resources.

Background

Low income countries have been facing deep-rooted and multiple health challenges. Besides the unfinished agendas of communicable diseases they are confronting, they are also facing non communicable diseases common to all income groups, such as heart disease, stroke, cancer, diabetes and chronic lung diseases in an alarming rate (1). On the other hand, most of these countries rely heavily on out-of-pocket payments to finance their health care (2). Out of pocket payments limits individuals to over paying the cost of their medical services that gradually leave them in poverty. According to World Health Organization (WHO) report, about 100 million individuals are pushed in to poverty, and about 150 million individuals face catastrophic health expenditure each year. The poverty in its turn forces them to pay more for their health services that creates a vicious cycle (3). Under such circumstance the pertinent question is whether the avoidable infant mortality could be avoided indeed in a foreseeable future, and if so what policy instruments may serve the purpose more efficiently.

Worldwide, it has been agreed that Universal Health Coverage (UHC) is essential. Hence, United Nations (UN) general assembly adopted UHC as part of the overall commitment to the Sustainable Development Goals (SDGs) as Goal 3.8 states "*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*" in 2030. As an attribute of this, more health aid, especially the one that channeled through public spending on health is expected to be associated with greater financial protection. Consequently, health aid in low income countries accounts for about 30% of current health expenditure on average, and it has been increasing over time in absolute terms (2). Leaving much of questions open, this paper concentrates on investigating the effect of health aid in low income countries towards the achievement of the indicated UHC goal.

Regardless of the ample evidences considering effect of aggregate aid on recipient countries national growth, fewer studies considered effects of health specific aid on health status of recipient countries. Besides, within the available part of the literature itself, there is disagreement concerning effect of health aid in low income countries. Some argue that health targeted aid improves health status in low income countries by improving resource availabilities for health service delivery. For instance, Levine argue that health is an area aid effect is noticeable because health programs such as communicable disease prevention and control through safe and adequate water supply, effective sanitation, immunizations, and better nutrition are directly related to the sought health outcomes(3). Easterly argue that with appropriate accountability, external aid leads to the decrease of infant mortality significantly (4). Mishra and Newhouse provide a strong empirical evidence for this argument. Using donor commitments data of 118 countries between the period of 1973 and 2004, they observed significant effect of health aid on health status of population. According to their finding, an increase in 1% per capita health aid improves infant mortality rate by 2%, (5). Similarly, Chauvet Gubert and Mesple-Somps, using a panel data of 109 developing countries from 1987 to 2004, reported results that suggest health aid significant effect on health improvement(6). Ebeke, and Drabo (7) and Mishra and Newhouse (8), Chauvet and Guillaumont (9) also report similar finding that suggest health aid's significant effect on health outcome of developing world.

On the other hand, the authors emphasized that health targeted aid is more effective in recipients of low income countries. According to Gormanee, Girma and Morrissey, the impact of aggregate aid on health status of low income countries is more evident due to the fact that it bridges the gap between the available and required resources that results in remarkable changes through direct public health related projects that enables communicable disease prevention and controls; access to safe and adequate water supplies, improved sanitation, combating malaria by draining swamps to minimize mosquito breeding sites, immunization of vaccine preventable diseases (10). Likewise, the positive effect of aggregate aid on health status of developing countries is reported elsewhere (11, 12).

In contrast, other scholars argue that there is no sufficient evidence to claim that health aid improves health status of the recipient countries. For instance, Williamson examined the impact of foreign aid's commitment by donors on health sector using a panel set of 208 countries both developed and developing world data between 1973 and 2004 and found insignificant effect(13). Wilson's empirical analysis from a panel data of 96 countries with high mortality during 1975–2005 periods shows that, health aid has no effect on recipient countries infant mortality rate (14).

The latter opponent group argues that health targeted aid is ineffective because recipient countries can transfer the resources to non targeted expenditures instead of being injected to the health sector for which it was targeted. According to Pettersson, such non targeted expenditures sourced from all development assistance are as high as 70% (15). Ineffectiveness of aid is also argued that it can negatively affect competitiveness of aid receiving countries, encourage dependency and disincentive adoption of good policies, and encourage corruption (16, 17).

