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Health Expenditure and Infant Mortality in Sub Saharan Africa: Evidence from Threshold Regression

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Abstract

This study aims to determine the impact of healthcare spending on infant mortality rates in 45 sub-Saharan African nations from 2000 to 2020. Utilizing threshold regression, it reveals that lower regime dependents exhibit a decrease in public health spending below a certain threshold, leading to a positive correlation between total public health expenditure and infant mortality rates. Conversely, external medical funding significantly reduces infant mortality in higher threshold regimes but not in lower threshold regimes.

Private health expenditure negatively and significantly impacts both lower and higher income groups, placing undue pressure on residents. However, the study does not fully account for sociocultural factors influencing infant mortality in the region. The research highlights that direct healthcare costs in the region meet the minimum threshold for health expenditure and are inversely related to infant mortality rates.

Keywords: *Threshold Regression; Health Expenditure; Infant Mortality; Healthcare; Sub Saharan Africa.*

JEL Classification: *A13, I15, I18, O55.*

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1. Introduction & Literature

This research seeks to pinpoint exactly what amount of health spending in sub-Saharan Africa area that serves as threshold to affect infant mortality rates. Out of the total of 55 countries in the region, 45 has been chosen for analysis and examination. Public health concerns have been raised by the impact of the healthcare system on humanity, particularly by policymakers in developed and developing countries alike. This has prompted attempts to discover a long-term fix, which has shown to be a burden because of numerous health issues, such as current pandemics and endemic diseases that have impacted people worldwide at all ages. Because health is viewed as an investment, there is a great deal of national heterogeneity in the healthcare finance methods (Barroy et al., 2016).

Over the last 15 years, public investment in the health care sector has increased in middle-income countries from 48% to 51% of present expenditure, while within nations with high incomes, it has increased from 66% to 70% (Barroy, et al., 2017). It is commonly known that countries with middle- and high-incomes direct a greater share of their health spending to mandatory prepayment sources, like government grants and social insurance investments (Barroy, et al., 2017; WHO, 2016; Charfeddine, & Mrabet, 2017). In many African nations, rising national incomes or revenue from government do not always translate into higher government health spending, with indigenous financing from the government in low-income nations dropping from 30% to 22% as financial assistance grew from 20% to 30% (WHO, 2017). When contrasted with other areas, Sub-Saharan Africa region has relatively lower health expenditures, which is worth noting.

Nevertheless, it is imperative to mention that numerous African nations have exhibited advancements in augmenting their fiscal appropriations towards healthcare over the past 15 years, as documented by the World Health Organisation in 2018. Even so, a significant portion of the healthcare funding within the area of SSA is derived from the private funding and predominantly comprises expenditures made directly by individuals. Based on estimations provided by the World Health Organisation (WHO) in 2017, it is indicated that a significant proportion, approximately 10% among the regional population is confronted with financial challenges on an annual basis due to out-of-pocket expenditures. Furthermore, it is observed that up to 4% of individuals are compelled to fall below the poverty threshold established within the territory (WHO, 2017).

Government support from external sources, including bilateral and multilateral agencies, is of utmost importance in bolstering the healthcare systems in economies with little income and a high incidence of diseases. The

provision of financial assistance has a noteworthy influence on enhancing health outcomes among the population, particularly in terms of mitigating newborn mortality rates (Rahman, Khanam, Rahman, 2018). Infant mortality simply means the occurrence of death among children under the age of five (Bairoliya, 2018). The mortality rate of babies in Sub-Saharan Africa (SSA), not only quite high according to Kiross et al. (2020), but also lacks sufficient information regarding the specific threshold of health spending required for policy guidance. Therefore, endeavours aimed at mitigating infant mortality are noted to be deeply rooted in the Sustainable Development Goals (Le Blanc, 2015; WHO, 2016).

In light of this observation, sub-Saharan African nations have embraced the approach of augmenting their healthcare expenditure, albeit allocating a smaller portion of their budgets to their economies compared to rich and emerging nations, mostly due to resource constraints and other contributing reasons (UNCTAD, 2020). Boosting the general health of citizens is associated with increased productivity in the workplace, improved earnings, and the overall well-being of the population. Consequently, increased health expenditure acts as a stimulus for economic growth (Kurt, 2015; Piabuo & Tieguhong, 2017; Raghupathi & Raghupathi, 2020). There is no doubt that placing greater emphasis on reducing infant mortality yields significant economic benefits. Research has established a clear association between higher infant mortality rates and adverse effects on adult health, as well as improvements in education and productivity (Akinlo & Odusanya, 2016; Novignon & Lawanson, 2017; Umar, 2017).

