

**Econometric analysis of health care expenditure and access
to Diphtheria Immunisation as predictors of under-five
mortality rate in selected African countries**

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Abstract

This study used annual panel data to assess the effect of healthcare expenditure and immunisation on the under-five mortality rate in 30 selected African countries for the period 2000-2017. Meanwhile, the multiple regression techniques were adopted for the data analysis and the robust fixed regression estimator was preferred to the random effects as determined by the Hausman test. The results indicated that domestic government general health expenditure had a significant negative effect (Coef=-.12834; T=-2.08; Sig. <0.046) on the under-five mortality rate. However, the effect (Coef=.0029; T=0.73; Sig.> 0.470) of domestic private health expenditure on under-five mortality was not significant while external health expenditure had a significant negative effect (Coef=-.0118; T=-4.16; Sig.<0.000) on under-five mortality rate. The effect (Coef= -.5341; T=-5.82; Sig. <0.000) of diphtheria immunisation on under-five mortality was significant. The authors concluded that except domestic private health expenditure, government and external forms of health expenditure coupled with diphtheria immunisation were significant factors for the reduction of the under-five mortality in the selected countries.



Key Words: Health Expenditure, Private Health, Diphtheria Immunisation, Under-five Mortality.

Introduction

Children are highly valued and viewed as a vital stakeholder in every culture around the globe. In terms of social security investment and prospects, children provide a window for the present generation to project into the future. Consequently, getting children is an avenue for evaluating success and accomplishment in certain cultures. In this case, childbirth generally attracts happiness and celebration among individuals. Marriage without children, on the other hand, is usually characterised by tension and conflict, particularly in Africa. Also, if the couple in question cannot produce at least a child out of it, such a marriage can be considered unproductive and unprofitable in most cultures. At the heart of many divorce cases in Africa for example, is the twin dilemma of barrenness and impotence, including to a lesser degree, male gender orientation and preference. Despite the high premium put on child ownership, child survival in Sub-Saharan Africa remains a major challenge ¹.

The concerted efforts aimed at achieving the Millennium Development Goals (MDGs) around the world, especially in developed countries, have reflected a marked decline in infant mortality. But this reduction is not fairly spread as most Sub-Saharan African countries are still battling with under-five mortality². It has been documented that the child mortality outlook in Sub-Saharan Africa is a gloomy one as the region is still recording the worst Under-Five Mortality Rate (UFMR)

¹Olusegun OL, Ibe RT and Ikorok MM, "Curbing maternal and child mortality: The Nigerian experience", *International Journal of Nursing and Midwifery* 4, no. 3(2012): PP 33-39.

² Rutstein SO, "Factors associated with trends in infant and child mortality in developing countries during the 1990s", *Bulletin of the World Health Organisation* 78, (2000): PP1256-1270.

scenarios in the world³. It is alarming to note that Africa has an unprecedented 4.6 million under-five deaths, out of which 98% occur in 42 less developed countries⁴. Optimistically, however, it has been estimated that the Sustainable Development Target (SDG) of a 25 per cent decrease in under-five mortality by 2030⁵ is likely to be reached by a few Sub-Saharan African countries if other variables remain constant.

Bio-medically, certain vaccine-preventable diseases such as measles, pertussis, diphtheria, polio, tuberculosis and tetanus have been linked to child mortality⁶. However, the problem of child mortality is remotely and complexly related to certain living conditions such as access to clean drinking water and sanitation facilities⁷. Interestingly, as captured in both the MDG4 and Sustainable Development Goals (SDGs), under-five mortality, which is the death of a child from day one to five years, has generated a great deal of interest and concern⁸. The phenomenon of child mortality transcends medical causes to include certain socio-economic and demographic variables in a broader context. As several studies have suggested, a multi-dimensional approach is needed to tackle this menace.^{9,10,11}

³ Tabutin D, Masquelier B, Grieve M, et al., Mortality Inequalities and Trends in Low- and Middle-Income Countries, 1990-2015, vol. 72(ed. 2002 Population English, 2017), PP 220-295.

⁴ Olusegun OL, Ibe RT and Ikorok MM, "Curbing maternal and child mortality: The Nigerian experience, P, 33-39.

⁵ Mejía-Guevara I, Zuo W, Bendavid E, et al., "Age distribution, trends, and forecasts of under-5 mortality in 31 sub-Saharan African countries: A modeling study", *PLoS Med* 16, (2019): PP 1-21.

⁶ Matthews Z and Diamond I, "The Expanded Programme on Immunisation: Mortality Consequences and Demographic Impact in Developing Countries", *Genus* 55, no. 1/2 (1999): PP 73-100.

⁷ Tabutin D, Masquelier B, Grieve M, et al., "Mortality Inequalities and Trends in Low- and Middle-Income Countries, 1990-2015", P, 220-295.

⁸ Pardosi JF, Adair T, Rao C, et al., "Measuring Subnational Under-5 Mortality: Lessons from a Survey in the Eastern Indonesian District of Ende." *Asia Pacific Journal of Public Health* 26, no. 4 (2014): PP 367-377.

⁹ Sastry N, "Trends in Socioeconomic Inequalities in Mortality in Developing Countries: The Case of Child Survival in São Paulo, Brazil", *Demography* 41, no. 3 (2004): PP 443-464.

¹⁰ Houweling TAJ, Kunst AE, Looman CWN, et al., "Determinants of under-5 mortality among the poor and the rich: a cross-

In different but related studies conducted by Sastry¹² and Pardosi et al.¹³, mother's age was not only a factor for the uneven distribution of mortality under the age of five but also influenced the chances of survival of a child. Some scholars have further noted that house settlement patterns and rural-urban differentials were risk factors for child mortality^{14;15;16}. Health care systems, health care financing, poverty and access to maternal health services are remotely and complexly identified as correlates of child mortality^{17;18;19;20}. For example, as a complex phenomenon, child mortality has been largely associated with maternal health status because children under

national analysis of 43 developing countries", *International Journal of Epidemiology* 34, (2005): PP 1257–1265.