The above controversy forms a dilemma to policy makers as to whether to treat the health aid as a complementary tool or just to disregard it and concentrate on domestic factors. One root of the controversy is methodological deficiencies in empirical studies, specifically misspecification problems, both weak functional form and omitted variables problems, in health estimating equations. Besides this, a separate short run health aid effects are rarely emphasized while the size and significance of the estimated marginal effects are strongly dependent on such time spans. Therefore, this research attempts to fill this gap by employing well specified estimation equation that is consistent with sound theoretical framework grounded on utility maximizing human behavior. (18, 19, 20, 21)

Methods

Framework of the study

Grossman, 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 these approach let the implicit function that relates these factors,

[Due to technical limitations, this equation is only available as a download in the supplemental files section.]

to health outcome $H(t)$ as

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Where $W_j(t)$ are input variables and for $j > k$ the variables are unobserved or not measured.

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]

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the marginal effects f'_j s are constants. Based on the constancy of marginal effects one can integrate equation [2] to get

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 mis-specification problem arising from wrong functional form.

In the specification of health estimating equation, besides the wrong functional form, one may face omitted variable problem, the case where 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 here it is assumed that the omitted variables follow auto regressive of order two which can be expressed as Second Order Difference Equation whose particular solution and complementary function together form a function of time, i.e. for omitted variable $W_j(t)$, $j > k$ we have $W_j(t) = f(t)$. Taking the total derivative of the variable and divide through by $W_j(t)$ to get

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is the elasticity of $W_j(t)$ with respect to time. Assuming this elasticity to be constant² and integrating both sides of equation [4], one gets

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

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Essentially equation [6] is 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], here 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 changes. That is, keeping all other things equal, a one percent change in an explanatory variable in a population with lower level of health status could have higher effect than when 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 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

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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

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Equation [8] represents the short run health function since the past effects of the input variables are excluded from the coefficients. Negeri G. and Haile Mariam D (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 lags of all input variables. Notice that if the system is already on its equilibrium path the regression assigns one to λ , that makes the transition path dynamics to have no effect in determining the level of $H(t)$. But if the system is on the transition to equilibrium fully the regression assigns zero to λ , which makes the equilibrium path dynamics to 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, it avoids the implausible prediction that the latter specification makes in the cases of extreme level 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 as well as equilibrium path dynamics together. That is once we estimate the short run function properly; it is possible to drive the estimate of 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. 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 as 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 the society (5, 28). Second, infant mortality explains substantial improvements in life expectancy it's self 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 inequality. 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 compose of direct foreign transfers and foreign transfers distributed by 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 higher level of income favors consumption of quality of goods and services, better nutrition, housing, and ability to pay for medical care services. Therefore, GDPP is considered to be explanatory variable of health status of the population under the 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

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Where the coefficient of each variable were obtained from the square of principal component that add up to unity.

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, 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-section and annual time series data from 2000 to 2017 for 34 low income countries (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

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where $W(i, t)$ is Infant mortality rate, $W(i, t-1)$ one period lagged infant mortality, $1nW_1(i, t)$ is log-health development assistance for health, $1nW_2(i, t)$ is log-GDP per capita, $1nW_3(i, t)$ is log yield $\exp W_4(i, t)$ is exponential of human capital index, $\exp W_5(i, t)$ is exponential of governance index, $\exp W_6(i, t)$ is adolescent fertility rate, $\exp W_7(i, t)$ is elderly dependency rate, in country i at time t for $i = 1, 2, \dots, 34$ (number of countries), $t = 1, 2, \dots, 17$ (number of time units), $\varepsilon(i, t)$ is error term with the property $E[\varepsilon(i, t)] = 0$ and $\text{var}[\varepsilon(i, t)] = (\sigma_\varepsilon)^2$; μ_0 is constant term; $\mu_1(i)$ and $\mu_2(t)$ 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 Blundel and Bond depending is recommended (24). However, in the cases of a weak

instrument problem in a dynamic panel data model like equation [9], first differenced GMM estimator have been found to have a poor precision (25). Therefore, system GMM estimator is recommended to provide better accurate estimate in the current IMR equation (5, 8, 26, and 27). However, for comparison purpose, 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 standard error vce (gmm).