Research has indicated that prioritising the protection of childhood health holds greater significance compared to other age groups. This is due to the fact that inadequate healthcare during the formative years of babies is likely to have long-lasting detrimental effects on their overall health throughout their lifespan (Belli, Bustreo, & Preker, 2005). In a considerable number of OECD nations during the past four decades, the rates of neonatal and child mortality have significantly decreased, accompanied by a substantial increase in life expectancy (Ebru, 2012). The disparity between sub-Saharan Africa's average allocation of 6.1 percent of total GDP towards healthcare and that of OECD countries is evident (WHO, 2016). One possible explanation for this phenomenon could be the comparatively smaller allocation of funds towards healthcare delivery in Sub-Saharan Africa (SSA).

Globally, an approximate total of 5.2 million infant mortalities were documented, with Sub-Saharan Africa being responsible for over 50% of these fatalities (UNICEF, 2020).

The literature has identified several socioeconomic determinants that contribute to the increasing infant mortality rate in Africa. These determinants include per capita income, unsuitable environmental conditions, ineffective female training and education, restricted government expenditure in the sector, and other factors (Piabuo & Tieguhuong, 2017). All of these obstacles could be linked to the SSA regions' comparatively lower per capita health expenditure.

Despite several attempts made by African leaders to increase the distribution of financial resources to the healthcare industry, there has been an incommensurate lack of significant outcomes. (Piabuo & Tieguhuong, 2017).

Previous research has sought to identify factors contributing to the rise in infant mortality rates by investigating the correlation between healthcare spending and newborn mortality rates in Africa. (Sarpong & Owoo, 2018; Kiross et al., 2020; Modibbo & Saidu, 2020). However, it is worth noting that most of the aforementioned research have not precisely investigated the precise threshold of health expenditure that either exacerbates or mitigates infant mortality in the African context. The primary motivation behind this study is to determine the precise thresholds at which healthcare expenditures have an effect on the rates of infant mortality within the Sub-Saharan African region. Also, the authorities may consciously assign scarce healthcare funds to treatments with the greatest influence on infant mortality reduction. Recognising the precise times when spending a greater sum becomes unproductive or even dangerous would allow us to deploy resources more efficiently and improve the health consequences for mothers and their children.

Hence, our contribution to the knowledge focus on meticulous drafting ensures that efforts are both effective and adaptable enough to the different socioeconomic and healthcare conditions prevalent in Sub-Saharan African countries. It serves as a foundation for evidence-based decision-making, allowing political leaders to enact policies that have the most positive impact on children's health, given the identified minimum threshold.

The following sections of the manuscript are organised in the following way: Section two focuses on providing a clear understanding of literature, while section three delves into the data and the methodology; findings and conclusions are also included in sections four and five respectively.

2. Literature Review

2.1. Grossman Health Production Theory

According to the Grossman theory, the concept of health can be understood as an investment in the context of the human capital production function. The underlying premise of this argument is that allocating resources towards healthcare and education facilitates the improvement of human knowledge and skills, resulting in a subsequent rise in the desire for improved health outcomes. The theory elucidated the distinction between the direct stock of health, which generates enjoyment through the consumption of commodities or services, and the indirect stock of health, which is derived from the time allocated to various market and non-market activities. The falling relative output of this production function is a significant determinant. The disparities in healthcare-related inputs and health status between industrialised and developing nations serve as indicators of the outcomes derived from the production function. Undoubtedly, there exist multiple factors that exert influence on an individual's health, encompassing societal, economic, environmental, and biological considerations. Hence, it can be shown that a range of social and economic factors exert an influence on the determinants that directly impact both positive and negative health risks, subsequently affecting health outcomes. The present study used the Grossman theory of investment in human capital as a conceptual framework. This theory postulates that the allocation of resources towards enhancing human capital, encompassing domains such as health and education, could significantly influence the overall health state of individuals. Consequently, this improved health status is believed to contribute to the advancement of economic growth. The decision was influenced by a thorough examination of critical evaluations pertaining to pertinent theories.