¹¹ Ayotunde T, Obiyan M, Agunbiade OM, et al., "Maternal Age at Birth and Under-5 Mortality in Nigeria", *East African Journal of Public Health* 6, no. 1 (2009): PP 11-14

¹² Sastry N, "Trends in Socioeconomic Inequalities in Mortality in Developing Countries: The Case of Child Survival in São Paulo, Brazil", P, 443-464.

¹³ Pardosi JF, Adair T, Rao C, et al., "Measuring Subnational Under-5 Mortality: Lessons from a Survey in the Eastern Indonesian District of Ende", P, 367-377.

¹⁴ Amouzou A and Hill K, "Child Mortality and Socioeconomic Status in Sub-Saharan Africa", *African Population Studies* 19, no. 1 (N.D): PP 1-12.

¹⁵ Ezeh OK, Agho KE, Dibley MJ, et al., "Risk factors for post-neonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis", *BMJ Open* 5, (2015). <https://doi.org/10.1136/bmjopen-2014-006779>.

¹⁶ Garcia J, "Urban–rural differentials in Latin American infant mortality", *Demographic Research* 42, no. 8 (2020): PP 203-244.

¹⁷ Palma-Solis MA, Díaz CA, Franco-Giraldo A, et al., "State Downsizing as a Determinant of Infant Mortality and Achievement of Millennium Development Goal 4", *International Journal of Health Services* 39, no. 2 (2009): PP 389-403.

¹⁸ Pritchard and Keen S, "Child mortality and poverty in three world regions (the West, Asia and Sub-Saharan Africa) 1988–2010: Evidence of relative intra-regional neglect?", *Scandinavian Journal of Public Health* 44, (2016):734–741

¹⁹ Yaya S, Bishwajit G, Okonofua F, et al., "Under-five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis", *PLoS ONE* 13, no. 10 (2018): PP 1-14.

²⁰ Agho KE, Ezeh OK, Ferdous AJ, et al., "Factors associated with under-5 mortality in three disadvantaged East African districts", *International Health* 12, (2020): PP 417-428.

five years of age have always been considered to be under the custody of their mothers except in certain exceptional circumstances. Consequently, the conditions of mothers influence the survival chances of the children ²¹.

Child death has some cross-cutting impacts on culture, economics, government and families as a significant public health problem for the population. For example, based on the infant mortality trend study of 2,976 million child deaths as of 2013, it was estimated that the African continent would suffer the effect of child deaths amounting to around 6 per cent of its non-health Gross Domestic Product (GDP)²². Rising infant mortality still has the ability soon to decrease the productive influence of the working population. Moreover, infant death leaves behind some devastating physical, psychological and emotional impacts on family members. Child death deprives ageing parents of future care in Africa, where the care of elderly persons is one of the major traditional responsibilities of family members.

As a way of tackling child mortality, many countries in the world depend on their respective healthcare system. But governments of most countries in Africa are yet to provide robust funding for their healthcare systems as many people still depend on out-of-pocket payment to receive health services. Similarly, child immunisation in Africa is still being confronted by a myriad of challenges ranging from religious belief, negative politicising, geographical inaccessibility, to poor or lack of physical infrastructural facilities. In the light of the foregoing, this study assessed the effects of health care expenditure and immunisation on the under-five mortality rate in selected African countries for the period of 17 years (2000-2017). In measurable terms, the study is bound by the following specific objectives, namely to: assess the effect of Domestic Government General Expenditure on Health (DGGEH) on Under-Five Mortality Rate (UFMR) in selected African countries; assess the effect of Domestic Private

²¹ Olusegun OL, Ibe RT and Ikorok MM, "Curbing maternal and child mortality: The Nigerian experience", P, 33-39.

²² Kirigia JM, Muthuri RDK, Nabyonga-Orem J, et al., "Counting the cost of child mortality in the World Health Organization African region", *BMC Public Health* 15, no. 1103 (2015): PP 1-13. <https://doi.org/10.1186/s12889-015-2465-z>

Health Expenditure (DPHE) on under-five mortality rate; examine the impact of External Health Expenditure (EHE) on UFMR in the selected countries; examine the impact of Diphtheria Immunisation (DI) on UFMR in the selected African countries.

Domestic government general expenditure on health is used as one of the proxies for health expenditure in this study. It can be referred to as both capital and recurrent health expenditure of the government, including revenue as domestic grants, transfers, health subsidies, organisational health financing programmes, voluntary health insurance beneficiaries and national health insurance schemes.²³ Some documented studies have linked health expenditure to health outcomes (child mortality). Some of these studies used data from time series in the health economics literature, while others used panel data sets. A study found a significant long-term association between government spending on health and child mortality in several developing countries.²⁴ Similarly, several different but related study results found that government spending on health was significantly associated with decreasing child mortality.^{25;26;27;28;29}. In contrast, a few studies

²³ Kiross GT, Chojenta C, Barker D, et al., “The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis”, *Health Economics Review* 10, no. 5 (2020): PP 1-9.

²⁴ Lu Z, Bandara JS and Paramati SR, “Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies”, *Aust Econ Pap.*, (2019), PP 1–21.<https://doi.org/10.1111/1467-8454.12167>.

²⁵ Anyanwu JC and Erhijakpor AEO, “Health Expenditures and Health Outcomes in Africa”, African Development Bank, Economic Research Working Paper Series, No 91, (2007).