To deal with omitted variables, it is assumed that the omitted variables follow auto regressive of order one, which is equivalent to assuming that they follow first order differential equations, whose solution will be 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 66. According to the dataset, it was as high as 114 in Sierra Leone and 103 in Central African per 1000 life-births. Good health performance was observed in Syria (16.0) and Korea Dem.Rep (26.0). During the covered period of study this estimate was 34.74 USD, but WHO (32) estimates that a minimum of US\$ 44 is needed per person per year to provide basic, life-saving health services. Besides this 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 low amount of HDA were Niger (2.70 USD), Senegal (2.98 USD), Togo (2.69 USD), Yemen, Rep. (2.00 USD), where as Zimbabwe (19.41 USD), Tanzania (23.0 USD) and Haiti (25.30 USD) were receiving relatively higher amount. Countries with low per capita GDPP were Burundi (227.85 USD) and Congo, Dem. Rep. (334.80USD) whereas countries with relatively higher per capita GDPP were Yemen, Rep (1106.76 USD) and Senegal (983.78 USD).

Besides this Fig.1.1 suggests that the IMR-HDA forms a downward-sloping curve or there is a negative semi-log linear relation between the two variables informing an increase in HDA could lead to a decline in IMR. On the other hand Fig. 1.2 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 marginal effect the lnHDA is confirmed, i.e. the log transformation of the HDA is appropriate in estimating 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.

Figure 1.1 about here Figure 1. 2. About here

Moreover, table–1 informs that the average human capital index was 1.60. The least index was observed in Burkina Faso (1.14) where as the highest index was observed in Tajikistan (3.14). The table also reports that for the income group average adolescent fertility was 107.30 births per 1,000 women aged 15–19. The indicator was the highest in Niger (208) and the least in Democratic People’s Republic of Korea (0.61). In fact, the data indicates that this indicator is falling overtime 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 least in Sierra Leone (4.53%) and the highest in 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 overall trend of the index reflects that it was declining, at 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 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 purpose only as indicated on Table 2, system GMM estimator was considered for detail description of the results for the reason that 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 over identified restriction the Sargan test is employed for it, unlike Hansen test which can be weakened by many instruments, 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 over identifying 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, $\chi^2(102) = 112.388 P = 0.2279$. 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 to 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 to get their short term effects. In its robust version indicates the Arellano-Bond test for

AR(2) in the first difference accepts the null hypothesis of no serial correlation in the idiosyncratic errors, which implying 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, $Wald \chi^2 (9) = 2890.76, P = 0.0000$ (Table 2). Moreover, as shown on Table 2, the coefficient estimate of log-HDA was -1.9818 and this was statistically significant ($P = 0.0000$). Similarly, 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 decline in adolescent fertility, increase in health aid and increase in per capita income play major role in reducing infant mortality. In explicit terms, from the observed average annual IMR decline is due to increase in health aid; is due to increase in per capita income and is due to 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 the short run health function analysis of the current study, the coefficient of log-HDA by the system GMM estimate is -1.9818 , and this is strongly significant($P = 0.000$), suggesting, that HDA has a strong reverse effect on IMR. Accordingly, in the considered panel of countries, doubling the health aid percapita saves the life of two infants per 1000 live births. This estimation result is quite comparable with the estimation results reported in Negeri G. & Haile Mariam D. (33) and Mishra and Newhouse (8). Based on the suitability of IMR as a proxy for health status, this estimation result supports the view that health aid improves health status of the population in low income countries. 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 in complementing prepayment mechanisms such as taxes or health insurances.

Similarly the table indicates that the coefficient estimate of log-GDPP is -9.6007 , which is statistically significant, $z = -4.2200$, $P = 0.0000$, suggesting that raising per capita income growth contributes to the improvement of population health in low income countries. In line with this estimation result, Pritchett and Summers (1996) argued, income is a crucial factor influencing health status, because higher income facilitates improvement in public health through infrastructures like safe water supply and improved sanitation (34). Better income also improves accessibility to health care service that reduces infant mortality. Preston also argued that the combined effect of changes in income, literacy and the supply of calories results in about a half of gain in life expectancy in developing countries (35). Similarly, Wang states that income is considered as a main explanatory input of health function (36).