2.2. Empirical Literature

Onoka, Onwujekwe, Hanson, and Uzochukwu (2011) examined the occurrence of catastrophic health expenditures in Nigeria by employing household consumption expenditure diaries and considering several thresholds. The household diaries were employed for collecting data on illnesses and consumption by the household for a total of 1128 households across the span of one month. The study focused on analysing catastrophic health cost using two different approaches: One approach relies on consistent threshold levels for non-food expenses, whereas the other uses a distinct set of adjustable thresholds. In the latter approach, the thresholds for different socioeconomic status (SES) groups were adjusted based on the proportion of household spending allocated to food. The study's findings indicate that 14.8% of the homes surveyed, totalling 167, encountered a catastrophic event when their non-food expenses reached a threshold of 40%. Among

these households, the poorest quintile experienced a higher rate of catastrophe at 22.6%, while the richest quintile had a lower

Similarly, the study conducted by Tobias, Armstrong, Zuza, Gasparrini, Linares, and Diaz (2012) investigated the effect of an excessive number of days with high temperatures on the rate of infant deaths in Spain, utilising official thresholds. The research utilised Generalised Estimating Equations (GEE) for Poisson regression analysis in order to evaluate the efficacy of the official cut off points that each provincial capital city's Ministry of Health has established. This was achieved through the process of quantification and comparison of the immediate impacts of days exceeding the specified thresholds on the overall daily death rate. The analysis revealed significant variability in the number of days surpassing the established limits, with certain provinces exhibiting a high frequency of surpassed days while other provinces shown infrequent or no instances of exceeding the standards. This provides further substantiation of the pressing need for the provision of care for children in Spain. The analysis revealed notable variability in the relative risk across the cities under investigation, suggesting that the established thresholds may have been excessively stringent for the specific places under scrutiny.

The study conducted by Goodness & Prosper (2017) looked at the influence of GDP growth upon the release of CO2 by employing the dynamic panel threshold approach. The research being conducted relies on statistics obtained through a panel of 31 emerging nations. The employed data indicated that during periods of poor economic growth, there is a correlation between an increase in CO2 emissions and a fall in economic growth. Nevertheless, during the period of rapid economic growth, there exists a close relation between the growth of the economy and an increase in CO2 emissions, with a more pronounced influence recorded in this particular period.

In a study conducted by Paudel (2019), an investigation was conducted regarding the threshold level of disastrous health expenditure in the context of healthcare, which has emerged as a significant public health issue in Nepal, particularly in the Kailali district. This district holds particular importance as it was the initial site in connection with the execution of the government health insurance programme in Nepal. A cross-sectional survey was undertaken over the period of January to February 2018, including a total of 1048 households, which consisted of 6480 persons. This survey was done subsequent to the implementation of the social health insurance programme for duration of 21 months. In the initial stage of the sample selection process, wards were chosen, and afterwards, households were picked. In aggregate, a total of 17.8% of households indicated experiencing catastrophic health expenditure, as defined as surpassing a threshold of 10% of out-of-pocket payment relative to the entirety of their household or domestic spending. The research uncovered that household without insurance for healthcare were living with low socioeconomic condition, and headed by individuals with little educational attainment

were more prone to experiencing financial hardship that surpasses the predetermined threshold, resulting in catastrophic expenditure..

In a similar vein, the research conducted by Yang (2020) examined the connections among health spending, the supply of labour and its effects upon the growth of the economy across the sample of 21 developing countries spanning from the years 2000 to 2016. The research employed a panel threshold model to conduct an empirical examination of the correlation involving national health spending and economic development across varying levels of human capital. The results show a solid correlation between health care consumption and economic development, which can be attributed to variations in levels of human capital. Studies have shown very strong negative connections between spending on healthcare and GDP growth in the economy, especially in economies where the levels of skilled labour are weak. Whenever the degree associated with human resources is moderate, the influence of the health care spending on the level of economic growth has positive sign, however, lacks statistical significance. The presence of a high level of human capital amplifies the favourable economic effects of health expenditure. Furthermore, it has been observed through subgroup analysis that the presence of increasing population ageing together with low fertility worsens the negative impact of health spending on economic growth in the entire region.

In a comprehensive examination of the empirical data, Rahman (2020) executed an investigation to analyse the effect of macroeconomic conditions upon the attainment of Sustainable Development Goals in Nigeria. Specifically, the author focused on the infants and under-5 rate of mortality in Nigeria during 1986 to 2017, employing the fully modified OLS approach for analysis. The author highlights the impact of an unfavourable macroeconomic policy environment, including factors such as female unemployment, foreign exchange rate, and CPI inflation, regarding neonatal and child mortality rates.

