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Impacts of Health Expenditure Financing on Infant Mortality and Diminishing Returns: Implications for Sub-Saharan Africa

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ABSTRACT

Purpose: This study examines the impacts of health expenditures on infant mortality.

Design/methodology/approach: This study is based on a comprehensive panel data of 100 countries (31 developed and 69 developing countries) for 18 years (2000-2017) and, based on the Hausman Test, applies fixed effect analyses.

Findings: Not only a negative relationship between health expenditures and the infant mortality rate but its diminishing returns are found. This pattern turns out to be stronger in developing countries, particularly in Sub-Saharan Africa. It appears that a country can easily target the most needed class or region to effectively minimize infant mortality given a limited amount of health expenditure, but that same amount may not suffice in reaching defined goals.

Research limitations/implications: This implies that the rising amounts of health expenditure would be needed if countries seek to decrease infant mortality at the same rate as they had previously done. To expedite a response, multi-agency or multi-national coordination is essential, and an effective means of mobilizing resources, such as basket funding or program-based approaches, would be desirable.

Originality/value: With an up-to-date dataset, this study confirms the effectiveness of health expenditure disbursement with its diminishing returns, which may shed light to developing countries in designing relevant policies.

Keywords: Health Expenditure, Infant Mortality, Diminishing Returns, Sub-Saharan Africa

1. Introduction

Health issues are associated with three major goals—Goal 4 (reduce child mortality), Goal 5 (improve maternal health) and Goal 6 (combat HIV/AIDS, malaria, and other diseases)—out of the total of eight Millennium Development Goals (MDGs) and have been continued in the era of the Sustainable Development Goals (SDGs). Given this, the impact

of health expenditures on national health outcomes, in terms of infant mortality, maternal mortality, HIV/AIDS prevalence, the health workforce, access to immunization, and so on have received attention (Akinkugbe and Mohanoe 2009; Akinlo and Sulola 2019; Bhalotra 2007; Blom *et al.* 2016; Elola and Navarro 1999; Evans *et al.* 2001; Gallet and Doucouliagos 2017; Kim and Lane 2013; Lane and Glassman 2007; Lensink and White 2001; Lim *et al.* 2013; Nixon and Ulmann 2006; Novignon *et al.* 2012; Ravishankar *et al.* 2009; Yaqub *et al.* 2012). Among the health indicators that are commonly tracked, infant mortality rate is among the most important because it is directly related to health in children, and it is of particular

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concern in developing countries, which often lack sufficient health infrastructure and resources (Self and Grabowski 2003; Rana *et al.* 2018).

In particular, Novignon *et al.* (2012) found that a 1% increase in total health expenditure in sub-Saharan Africa would reduce the number of infant mortality by 3 (infants per 1000 live births) and increase life expectancy at birth. Based on this finding, this study put emphasis on the public-private partnerships of health care industry to facilitate investment in health status improvement. In the same direction, Kiross *et al.* (2020) showed that a 1% increase in total health expenditure reduces infant mortality of 0.1% in Sub-Saharan Africa and that the impact gets larger where health infrastructure is poorly managed.

In line with these studies, this paper empirically investigates the relationship between current health expenditures and rates of infant mortality, with particular reference to Sub-Saharan Africa. It is natural to assume that health expenditures disbursement will reduce infant mortality and not surprising to have previous studies that confirm this. However, it is still worth re-examining this, given that this study analyzes the most recent dataset, covering up to 2017 and aims to find *diminishing returns* of health expenditure in terms of reducing infant mortality to check whether the infant mortality, with the increase of health expenditure disbursement, is decreasing at an increasing or decreasing rate. For this purpose, this study adds the square term of health expenditures to the linear representation and breaks down the dataset into sub-groups to derive group-specific differences and associated policy implications.

The remaining part of the study is organized as follows: Chapter 2 explains how we design our research and detailed method will be presented. Chapter 3 shows empirical results with a focus on statistical significance. And the Chapter 4 concludes and provides policy implications for sub-Saharan Africa.