²⁶ Burfeind LR, “The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries”, *Electronic Theses and Dissertations*, (2014), P 100. <https://digitalcommons.du.edu/etd/00>.

²⁷ Barenberg AJ, Basu D and Soylu C, “The Effect of Public Health Expenditure on Infant Mortality: Evidence from a Panel of Indian States, 1983-1984 to 2011-2012”, *The Journal of Development Studies*, (2016), PP1-20. <https://DOI: 10.1080/00220388.2016.1241384>

²⁸ Eboh A, Abba JY and Fatoye HA, “Impact Assessment of the Public Health Expenditure on the Health Outcome in Nigeria”, *International Journal of Social and Administrative Sci*

have found that public health spending in high-income countries has not had a significant impact on child mortality.^{30;31}

Another form of health expenditure is Domestic Private Health Expenditure (DPHE). This encompasses household out-of-pocket, funds from corporations and non-governmental organisations. The extent to which DPHE impact child mortality was examined by Lu et al.³² and the finding showed that the former had a significant influence on the latter. That is, private expenditure on health reduced child mortality significantly. Also, total health expenditure in 47 African countries has been found to have a significant impact on under-five mortality³³. Kiross et al.³⁴, however, discovered from their studies that the association between private health spending and child mortality was negligible.

As part of the expenditure component, External Health Expenditure (EHE) comprises all financial inflows and resources that come into the national health system from outside the

ences 3, no. 2 (2018): PP

62-72. <https://doi.org/10.18488/journal.136.2018.32.62.72>.

²⁹ Kiross GT, Chojenta C, Barker D, et al., “The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis”, P, 1-9

³⁰ Dhriifi A, “Health-care expenditures, economic growth and infant mortality: evidence from developed and developing countries”, *CEPAL Review* 125, (2018): PP 70-91

³¹ Akinlo AE and Sulola AO, “Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa”, *Journal of Policy Modeling* 41, (2019): PP 168–178.

³² Lu Z, Bandara JS and Paramati SR, “Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies”, *Aust Econ Pap.*, (2019): PP 1–21. <https://doi.org/10.1111/1467-8454.12167>.

³³ Anyanwu JC and Erhijakpor AEO, “Health Expenditures and Health Outcomes in Africa”, African Development Bank, Economic Research Working Paper Series, (2007): No 91.

³⁴ Kiross GT, Chojenta C, Barker D, et al., “The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis”, P, 1-9.

country³⁵. More importantly, the issue is the effects of such inflows and resources on health outcome like child mortality. Against this background, Mishra and Newhouse³⁶ opined that external spending on health in the form of aid had a significant impact on the mortality of children under five. Another research has also reaffirmed that external health investment was strongly correlated with child and neonatal mortality³⁷. In the same way, Burfeind³⁸ showed that when external health resources are improved, they contribute to a reduction in infant mortality. A study focusing on selected African countries equally found that external health spending in the form of aids and immunisation was an effective factor in reducing mortality for children under five³⁹.

One of the main ways of addressing childhood morbidity worldwide has been the regular and periodic immunisation of children under five. Some of the diseases that can be treated by the Expanded Immunisation Programme (EPI) include measles, pertussis, diphtheria, polio, tuberculosis, and tetanus⁴⁰. However, the interest of this study is partly to assess the effect of diphtheria immunisation access (% of children ages 12-23 months) on the under-five mortality rate in selected African countries. In addition, Morris, Black and Tomaskovic⁴¹ and

³⁵ Kiross GT, Chojenta C, Barker D, et al., “The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis”, P, 1-9.

³⁶ Mishra P and Newhouse D, “Health Aid and Infant Mortality”, *IMF working paper*, (2007), WP/07/100.

³⁷ Kiross GT, Chojenta C, Barker D, et al., “The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis”, P, 1-9.

³⁸ Burfeind LR, “The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries”, P, 100.

³⁹ Akinlo AE and Sulola AO, “Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa”, P, 168–178.

⁴⁰ Matthews Z and Diamond I, “The Expanded Programme on Immunisation: Mortality Consequences and Demographic Impact in Developing Countries”, *Genus* 55, no. 1/2 (1999) : PP 73-100.

⁴¹ Morris SS, Black RE and Tomaskovic L, “Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems”, *International Journal of Epidemiology* 32, (2003): PP 1041–1051.

Boco⁴² have stated that immunisation is an important factor in reducing the mortality of children. According to Ushie, Fayehun and Ugal⁴³, immunisation raises the probability of infant survival and has been regarded as one of the most effective ways to stem the tide of child mortality. The accessible literature reviewed in this study has indicated that there was still a need for further research relating to the effects of private health spending, external health expenditure and immunisation on under-five mortality. This was the plausible gap that this study has bridged in the literature. Besides, the time frame covered in the available literature needs to be updated as the current study filled in the time gap (2000-2017).

Concerning the theoretical perspective, Grossman's health production and investment model is being adopted for this research. Health is conceptualised as both a consumable item and an investment resource according to Grossman, as derived from Becker⁴⁴. The model opined that an individual chooses their level of health and by extension, their life span. It further postulated that time was a variable factor that contributes to declining health status in both objective and subjective terms. However, through certain social determinants such as diet, exercise, medical care and lifestyle decisions, it could be replenished and counter-balanced. On the other hand, ageing, smoking, extreme opioid use and exposure to other toxic compounds may make the health capital of an individual depreciate. In this context, the level of health an individual has is a function of the amount of resources allocated to its investment. Also, an individual is viewed as a "manufacturer" as well as a "user" of health and that the demand for health is not for immediate consumption but the

⁴² Boco AG, "Individual and Community Level Effects on Child Mortality: An Analysis of 28 Demographic and Health Surveys in Sub-Saharan Africa", *DHS Working Papers*, (2010), No. 73. Calverton, Maryland, USA: ICF Macro.