In the investigation undertaken by Abdullah et al (2023), the aim was to examine the tangible effects of various categorizations of environmental levies imposed on carbon dioxide (CO2) emission in 34 OECD member countries between 1995 and 2019. Likewise, the study conducted by Seo and Shin (2016) employed the dynamic panel threshold regression framework for assessing the conditional association linking CO2 emissions with taxes on the environment, while considering a certain threshold level. The analysis identified one major threshold as well as two distinct regimes (the upper and the lower) for every kind of environmental tax. According to the findings of the dynamic panel threshold regression analysis, the overall implementation of environmental, energy, and pollution taxes collectively decreases CO2 emissions when a specified threshold level is exceeded. The criteria for the overall environmental tax, energy tax, and pollution tax are set at 3.002% of GDP, 1.991%, and 0.377% accordingly.

3. Data and Methodology

3.1. Data Source

The investigation utilised an ex post facto research design and collected data included forty-six out of fifty-five nations in the Sub-Saharan area of Africa. The time frame for data collection spanned from 2000 to 2020, as reported by the World Development Indicators (WDI, 2020). This imperative arises due to the realisation that the selected nations possess the requisite data pertaining to the significant variables employed in the investigation.

The current study incorporates a solitary dependent variable, which encompasses infant mortality, in conjunction with seven independent variables. The rationale for incorporating these variables is grounded in theoretical propositions. For instance, in the case of infant mortality, which is a term that describes the amount of newborns or children that do not survive to reach the age of one year, Grossman posited that individuals possess a stock of health that diminishes over time. Additionally, investment in health through various forms of health spending (such as public, private, and external sources) can be viewed as an inflow of funds into the health sector. It is anticipated that, such investment would result in detrimental impact upon the death rate of infants. This viewpoint is supported by the findings of Novignon and Lawanson (2017) as well as Akinlo and Sulola (2018). Similarly, with regards to female literacy, Grossman's health demand theory posits that when it comes to predicting the likelihood of a child's survival, the amount of education that a mother possesses is a critically important factor. This assertion is further corroborated by the findings of Akinkugbe and Mohanoe (2009). In relation to immunisation, it has been asserted that a child achieves sufficient immunisation against measles upon taking a single dose of vaccine, leading to a decrease on the danger of death among infants. This claim is backed by the research conducted by Akinkugbe and Mohanoe (2009) as well as Akinlo and Sulola (2018). The consideration of carbon dioxide (CO2) emissions acknowledges the significance of maintaining a pristine environment, a factor that has also been factored into the economic assessment of infant mortality. This aligns with the findings of Dhrifi (2018).

3.2. Model Specification

The current research makes use of the research that Ouedraogo *et al.* (2020) have conducted, which serves as an expansion of Grossman's health demand and production theory (1972). The research highlights the notion that increasing performance may be achieved by directing resources to the investment in human capital which encompasses both physical well-being and intellectual or educational development. This is the foundation of the research. According to this idea, every single person, on a micro level, is the one who is responsible for their

own health. In addition to this, the idea accepts the possibility that one's health may be regarded as an investment that is losing value over time. Individuals, who are aware of the significance of their own health, have the ability to allocate resources to improve their health condition, even if the value of their healthcare assets is decreasing. This is the essential idea that underpins this concept. There are numerous health outcomes that can be improved by investing in health resources, as Grossman (1972) demonstrated. These outcomes include a healthier lifespan, increased longevity, and a decrease in the infant's mortality rate.

The theoretical framework posits that better health experiences a decline in value over time and may be examined as a kind of capital. Based on the established theoretical framework and drawing from prior research conducted by Novignon et al. (2012) and Akinlo & Sulola (2019); the following describes the empirical framework that was used in this investigation.;

$$IM_{it} = \varphi_0 + \varphi_1 HE_{it} + \varphi_2 CV_{it} + \varepsilon_{it} \quad (i)$$

Where IM denotes infant mortality which explains the modifications to H_t ; HE is the vector of health expenditure variables (private, public, external); CV is a collection of elements arranged in a specific order (vector) theoretically motivated (controlled) variables; ε means the error term;φ_0 is the constant; $\varphi_1, \varphi_2, \varphi_3$,are the parameter estimates; while i and t respectively denotes country and time effects.