II. Research Design: Data and Methodology

This study uses comprehensive panel data covering 100 countries (31 developed and 69 developing countries) from 2000 to 2017. To eliminate outliers, this study does not include countries categorized as low income and those in Sub-Saharan Africa. In addition, countries with too many missing values were also excluded. These missing values prompted a reduction of the 18-year time span to 6 periods, averaging 3 years. The regression equation is as follows:

$$\begin{aligned} Imr = & \beta_0 + \beta_1 \ln hex + \beta_2 \ln hex^2 + \beta_3 \ln [L.unem] \\ & + \beta_4 \ln [L.pgdp] + \beta_5 \ln gini + \beta_6 \ln fter \\ & + \beta_7 fert + \beta_8 \ln flit \end{aligned} \quad (1)$$

Imr: the infant mortality rate (per 1,000 live births)

lnhex: log of health expenditure per capita (current US\$)

lnhex²: log of square term of health expenditure (current US\$)

ln[L.unem]: log and lag of unemployment rate (% of total labor force)

ln[L.pgdp]: log and lag of GDP per capita (current US\$)

ln gini: log of the Gini index

lnfter: log of female tertiary school enrollment (% gross)

fert: total fertility rate (births per woman)

lnflit: log of female literacy rate (% of females 15 and above)

Almost all the variables are log-transformed, and some (unemployment rate and GDP per capita) are lagged by 1 year to avoid potential endogeneity issues. In addition, this study uses White's robust standard errors to assess heteroscedasticity and will use either fixed-effects or random-effects depending on the Hausman Test. If the test reveals a systematic difference between the two effects, this study will use the fixed effects, as it allows error term to disappear that is correlated with explanatory variables, in which the

endogeneity issue can be effectively tackled¹⁾.

The major explanatory variable in this study is *lnhex*. Because a negative relationship between health expenditures and infant mortality is hypothesized, the expected sign for β_1 is negative. In addition, *lnhex*² measures whether the impact of health expenditures on reducing infant mortality shows diminishing returns. If β_1 is positive, quadratic fit is expected to show a convex downward path, confirming diminishing returns, which indicates that growing health expenditures will continue to reduce infant mortality, but this effect will gradually fade.

Other variables are included based on the literature review. For example, per capita GDP, Gini Index, fertility rate, and HIV prevalence rate are frequently used variables in a number of studies (Akinlo and Sulola 2019; Nixon and Ulmann 2006; Novignon et al. 2012; Yaqub et al. 2012). In particular, Gini Index has been interacted with health expenditure to examine its marginal effect. On top of these, this study included female literacy rate and female tertiary school enrollment rate to examine gender-specific impact on infant mortality.

Unemployment and inequality (Gini index) are expected to increase infant mortality, and per capita GDP may contribute in the opposite way. Thus, β_3 , β_4 , and β_5 are expected show positive, negative, and positive signs, respectively. Likewise, while female tertiary school enrollment and the female literacy rate are expected to decrease infant mortality, the total fertility rate would naturally increase infant mortality, and the signs of the corresponding coefficients (β_6 , β_7 , and β_8) are expected to be negative, positive, and negative, respectively.

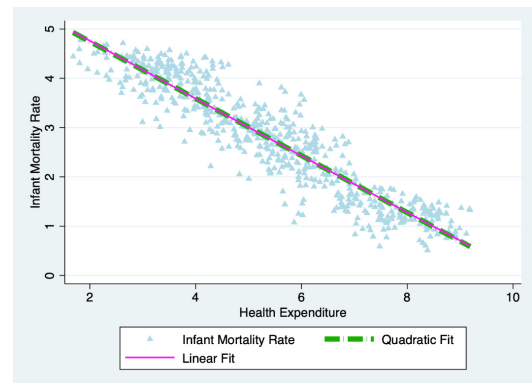
1) Addressing the comment from an anonymous reviewer, we conducted a tobit analysis as an alternative specification for a non-linear model under the assumption that the dependent variable is censored at zero. The result is not shown in the paper as it turns to be not significantly different from the existing ones but can be released upon request.

III. Empirical Results

As expected, a significantly negative relationship was found between current health expenditures and infant mortality. Next, the square term shows significantly positive coefficients in all models. The quadratic fit between health expenditures and infant mortality is concave downward, as illustrated in Figure 1.