⁴³ Ushie BA, Fayehun OA and Ugal DB, "Trends and patterns of under-5 vaccination in Nigeria, 1990–2008: what manner of progress?", *Child: care, health and development* 40, no. 2 (2013): PP 267-274.

⁴⁴ Nocera S and Zweifel P, "The Demand for Health: An Empirical test of the Grossman Model Using Panel Data. In Zweifel, P. Health, the Medical Profession and Regulation", *Developments in Health Economics and Public Policy* 6, (1998): PP 35-49. Boston: Kluwer. [https://DOI: 10.1007/978-1-4615-5681-7_2](https://doi.org/10.1007/978-1-4615-5681-7_2).

production of other goods. So, one's level of health is not attributed to certain external social factors but endogenously influenced. In other words, Grossman's main argument for health investment is that health care services are not requested for their purposes, but for the impact on health itself. Ageing influences the state of health and requires constant health care services. However, the impact of ageing on well-being is mitigated by educational level and a balanced style of living.⁴⁵

The model can be sustained in this study when health expenditure (domestic government general, domestic private, external health expenditures and access to diphtheria immunisation) is viewed as an investment tailored towards improving maternal and child health status (reduction in under-five mortality). In this case, expenditure on and utilisation of maternal and child health services is considered as derived demand capable of impacting on child mortality rate. Within the theoretical purview of the household health production function of Grossman, both increase and decrease in child mortality are predicated on the amount of resources allocated to health. It is taken for granted that more increase in health and education is likely to translate into a reduction in under-five mortality in the selected African countries. Moreover, it can be deduced that the age-long uneven distribution of child mortality across and within various regions of the world is neither accidental nor incidental but it could be related to varying investment in health capital among other factors. "Other things being equal", the insightful understanding of Grossman's model is that more investment in health capital leads to desirable child health status and by extension declining child mortality. Even though Grossman's model is subject to some methodological and empirical flaws, the theory has continued to stand the test of time concerning investment in health capital.

Methods

The *ex post facto* research design was considered appropriate for the study since it involves examining the statistical impacts of the

⁴⁵ Nocera S and Zweifel P., "The Demand for Health: An Empirical test of the Grossman Model Using Panel Data. In Zweifel, P. Health, the Medical Profession and Regulation", P, 35-49.

independent or explanatory variables on the dependent or outcome variable over past time. The independent variable in this study is health expenditure, which is proxied by Domestic Government General Expenditure on Health (DGGEH), Domestic Private Health Expenditure (DPHE) and External Health Expenditure (EHE). Immunisation as an independent variable is also represented by access to Diphtheria Immunisation (DI). On the other hand, Under-Five Mortality Rate (UFMR) serves as the dependent variable.

Data Description and Sources

The study utilised the annual panel data that comprised 30 African countries for the period of 17 years (2000-2017). The data were sourced from the 2017 published reports and accounts of the World Bank on the world development indicators. Meanwhile, the filter criteria for selecting the 30 countries were based on the availability of the annual data spanning 2000-2017. It means the study has balanced panel data with 540 observations. The names of the selected countries are: Nigeria, The Gambia, Ghana, Benin, Senegalr, South Africa, Kenya, Morocco, Tanzania, Rwanda, Zambia, Madagascar, Angola, Chad, Congo Democratic Republic, Algeria, Tunisia, Botswana, Namibia, Mozambique, Malawi, Burkina Faso, Sierra Leone, Togo, Ethiopia, Mauritania, Uganda, Central African Republic, Congo, Dep. Rep. and Gabon. The study adopted multiple regression techniques for the data analysis because of several independent variables involved. This is to enable the authors to determine the impacts of DGGEH, DPHE, EHE and DI on UFMR in the selected countries. The analysis of data was facilitated by the application of the STATA 12 software version and the study hypotheses were extrapolated from the results and tested at the pre-determined 5% level of significance. The analysis was patterned after the econometric styles used by Anyanwu and Erhijakpor⁴⁶, Burfeind⁴⁷, Lu, Bandara and Paramati⁴⁸, and Kiross et al.⁴⁹

⁴⁶ Anyanwu JC and Erhijakpor AEO., "Health Expenditures and Health Outcomes in Africa", P, No 91.

⁴⁷ Burfeind LR, "The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries", Electronic Theses and Dissertations, (2014): P. 100. <https://digitalcommons.du.edu/etd/100>.

respectively. Moreover, to ensure the validity of the results, several robustness tests were conducted to check for multicollinearity, heteroskedasticity, data normality and model specification. The results of the various tests eventually necessitated the decision to adopt the robust fixed-effects regression model.

Model Specification

General Panel Linear Model

$$Y_{it} = \alpha_i + \beta_1 X_{1it} + \beta_2 X_{2it} + e_{it} \dots \dots \dots (1)$$

$$\log U_{FMR} = F(DGGEH, DPHE, EHE, \log DI) \dots \dots \dots (2)$$

Econometric model:

$$\log U_{FMR_{it}} = \alpha + \beta_1 DGGEH_{it} + \beta_2 DPHE_{it} + \beta_3 EHE_{it} + \beta_4 \log DI_{it} + e_{it} \dots \dots \dots (3)$$

Where: β_1 - β_4 =parameters to be estimated with a priori expectations; U_{FMR}= Under-Five Mortality Rate (per, 1,000 live births) as the dependent variable; DGGEH = Domestic Government General Expenditure on Health (% of Gross Domestic Product) as an independent variable; DPHE = Domestic Private Health Expenditure % of (Current Health Expenditure) as an independent variable; EHE= External Health Expenditure (% of Current Health Expenditure) as an independent variable; DI= Diphtheria Immunisation (% of children ages 12-23 months); α = Constant; e = Error term; i = countries and t = Period.