Through the utilisation of Panel Threshold Regression (PTR) model established by Hansen (1999), it is feasible to ascertain the minimum level of economic growth and health spending that must be undertaken in order to lower infant mortality. The estimation of the endogenous threshold is made possible by this model; hence, the Panel Threshold Regression model can be defined in the following manner:

$$IM_{it} = \alpha_i + \beta X + PUE,PHE,EXHEP.\ I(q_{it} \leq \Upsilon) + PHE\ PUE\ EXHEP\ .\ I(q_{it} > \Upsilon) + \varepsilon_{it} \quad \text{(ii)}$$

The dependent variable IM_{it} represents the measure of infant mortality; While the threshold variable (q_{it}) is the health expenditure and economic ratio to infant mortality. Υ is the threshold parameter. I(.) is the indicator function. The country-fixed effects are denoted by αi. The study's control variables (immunisation, CO2 emission, and female literacy) are contained in X. The temporal dimension (2000-2019) is denoted by the index t (t=1…T), while the individual dimension (46 Sub-Saharan African countries) is denoted by the index i (i=1… N). The estimate of this model necessitates several procedural stages. For instance, the equation is estimated by the OLS approach to be able to ascertain the threshold. Subsequently, sum of squares residuals is calculated for each

conceivable value of the threshold y, and the iterative procedure persists. The linear threshold model is defined as;

$$IM_{i\,t} = \beta_0(q)Phe_{\,i\,t}\beta_1(q)Pue_{\,i\,t} + \beta_2(q)Exhep_{\,i\,t} + \gamma(q)'CV_{i\,t} + \varepsilon_{i\,t} \quad \text{(iii)}$$

Where$\beta_0(q)$, $\beta_1(q)$and $\gamma(q)$are the unknown parameters associated with the qth quantile; all other variables remain as defined in equation above.

4. Results and Discussion

4.1. Preliminary Test

The statistical independence of variables - namely infant mortality (INF), private health expenditure (PHE), external health expenditure (EXHEP), carbon dioxide (CO2) emissions, immunisation (IMM), education (EDU), urbanisation (URB), and public health expenditure (PUB) - can be inferred from the observed mean and median values presented in Table 1. These values fall within the range of maximum and minimum values, indicating that the variables are statistically independent. Furthermore, the table clearly demonstrates that the measures of dispersion, particularly the standard deviation, exhibit significant magnitudes.

Table 1. Descriptive Statistics

Variables	Measurement of Variables	Mean	Median	Std.Dev.	Max.	Min.
INF	**Infant Mortality**	58.805	57.200	24.255	11.800	139.500
PHE	**Private Health Expenditure**	48.670	48.578	18.458	8.465	88.109
EXHEP	**External Health Expenditure**	20.296	16.294	16.572	0.000	74.986
PUB	**Public Health Expenditure**	31.033	27.948	16.419	4.062	82.112
CO_2	**Carbon Dioxide**	0.993	0.295	1.864	0.016	11.676
IMM	**Immunisation**	74.587	77.000	17.540	16.000	99.000
EDU	**Education**	34.974	29.493	22.199	2.561	94.277

Table 2 displays the correlation matrix for the research series. Based on the data presented in the table, there exists a negative association of relatively low strength between infant mortality and private health expenditure, as indicated by a correlation coefficient of -0.38. In addition, it is intriguing to see, based on the correlation matrix, that

there exists a slight association (r = 0.36) between the index of public health expenditure and education (EDU). There exists an inverse correlation between newborn mortality and education or literacy levels, indicating that when baby death rates rise, education levels tend to decline, and vice versa. The analysis conducted in the study reveals that there is a lack of strong connection among the proposed explanatory variables. This finding suggests that the models utilised in the study do not suffer from a significant issue of multicollinearity.

Table 2. Pair-wise Correlation Matrix Results

	INF	**EDU**	**PHE**	**PUB**	**EXHEP**	**CO_2**	**IMM**	**URB**
INF	1.000							
EDU	-0.303*	1.000						
PHE	-0.380*	-0.348*	1.000					
PUB	-0.369*	0.344*	0.327*	1.000				
EXHEP	0.019*	-0.090*	-0.449*	-0.149*	1.000			
CO_2	-0.288*	0.363*	0.450*	0.288*	-0.406*	1.000		
IMM	-0.027*	0.178*	0.100*	0.404*	0.276*	0.021	1.000	
URB	-0.250	0.350*	0.280	0.320*	-0.150	0.042*	0.030	1.000

Note: The * and ** imply statistical significances at 1% and 5% levels respectively.