This clearly indicates that, regardless of the analytical method, the impact of health expenditures tends to show diminishing returns, and this result is very robust. In the incipient stage, a government can easily target the most needed class or region, effectively minimizing infant mortality, but, at the second stage, the same amount of expenditures may not reach the goal as easily as it previously had. This is a typical pattern found in poverty eradication, where the goal of halving global poverty through the MDGs has been already met, but ending poverty through the SDGs is not easy to do with the same amount of effort that was made in the MDG era (Besley and Burgess 2003; Page and Pande 2018).

The p -value from the Hausman Test is less than 0.05, indicating that fixed effects are systematically different from the random effects. Therefore, taking endogeneity into consideration, this study adopts the



Note: The horizontal axis is log-transformed, making the trend linearized. Based on this, the quadratic fit almost overlaps with the linear fit. A quadratic curve looks significantly different from a linear fit line in a scatter plot without log transformation. The graph can be provided upon request.

Figure 1. Health Expenditure and Infant Mortality Rate: Scatter Plot, Linear Fit, and Quadratic Fit

results from the fixed effects, as shown in Table 1 and Table 2.

Although unemployment does not seem to be a crucial factor in reducing infant mortality, per capita GDP is very important, for self-explanatory reasons. Female education, measured by tertiary education enrollment and literacy rate, does not seem to directly affect infant mortality, as their coefficients are nonsignificant in all models. Further, the fertility rate strongly affects infant mortality; although fertility may be interpreted as a simple control variable, this

Table 1. Regression Results

	Model 1	Model 2
lnhex	-18.874*** (3.557)	-27.287*** (8.014)
(lnhex) ²	1.588*** (0.267)	1.605*** (0.270)
ln[L.unem]	-0.905 (0.792)	-0.982 (0.778)
ln[L.pgdp]	-5.331*** (0.796)	-5.169*** (0.750)
lngini	-4.312 (4.909)	-15.643 (13.392)
lnfter	-0.703 (1.289)	-0.683 (1.292)
fert	9.415*** (2.363)	9.817*** (2.397)
lnflit	2.373 (4.395)	1.706 (4.249)
lnhex * lngini		2.226 (1.979)
constant	103.585*** (25.318)	146.805*** (50.815)
Observations	339	339
Number of countries	100	100
Estimation method	FE	FE

note: .01 - ***; .05 - **; .1 - *;

Notes: Robust t-statistics in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively; Standard errors calculated with White's correction for heteroskedasticity. Unemployment rate and GDP per capita are lagged one year to avoid simultaneity issues; Model 1, Model 2: Fixed effect; Model 3, Model 4: Random effect; lnhex: log of current health expenditure per capita (current US\$); (lnhex)²: square term of log-transformed current health expenditure (current US\$); ln[L.unem]: log and lag of unemployment rate (% of total labor force); ln[L.pgdp]: log and lag of GDP per capita (current US\$); lngini: log of the Gini index; lnfter: log of female tertiary school enrollment (% gross); fert: total fertility rate (births per woman); lnflit: log of female literacy rate (% of females 15 and above)

finding implies that policy campaigns that promote birth control and produce reductions in the fertility rate can be effective means of reducing infant mortality.

Last but not least, although health expenditures show negative coefficients when viewed alone, the coefficients become positive when it interacts with the Gini coefficient. This implies that the impact of increased health expenditures on reducing infant mortality is stronger where the level of inequality is lower and becomes weaker and may not produce more benefits as the level of inequality increases. However, this finding should be interpreted with caution due to its lack of statistical significance.

In its second stage, this study breaks the dataset down into two income groups. The results are provided in Table 2. The diminishing returns for health expenditures (linearly negative and quadratically positive) remain, but their impact is stronger in developing countries; the same amount of disbursement produces a greater change in developing countries; this in itself may be evidence of diminishing returns, as the needs are greater in the developing world. A visual illustration of this finding is provided in Figure 2; the line for developing countries is clearly steeper than that for developed countries. Table 3 confirms a negative relationship between health expenditure and infant mortality rate. Given the comparison between the slope in Figure 2, we assume that health expenditure is much more decisive in developing countries than