Note: U_{FMR} and DI were in their natural log forms.

Results

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
U _{FMR}	540	90.96896	45.0766	17.1	234
DGGEH	540	1.786976	1.057063	.062362	5.275046
DPHE	540	47.03394	16.88815	8.119548	83.63081

⁴⁸ Lu Z, Bandara JS and Paramati SR, "Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies", Aust Econ Pap. (2019): PP 1–21. <https://doi.org/10.1111/1467-8454.12167>.

⁴⁹ Kiross GT, Chojenta C, Barker D, et al., "The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis", P, 1-9.

EHE	540	19.77534	17.491	.0122321	79.9847
DI	540	75.8537	20.36155	8	99

Source: Researchers' Computation using STATA 12.0 software

It can be deduced from Table 1 above that the average Under-Five Mortality Rate (UFMR) in the selected countries for the period under review stood at 90.968 per 1, 000 live births; with the minimum and the maximum UFMR being 17.1 and 234 per 1, 000 live births. In addition, Domestic Government General Health Expenditure (DGGHE) accounted for an average of 1.786; with the minimum and maximum being 0.062 and 5.275 respectively within the same period (2000-2017). It has been noted that DDGGHE shows the standard deviation of 1.057 from its mean. On average, Domestic Private Health Expenditure (DPHE) and External Health Expenditure (EHE) in the selected countries were 47.033 and 19.775. On the other hand, the maximum DPHE and EHE were 83.630 and 79.984 while the minimum stood at 8.119 and 0.012 respectively. Similarly, the average Diphtheria Immunisation (DI) of children ages 12-23 months was 75.85% while the maximum and the minimum number of under-5 children that received DI accounted for 99% and 8% proportionately across the selected African countries. Given the respective standard deviations of all the variables (45.076, 1.057, 16.888, 17.491 and 20.361) being lower than their corresponding mean values, it suggests that the variables had slow growths within the period under review.

Table 2: Correlation matrix Test for Multicollinearity

Variable	UFMR	DGGEH	DPHE	EHE	DI
UFMR	1.0000				
DGGEH	-0.4005	1.0000			
DPHE	0.2966	-0.3780	1.0000		
EHE	0.0922	-0.2811	-0.5136	1.0000	
DI	-0.6836	0.3547	-0.3360	0.1948	1.0000

Source: Researchers' Computation using STATA 12.0 software

To ascertain whether multicollinearity among the explanatory variables was a problem in the analysis or not, the authors adopted the Pearson correlation test. The result in Table 2 above shows that Domestic Private Health Expenditure (DPHE) has a negatively weak relationship with Domestic Government General Expenditure on Health (DGGEH) as indicated by the correlation coefficient of 37%. Similarly, a weak and moderate negative

relationship was noted to have existed between External Health Expenditure (EHE) on one hand, and DGGEH and DPHE on the other hand as shown by the corresponding coefficients of 28% and 51%. It was also observed that Diphtheria Immunisation (DI) and Domestic Government General Expenditure on Health (DGGEH) were weakly and negatively correlated by 35%. Meanwhile, there was a weak (33%) and negative relationship between DI and DPHE in the same table above. When DI was further correlated with EHE, it equally showed a negatively weak relationship as represented by the coefficient of 19%. Since the correlational relationships between the independent variables have not exceeded the 85% "rule-of-thumb" suggested by Hair et al. (2005) and Garson (2012), it could be deduced that multicollinearity was not an issue or a problem in this study. However, the authors subjected the deduction to the test of the Variance Inflation Factor (VIF) for further validation to avoid any doubt of inflated results or spurious regression outcomes.

Table 3: Test for Multicollinearity using Variance Inflation Factor (VIF)

	DPHE	EHE	DGGEH	DI
VIF	2.27	2.24	2.06	1.28
1/VIF	0.439903	0.446048	0.484265	0.779996

Source: Researchers' Computation using STATA 12.0 software

From Table 3, the Variance Inflation Factor (VIF) values of the independent variables were less than 10; which implies a total absence of multicollinearity in the analysis of the independent variable components. This is also in tandem with the recommendation made by Neter et al.

Table 4: Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

chi2(1)	4.41
Prob> chi2	0.0358

Source: Researchers' Computation using STATA 12.0 software

At this juncture, the problem of heteroskedasticity in the model has been detected as revealed in Table 4 above. The Breusch Pagan/Cook-Weisberg test shows the chi2 (1) value of 4.41 and the corresponding probability value of 0.035 which is statistically

significant at 1% alpha level ($p\text{-value} < 0.05$). Consequently, the problem of heteroskedasticity in the model has flouted the homoskedastic principle of the general linear regression model. It was on this basis that the authors considered it imperative to correct the pitfall by adopting the robust fixed effect regression model after conducting the Hausman specification test.

Table 5: Shapiro-Francia W' Test for Normal Data

Variables	Obs	W'	V'	Z	Prob>Z
UFMR	540	0.97080	11.281	5.342	0.00001
DGGEH	540	0.92117	30.460	7.532	0.00001
DPHE	540	0.98892	4.281	3.206	0.00067
EHE	540	0.90715	35.875	7.892	0.00001
DI	540	0.90436	36.954	7.958	0.00001

Source: Researchers' Computation using STATA 12.0 software

Shapiro-Francia W' Test for normal data in Table 5 revealed that UFMR, DGGEH, DPHE, EHE and DI did not follow the normal pattern of distribution around their central means as shown in the respective probability values of less than 0.05 level of significance. Again, an assumption of the general linear regression model of normal distribution of data has been violated at this point. The possible approach to be adopted was the robust fixed effect estimator to correct this statistical anomaly.