The effect of cereal yield on IMR was found to be statistically insignificant in the short run. In the literature several writers argued that it has got significant effect on health. For example, Cutler et al (2006) argued that improved nutrition that results from improvements in agricultural yields to be one of the main factors that determine decline in mortality. They argue that better fed people resist most bacterial disease better, and recover more rapidly and more often. Fogel, based on historical evidences, also argues that improved nutrition results in mortality decline. The difference between the finding here and the once in the literature might be due to the attention given in the short run in the current study (37). In the same way the estimator gives -0.8945 as a coefficient estimate of expHC, which again is statistically significant at 10% level of significance, $z = -1.9500$ $P = 0.051$, implying that human capital accumulation could serve as one of the useful policy instruments in attempts made to improve health status of low income countries. In explaining the way in which human capital improves health status, Link and Phelan, notes that whenever there exists an improved mechanism or technology that improves health individuals with higher human capital are well situated to use them for their health. A family with better human capital can serve better as a primary health care takers, implement the behaviors that can improve their children's health than their counterparts. Besides these it is argued that individuals with higher human capital are less likely to smoke which affects health adversely (38).

Similarly the estimator gives -7.8092 as a coefficient of expINST, which is again statistically significant, $z = -2.4100$ $P = 0.0160$. This estimate suggests that if this income group could halt the deterioration of governance quality and raises its index to 0.5816, from improvement in governance alone it could be possible to save the life of 2 infants per 1000 live births, which is comparable to the health out come from doubling the health aid. This informs that improvement in institutional quality could serve as a reliable an additional policy measures that low income countries can take. As it was indicated in the descriptive, the observed average governance index was negative and falling over time.

At last,, it can be understood that only 46% of the decline in IMR was due to the selected input variables, which imply that there is a broad room for further searching policy instruments that could be more feasible.

Conclusions

Whether health aid is effective in improving health status of low income countries is controversial. To explore this controversy, focusing on mis-specification problems, building on results of optimal control analysis and partial adjustment models, short run health equation functions were constructed. Using these functions and a panel data constructed from 34 low income countries during the period of 2000–2017 and infant mortality as a proxy for health outcome, the effectiveness of health aid on health outcomes was examined. The estimation results inform that during the covered period of study in the considered income group, health aid has effective short run effect on reducing infant mortality. More specifically, while doubling health aid saves the lives of 2 infants per 1000 live births in the short run.

WHO recommends moving away from direct out-of-pocket payments that pushes individuals to the vicious cycle of poverty towards using prepaid mechanisms to raise funds (32). In this light of thought, donor funding should increasingly be injected in a way that reduces out of pocket health expenditure. Besides the funds that comes from donors, private foreign direct investment and workers' remittances, have to get enough attention in making them as a complementary source of external health financing. On the recipient side, the countries should find alternative ways of domestic resource pooling mechanisms that protects their population from catastrophic health expenditure as persistent reliance on external resource for health sector is not recommended. However, from the findings of this paper, it can be concluded that health aid could be one of the tools with which the broader health status gap currently observed between high income and low income groups, could be narrowed and hence the target of Universal Health Coverage is met.

Abbreviations

AFERT: Adolescent Fertility Rate

EDEP: Elderly Dependency Rate

GDPP: Gross Domestic Product Per capita

GMM: Generalized Method of Moments

HC: Human Capital

HDA: Health Development Aid

IMR: Infant Mortality Rate

INST: Worldwide Governance Indicator

UHC: Universal Health Coverage

USD: United States

WB: World Bank

WHO: World Health Organization

YIELD: Cereal Yield

Declarations

Ethics approval and consent to participate Not applicable

Consent for publication Not applicable

Availability of data and material available from the corresponding author on request.

Competing interests The author declare that there is no competing interests

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Authors contributions: The researcher is a solo author who initiated the study, collected the data, analyzed and reported.