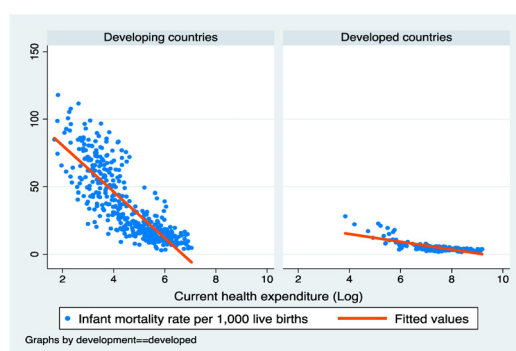


Figure 2. Health Expenditure and Infant Mortality Rate: Scatter Plot and Linear Fit in Developing and Developed Countries

Table 2. Regression Results by Income Group

	Model 1	Model 2	Model 3	Model 4
lnhex	-19.008*** (4.834)	-12.860 (13.244)	-9.080*** (2.278)	-12.607* (6.432)
(lnhex) ²	1.806*** (0.424)	1.860*** (0.446)	0.629*** (0.143)	0.683*** (0.152)
ln[L.unem]	-2.175 (1.342)	-2.095* (1.239)	-0.632*** (0.170)	-0.626*** (0.174)
ln[L.pgdp]	-7.117*** (1.093)	-7.393*** (1.167)	-2.154*** (0.373)	-2.143*** (0.382)
lngini	-7.718 (6.404)	-0.197 (18.549)	0.446 (1.488)	-5.485 (11.611)
Lnfter	-1.027 (1.607)	-0.903 (1.592)	0.723 (0.490)	0.781 (0.468)
fert	10.424*** (2.744)	10.184*** (2.769)	-0.476 (0.894)	-0.333 (0.987)
Lnflit	1.701 (5.320)	2.181 (5.220)	0.961 (1.757)	0.516 (1.352)
lnhex * lngini		-1.789 (3.740)		0.775 (1.415)
constant	128.433*** (32.186)	101.947 (64.916)	51.831*** (9.834)	76.788* (43.738)
Observations	200	200	139	139
Number of countries	69	69	31	31
Estimation method	FE	FE	FE	FE

note: .01 - ***; .05 - **; .1 - *.

Notes: Robust t-statistics in parentheses; *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Standard errors calculated with White's correction for heteroskedasticity; Unemployment rate and GDP per capita are lagged one year to avoid simultaneity issues.; Model 1, Model 2: Developing countries, Model 3, Model 4: Developed countries; Only fixed effect model is applied since p-value was less than 0.05 in the Hausman test; lnhex: log of current health expenditure per capita (current US\$); (lnhex)²: square term of log-transformed current health expenditure (current US\$); ln[L.unem]: log and lag of unemployment rate (% of total labor force); ln[L.pgdp]: log and lag of GDP per capita (current US\$); lngini: log of the Gini index; lnfter: log of female tertiary school enrollment (% gross); fert: total fertility rate (births per woman); lnflit: log of female literacy rate (% of females 15 and above)

Table 3. Regression: Dummy Variable and Interaction with Health Expenditures

Lnhex	-17.112*** (0.596)
lnhex * group: developing countries (0); developed countries (1)	14.234*** (0.692)
constant	114.649*** (3.149)
R ²	0.7718

Notes: Robust t-statistics in parentheses; *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively; Standard errors calculated with White's correction for heteroskedasticity; Model 1: interaction model (lnhex * group); lnhex: log of current health expenditure per capita (current US\$); developing: dummy variable (group: 0, developing countries; 1, developed countries)

developed countries.

Another interesting comparison is differences in fertility, which only show positive coefficients in developing countries. It could be conjectured that

the suggested policy campaign for birth control can work only in developing countries and not elsewhere. The discrepancy for incomes can be confirmed in the following small-scale analysis, where a dummy

Table 4. Countries with High Infant Mortality and Low Health Expenditure

Rank	Countries (High Infant Mortality)	Countries (Low Health Expenditures)
1	Democratic Republic of the Congo	Democratic Republic of the Congo
2	Mali	Ethiopia
3	Liberia	Burundi
4	Cote d'Ivoire	Bangladesh
5	Lesotho	Madagascar
6	Mozambique	Guinea
7	Guinea	Mozambique
8	Pakistan	Nepal
9	Benin	Burkina Faso
10	Cameroon	Pakistan

variable for developing countries interacts with health expenditure; the coefficient of the interaction term is significantly positive at the 99% level, confirming the stronger impact of health expenditures on reducing infant mortality in developing part of the world.

$$Imr = \beta_0 + \beta_1 \ln hex + \beta_2 \ln hex * developing \quad (2)$$

Imr: the infant mortality rate (per 1,000 live births)
 ln hex: log of current health expenditure per capita
 (current US\$)

*group: 0, developing countries; 1, developed countries

IV. Conclusions and Implications for Sub-Saharan Africa

The fact that health expenditures tends to show diminishing²⁾ returns has special implications for Sub-Saharan African countries; even slight increases in health expenditures should produce large effects in many health indicators, including infant mortality.