Table 6: Hausman Specification Test

Chi2	1954.27
Prob. Chi2	0.0000

Source: Researchers' Computation using STATA 12.0 software

Since the study involved the panel data, the authors opted for the Hausman specification test to determine whether the fixed effects or the random effects estimator was appropriate. The result of the Hausman test suggested the robust fixed-effect model being appropriate for this study as indicated by the chi2 value of 1954.27 and the corresponding significant Prob. Chi2 of 0.000. Besides, the problem of the non-normal distribution of the data equally warranted the application of the robust fixed-effect model.

Table 7: Robust Fixed Effect Regression

Robust

LogUFMR	Coef.	Std. Err.	T	p> t
DGGEH	-.1283442	.0615876	-2.08	0.046
DPHE	.0029441	.0040208	0.73	0.470
EHE	-.0117876	.002837	-4.16	0.000
LogDI	-.5340983	.0917289	-5.82	0.000
_cons	6.978459	.5409469	12.90	0.000
Overall R-sq	0.1696			
F-Statistic	21.06			
Prob. >F	0.0000			

Source: Researchers' Computation using STATA 12.0 software

For the period under review, the result from Table 7 above reflects the overall coefficient of determination of 0.169. This suggested that the independent variables, namely: DGGEH, DPHE, EHE and DI exerted an estimate of 16% joint effects on the changes in the dependent variable (UFMR) for the period. The probability value of the F-Statistic is significant at 1% which implies the fitness of the study model and its suitability for reliable decision making.

Test of Hypotheses

Ho1: Domestic government general expenditure on health has no significant impact on the under-five mortality rate in selected African countries.

Ho2: Domestic private health expenditure has no significant effect on the under-five mortality rate in the selected countries.

Ho3: External health expenditure has no significant effect on the under-five mortality rate in the selected countries.

Ho4: Diphtheria immunisation has no significant effect on the under-five mortality rate in the selected African countries.

It was noted in Table 7 that the domestic government general expenditure on health had a significant negative effect on the under-five mortality rate in the 30 selected African countries as shown in the probability value less than 5% (0.046) and the corresponding coefficient of -.128. On the strength of this result, the null hypothesis which stated that domestic government general expenditure on health has no significant impact on under-five mortality rate is hereby rejected. Also, the impact of domestic private health expenditure on under-five mortality was not significant as reflected in the probability value of 0.470

(47%) which is above the a priori assumption of 5% level of significance and the coefficient of 0.002 respectively. In consequence, the null hypothesis which stated that domestic private health expenditure has no significant effect on the under-five mortality rate is accepted.

Furthermore, the result in Table 7 shows that external health expenditure exerted a significant negative effect on the under-five mortality rate. This was underscored by the P-value of 0.000 and the coefficient of -0.0117. Since the P-value is significant at 1%, the null hypothesis three (Ho3) is rejected. Similarly, diphtheria immunisation has a significant negative effect on under-five mortality as indicated by the P-value of 0.000 and the corresponding coefficient of -0.534. On this premise, the null hypothesis which stated that diphtheria immunisation has no significant effect on the under-five mortality rate in the selected African countries is hereby rejected.

Discussion

The main objective of the study was to assess the impact of health expenditure and immunisation on the under-five mortality rate in selected African countries. Firstly, the study revealed that domestic government general expenditure on health had a significant negative effect on the under-five mortality rate in the 30 selected African countries. This shows that a 1 per cent unit increase in government health spending will reduce the under-five mortality rate by -0.128 if other variables are held constant. The finding is consistent with some previous studies carried out by Lu, Bandara and Paramati⁵⁰, Anyanwu and Erhijakpor⁵¹, Burfeind⁵², Barenberg, Basu and Soylu⁵³, Eboh, Abba and

⁵⁰ Lu Z, Bandara JS and Paramati SR., "Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies", P, 1-21.

⁵¹ Anyanwu JC and Erhijakpor AEO., "Health Expenditures and Health Outcomes in Africa", P, No 91.

⁵² Burfeind LR, "The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries", P, 100.

⁵³ Barenberg AJ, Basu D and Soylu C, "The Effect of Public Health Expenditure on Infant Mortality: Evidence from a Panel of Indian States, 1983–1984 to 2011 2012", P, 1-20.

Fatoye⁵⁴, and Kiross et al. ⁵⁵. However, it is at variance with a study involving some high-income countries where no significant relationship was found between public health spending and child mortality⁵⁶.

Contrary to the a priori expectation, this study found that the impact of domestic private health expenditure on under-five mortality was not significant. In other words, when other variables remain unchanged, a unit increase in domestic private health expenditure will lead to an increase of 0.002 in under-five mortality rate per time. While the finding is in agreement with a couple of studies conducted in the previous years.^{57;58}, it is, however, in contrast to studies carried out by Morris, Black and Tomaskovic⁵⁹, and Akinlo and Sulola⁶⁰. Moreover, the study found that external health expenditure had a significant negative effect on the under-five mortality rate for the period under review. That is, an increase of 1% in external health expenditure will produce a corresponding impact of -0.011 on the under-five mortality rate in the 30 African countries within the determined time frame. The above finding aligns with some studies in the literature ^{61; 62;63;64}. Similarly, immunisation in the form of

⁵⁴ Eboh A, Abba JY and Fatoye HA, "Impact Assessment of the Public Health Expenditure on the Health Outcome in Nigeria", P, 62-72.

⁵⁵ Kiross GT, Chojenta C, Barker D, et al., "The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis", P, 1-9.

⁵⁶ Dhrifi A, "Health-care expenditures, economic growth and infant mortality: evidence from developed and developing countries", *CEPAL Review* 125, (2018): PP 70-91.