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Tables

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

Table 2. Estimate of IMR Estimating Equation, 2000-2017, One-step GMM results

Variable	First Difference GMM				System GMM				
	Coef.	Std. Err.	z	P value	Coef.	Std. Err.	z	P value	
L.IMR	0.6030	0.0541	11.1400	0.0000	0.5372	0.0476	11.2700	0.0000	
LnHDA	-1.6653	0.6891	-2.4200	0.0160	-1.9818	0.4919	-4.0300	0.0000	
lnGDPP	-8.8893	3.1900	-2.7900	0.0050	-9.6007	2.2734	-4.2200	0.0000	
LnYIELD	0.3882	1.2592	0.3100	0.7580	0.5115	1.1601	0.4400	0.6590	
ExpHC	-0.8519	0.7793	-1.0900	0.2740	-0.8945	0.4589	-1.9500	0.0510	
ExpINST	-4.7728	4.1800	-1.1400	0.2540	-7.8092	3.2433	-2.4100	0.0160	
AFERT	0.0485	0.0617	0.7900	0.4320	0.0921	0.0373	2.4700	0.0130	
EDEP	1.5025	1.1151	1.3500	0.1780	1.9293	0.9289	2.0800	0.0380	
LnTIME	-3.5430	1.2644	-2.8000	0.0050	-3.5444	1.0611	-3.3400	0.0010	
_cons	82.6748	26.8142	3.0800	0.0020	86.4150	19.7937	4.3700	0.0000	
<i>Sargan test of overidentifying restrictions</i>					<i>Sargan test of over identifying restrictions</i>				
<i>H0: overidentifying restrictions are valid</i>					<i>H0: over identifying restrictions are valid</i>				
$\chi^2 (89) = 86.9263 P = 0.5424$					$\chi^2 (102) = 112.388 P = 0.2279$				
<i>Arellano-Bond test for AR(1) in first differences:</i>					<i>Arellano-Bond test for AR(1) in first differences: z =</i>				
<i>z = -1.2039 P = 0.2286</i>					<i>-1.247 P = 0.2125</i>				
<i>Arellano-Bond test for AR(2) in first differences:</i>					<i>Arellano-Bond test for AR(2) in first differences: z =</i>				
<i>z = 1.2937 P = 0.1958</i>					<i>= 1.411 P = 0.158</i>				
<i>Wald $\chi^2 (9) = 5121.08 P = 0.0000$</i>					<i>Wald $\chi^2 (9) = 2890.76 P = 0.0000$</i>				
<i>Number of Instruments 99 , Number of Countries 24, Number of Observations 265</i>					<i>Number of Instruments 112 , Number of Countries 24, Number of Observations 289</i>				

Table 3. Estimates of 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	

Figures

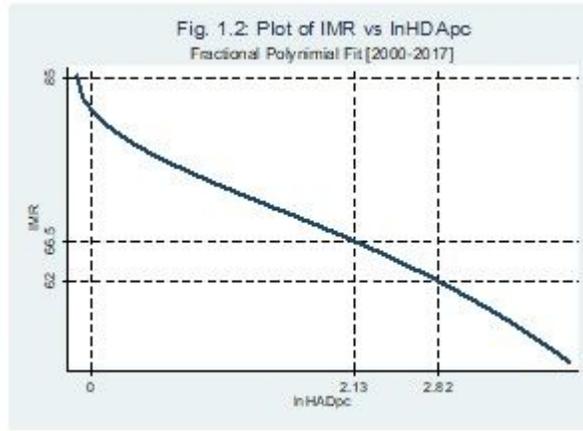
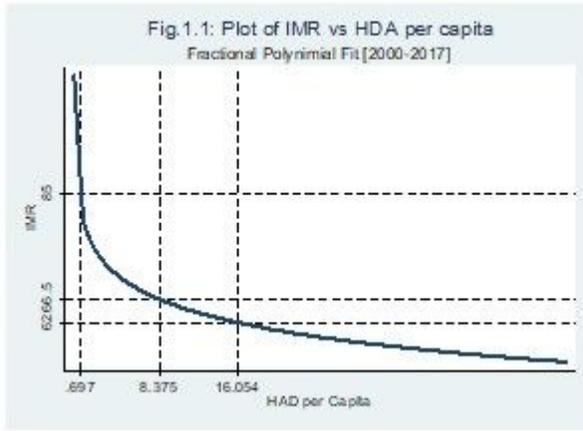


Figure 1

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