2) In fact, the diminishing returns are common in the development field. Besley and Burgess (2003) and Page and Pande (2018) agreed that ending global poverty in the second phase of the SDG era would be more challenging than halving it had been during the first phase of the MDG era, as the poor who remained for the second phase would be harder to reach with the same amount of resources.

Table 4 indicates that almost all of the top-ranked countries for both high infant mortality and low health expenditures are in Sub-Saharan Africa, implying that these countries may find that extra attention is worth every penny. This is more important in a crisis such as a global pandemic, during which the least developed countries are most vulnerable, due to their fragile health care systems and insufficient healthcare capacity (Gilbert et al. 2020; Paintsill 2020).

An effective mobilization of financial resources in this region would be particularly helpful. For instance, the Health Basket Funding program implemented in Tanzania,³⁾ in which earmarked pooled donor funds from several donor agencies⁴⁾ could be exported to other countries. This approach effectively supports the country's healthcare sector by scaling up aid (Alvarez et al. 2016; Han and Oh 2019; Mubyazi and Njunwa 2013).

This type of funding can be broadly understood as forming part of the program-based approach, which is, unlike the traditional project-based approach, "a

3) Tanzania is a good example here because it actively applies this type of funding, broadly known as the program-based approach, to its aid system. It has come to be known as "a laboratory for innovative approaches" (Janus and Keijzer 2015). A harmonized framework for aid was established as the fruit of the consistent efforts of the Tanzanian government, and the share of general budget support and basket funding has been over 50%, higher than any other country (Janus and Keijzer 2015)

4) Denmark, Ireland, Switzerland, UNICEF, World Bank, Canada, and the Republic of Korea

way of engaging in development cooperation based on the principle of coordinated support for a locally owned program of development, such as a national poverty reduction strategy, a sector program, a thematic program or a program of a specific organization” (OECD 2006). Further, the problem of a possible misuse of funds could be prevented by a results-based approach, which is also widely employed in Tanzania, particularly in education.⁵⁾

Regarding diminishing returns, the result should be interpreted with caution⁶⁾. The fact that the infant mortality rate is low may indicate that other forms of public health intervention might have already arisen, which may have affected the diminishing returns. Or, the returns could be used intentionally with an underlying assumption that every life matters. As a matter of fact, whether the law of diminishing returns could be applied to infant mortality has been a controversial issue. Dzakpasu *et al.* (2000) examined the so-called the ‘Matthew effect’ and argued that the infant mortality does not match with diminishing returns given that percentage changes in infant mortality are actually larger where infant mortality is lower. On the other hand, Bishai *et al.* (2006) mentioned that countries require more investments in less cost-effective measures when the diminishing returns are becoming dominant. In this stage, channeling abundant financial resources for health expenditure would be of big importance (Akinkugbe and Mohanoe 2009; Kiross *et al.* 2020; Novignon *et al.* 2012).

It would be more desirable to determine whether unique characteristics can be found in a particular region or a country⁷⁾. Additionally, study of the impact of other expenditures, on education, gender, or

governance, for example, on related factors would be interesting, as well. All of these must await further research.

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5) “Big Results Now” in the Tanzanian education sector focused on delivering results-based solutions such as financial rewards for school performance, early grade student assessments, or targeted support to lagging students, which is a key ingredient of the program’s overall approach.

6) This was suggested by an anonymous reviewer. In fact, these are “non-mutually exclusive and non-collectively-exhaustive policy rationale,” using the term of the reviewer. The authors appreciate the reviewer’s implication.

7) North Korea can be regarded as a good candidate for active economic cooperation if its political uncertainty could be lifted (Choi, Kim, and Oh (2017) and Oh (2007))

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