⁵⁷ Anyanwu JC and Erhijakpor AEO, "Health Expenditures and Health Outcomes in Africa", P, No 91.

⁵⁸ Lu Z, Bandara JS and Paramati SR, "Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies", P, 1-21.

⁵⁹ Morris SS, Black RE and Tomaskovic L., "Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems", P, 1041–1051.

⁶⁰ Akinlo AE and Sulola AO, "Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa", P, 168–178.

⁶¹ Mishra P and Newhouse D, "Health Aid and Infant Mortality", P, WP/07/100.

⁶² Burfeind LR, "The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries", P, 100.

diphtheria was found to have a significant negative effect on under-five mortality. In other words, holding domestic government general health expenditure, domestic private health expenditure and external health expenditure constant, 1% increase in immunisation will lead to -0.534 significant decline in the under-five mortality. The above finding is anchored on some previous studies^{65,66,67} that established a negative significant relationship between immunisation of children and child mortality.

Conclusion and Policy Implications of the Study

To tackle the problem of under-five mortality in African countries, a multi-dimensional approach is required as this study indicated. Government general health expenditure, external healthcare expenditure and diphtheria immunisation have been noted as significant factors for the reduction of under-five mortality in the selected countries. On the other hand, domestic private health expenditure did not have any significant contributory impact on the under-five mortality rate. This may not be unconnected with the harsh socio-economic realities prevalent in most African countries that constrain access to antenatal, prenatal and post-natal health care services. So, many mothers and their under-five children rely more on health services being offered by government.

Based on the study findings above, it is suggested that governments of the various African countries should step up domestic health expenditure in the area of maternal and child

⁶³ Akinlo AE and Sulola AO, "Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa", P, 168–178.

⁶⁴ Kiross GT, Chojenta C, Barker D, et al., "The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis", P, 1-9.

⁶⁵ Morris SS, Black RE and Tomaskovic L, "Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems", P, 1041–1051.

⁶⁶ Boco AG "Individual and Community Level Effects on Child Mortality: An Analysis of 28 Demographic and Health Surveys in Sub-Saharan Africa", P, No. 73.

⁶⁷ Akinlo AE and Sulola AO, "Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa", 168–178.

health. Besides, the issue of diversion of funds meant for the health sector by some corrupt individuals and their syndicates must be checkmated by the various governments if the intended health outcome must be maximised. The countries should create an enabling environment comprising good roads, electricity, pipe-borne water, security and other health-related infrastructure that may attract more grants for maternal and child health from international external sources.

Also, the governments of the African region should pool their resources together and start the production of vaccines locally to address the issue of certain childhood killer diseases like diphtheria, measles, tuberculosis and many other preventable health afflictions, instead of relying on foreign-based vaccines for immunisation. This is so because a time may come that the donor agencies supporting the immunisation of the under-five African children may not be able to sustain it due to some unforeseeable circumstances and vagaries surrounding international politics and economy. African governments should try and make access to maternal and child health-care services free and compulsory for mothers and their under-five children. In effect, it may help to solve the problem of access and further reduce the challenge of under-five mortality in the region.

Bibliography

Agho KE, Ezeh OK, Ferdous AJ, et al., "Factors associated with under-5 mortality in three disadvantaged East African districts", *International Health* 12, (2020): PP 417-428.

Akinlo AE and Sulola AO, "Healthcare Expenditure and Infant Mortality in Sub-Saharan Africa", *Journal of Policy Modeling* 41, (2019): PP 168-178.

Amouzou A and Hill K, "Child Mortality and Socioeconomic Status in Sub-Saharan Africa", *African Population Studies* 19, no. 1 (N.D): PP 1-12.

Anyanwu JC and Erhijakpor AEO, "Health Expenditures and Health Outcomes in Africa", African Development Bank, *Economic Research Working Paper Series*, No 91, (2007).

Ayotunde T, Obiyan M, Agunbiade OM, et al., "Maternal Age at Birth and Under-5 Mortality in Nigeria", *East African Journal of Public Health* 6, no. 1 (2009): PP 11-14.

Barenberg AJ, Basu D and Soylu C, "The Effect of Public Health Expenditure on Infant Mortality: Evidence from a Panel of Indian States, 1983 1984 to 2011 2012", *The Journal of Development Studies*, (2016), PP1 20. [https://DOI: 10.1080/00220388.2016.1241384](https://doi.org/10.1080/00220388.2016.1241384)

Boco AG, "Individual and Community Level Effects on Child Mortality: An Analysis of 28 Demographic and Health Surveys in Sub-Saharan Africa", *DHS Working Papers*, (2010), no. 73. Calverton, Maryland, USA: ICF Macro.

Burfeind LR, "*The Effects of Foreign Aid for Health on Health Outcomes in Developing Countries*", *Electronic Theses and Dissertations*, (2014), P 100. <https://digitalcommons.du.edu/etd/00>.

Burggraf C, Glauben T and Grecksch W, "New impacts of Grossman's health investment model and the Russian demand for medical care", *Journal of Public Health* 24, (2016):41-56. [https://DOI 10.1007/s10389-015-0692-5](https://doi.org/10.1007/s10389-015-0692-5).

Dhrifi A, "Health-care expenditures, economic growth and infant mortality: evidence from developed and developing countries", *CEPAL Review* 125, (2018): PP 70-91

Eboh A, Abba JY and Fatoye HA, "Impact Assessment of the Public Health Expenditure on the Health Outcome in Nigeria", *International Journal of Social and Administrative Sciences* 3, no. 2 (2018): PP 62 72. [https://DOI: 10.18488/journal.136.2018.32.62.72](https://doi.org/10.18488/journal.136.2018.32.62.72).

Ezeh OK, Agho KE, Dibley MJ, et al., "Risk factors for post-neonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis", *BMJ Open* 5, (2015). [https://doi:10.1136/bmjopen-2014-006779](https://doi.org/10.1136/bmjopen-2014-006779).

Fitaw YB and Worku A, "Impact of Child Mortality and Fertility Preferences on Fertility Status in Rural Ethiopia", *East African Medical Journal* 81, 6 (2004): PP 300-306.

Frey RS and Field C, "Social Indicators", *Research* 52, 3 (2000): PP 215–234. <https://doi.org/10.1023/a:1007093631977>.

Garcia J, "Urban-rural differentials in Latin American infant mortality", *Demographic Research* 42, no. 8 (2020): PP 203-244.

Garson GD, "Testing Statistical Assumptions", USA: Statistical Publishing Associates, (2012), P,50.
<https://www.statisticalassociates.com>.

Hair JF, Tathan RI and Anderson RE, 'Multivariate data analysis (6th Ed. 2005). Prentice-Hall. Houweling TAJ, Kunst AE, Looman CWN, et al., "Determinants of under-5 mortality among the poor and the rich: a cross-national analysis of 43 developing countries", *International Journal of Epidemiology* 34, (2005): PP 1257–1265.

Kayode GA, Adekanmbi VT and Uthman OA, "Risk factors and predictive model for under-five mortality in Nigeria: evidence from Nigeria demographic and health survey. *BMC Pregnancy and Childbirth* 12, 10 (2012): PP 1-11.

Kirigia JM, Muthuri RDK, Nabyonga-Orem J, et al., "Counting the cost of child mortality in the World Health Organization African region", *BMC Public Health* 15, no. 1103 (2015): PP 1-13.
[https://DOI 10.1186/s12889-015-2465-z](https://doi.org/10.1186/s12889-015-2465-z).

Kiross GT, Chojenta C, Barker D, et al., "The effects of health expenditure on infant mortality in sub-Saharan Africa: evidence from panel data analysis", *Health Economics Review* 10, no. 5 (2020): PP 1-9.

Lu Z, Bandara JS and Paramati SR, "Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies", *Aust Econ Pap.*, (2019), PP 1–21.
<https://doi.org/10.1111/1467-8454.12167>.

Matthews Z and Diamond I, "The Expanded Programme on Immunisation: Mortality Consequences and Demographic Impact in Developing Countries", *Genus* 55, no. 1/2 (1999): PP 73-100.

Meji'a-Guevara I, Zuo W, Bendavid E, et al., "Age distribution, trends, and forecasts of under-5 mortality in 31 sub-Saharan African countries: A modeling study", *PLoS Med* 16, (2019): PP 1-21.

Mishra P and Newhouse D, "Health Aid and Infant Mortality", *IMF Working Paper*, (2007), WP/07/100.

Morris SS, Black RE and Tomaskovic L, "Predicting the distribution of under-five deaths by cause in countries without adequate vital registration systems", *International Journal of Epidemiology* 32, (2003): PP 1041-1051.

Mugarura A and Kaberu W, Multilevel Analysis of Factors Associated with Child Mortality in Uganda. *African Journal of Economic Review* III, 2 (2015): PP 125-139.

Neter J, Kutner MH, Nachtsheim CJ, et al., *Applied linear statistical models*. Chicago, (1996), USA: Irwin Company Inc.

Nocera S and Zweifel P, "The Demand for Health: An Empirical test of the Grossman Model Using Panel Data. In Zweifel, P. Health, the Medical Profession and Regulation", *Developments in Health Economics and Public Policy* 6, (1998): PP 35-49. Boston: Kluwer. [https://DOI: 10.1007/978-1-4615-5681-7_2](https://doi.org/10.1007/978-1-4615-5681-7_2).

Olusegun OL, Ibe RT and Ikorok MM, "Curbing maternal and child mortality: The Nigerian experience", *International Journal of Nursing and Midwifery* 4, no. 3(2012): PP 33-39.

Palma-Solis MA, Díaz CA, Franco-Giraldo A, et al., "State Downsizing as a Determinant of Infant Mortality and Achievement of Millennium Development Goal 4", *International Journal of Health Services* 39, no. 2 (2009): PP 389-403.

Pardosi JF, Adair T, Rao C, et al., "Measuring Subnational Under-5 Mortality: Lessons from a Survey in the Eastern Indonesian

District of Ende." Asia Pacific Journal of Public Health 26, no. 4 (2014): PP 367-377.

Pritchard and Keen S, "Child mortality and poverty in three world regions (the West, Asia and Sub-Saharan Africa) 1988–2010: Evidence of relative intra-regional neglect?" *Scandinavian Journal of Public Health* 44, (2016):734–741

Rutstein SO, "Factors associated with trends in infant and child mortality in developing countries during the 1990s", *Bulletin of the World Health Organisation* 78, (2000): PP1256-1270.

Sastry N, "Trends in Socioeconomic Inequalities in Mortality in Developing Countries: The Case of Child Survival in São Paulo, Brazil", *Demography* 41, no. 3 (2004): PP 443-464.

Tabutin D, Masquelier B, Grieve M, et al., Mortality Inequalities and Trends in Low and Middle-Income Countries, 1990-2015, vol. 72 (ed. 2002 Population English, 2017), PP 220-295.

Ushie BA, Fayehun OA and Ugal DB, "Trends and patterns of under-5 vaccination in Nigeria, 1990–2008: what manner of progress?" *Child: care, health and development* 40, no. 2(2013): PP 267-274.

Yaya S, Bishwajit G, Okonofua F, et al., "Under-five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis", *PLoS ONE* 13, no. 10 (2018): PP 1-14.