4.2. Regression Results

Table 3 provides the result of the threshold of public spending on healthcare for reducing newborn babies especially sub-Saharan Africa's rates of newborn mortality. The upper part of this table displays the presents estimated threshold for public health expenditure together with the related 95% confidence interval. The centre section of the analysis displays the coefficients of the regime-dependent variable, namely the influence of public health spending upon the infant mortality rate under the lower (higher) regime of government health expenditure. Regarding infant mortality in SSA, the regime dependant specifically highlights the influence of government health spending. The threshold value of 4.15% is situated inside both the lower and upper bounds of public health expenditure, as well as falling within the confidence range (see table 3). This indicates that the ratio of public health spending allocated to the lower region (4.13%) falls below the established threshold value, while the proportion allocated to the upper region (4.16%) exceeds the threshold parameter. The threshold level implies that if public health expenditure levels drop below 4.15%, there is a probability of observing a rise in newborn death rates.

The value for the coefficient that represents the sum of financial resources used to fund public health in the lower regime exhibited a negative correlation with infant mortality, as it fell below the threshold value of 4.15%. The findings demonstrates that an increase of one percent in government spending on health care in lower regime dependent areas is connected with an 0.0324% rising rate of infant mortality, with statistical significance at the 5% level. Nevertheless, the findings indicate that when examining the higher level regime, the outcome over the threshold exhibited a negative coefficient (-0.0797), suggesting a substantial association between the threshold and the rate of infant mortality in the respective area. The region's underfunding of healthcare, according to the positive coefficient on SSA, may impede efforts to lower infant death rates. In order to effectively tackle this issue in SSA area, it is imperative for the government to commit supplementary financial resources to the health sector, above a specific threshold. Only when health expenditure reaches a higher threshold level will infant mortality be reduced in the region. A one percent increase in the amount spent on public health within a higher level regime has been found to result in a reduction of infant mortality of 0.079% in the region. This statement implies that insufficient effectiveness among governments in sub-Saharan Africa (SSA) to adhere to the Abuja, 2000 declaration, which mandates a 15% increase in national health expenditure, could potentially prevent the region from achieving its goal of lowering the rates of infant mortality.

Similarly, the findings presented in Table 3 demonstrate that immunisation has led to a decrease in newborn death rates within the region. A 1% increase in the level of immunisation among children resulted in a reduction of infant mortality by 0.192% within the specified region. In the context of sub-Saharan Africa (SSA), enhancing parental understanding of immunisation and improving access to information regarding childhood immunisation through diverse channels may have an important influence in lowering child mortality rates by ensuring proper and adequate immunisation among children.

The findings shown in Table 3 indicate a negative correlation between education and infant death rates for the specified time, albeit lacking statistical significance. In the region, there was seen a negative correlation between education and newborn mortality, whereby a 1 percent increase in education was associated with a drop of 0.009 in infant death. The decrease in death rates across region of Sub-Saharan Africa can be attributed to the presence of education. This is particularly evident among the educated labour force, with a specific focus on females in the context of this study. These individuals possess enhanced skills, provide children with nutritious food, and are more likely to contribute to increased productivity. The study's results indicated a negative correlation between carbon dioxide levels and infant mortality. However, it is important to note that this correlation did not reach statistical significance within the given time frame. The observed outcome presented by carbon dioxide (CO2) serves as evidence that a significant number of governments within the Sub-Saharan Africa (SSA) region have not effectively implemented

a sustainable green economy approach. This deficiency can be attributed to either the limited capacity of policymakers or the insufficient enforcement of legislation pertaining to the regulation of atmospheric pollutants by the relevant sector.

Table 3. Threshold of Public Health Expenditure on Infant Mortality in SSA

Model		Threshold		Lower	Upper
TH-1		4.154		4.139	4.164
	Coefficient	**Std.Error**	**t-Stat.**	**Prob.**	**95% Conf.**
LnEDU	-0.0096	0.0087	-1.11	0.269	-0.0267
LnIMM	-0.1928	0.0289	-6.66	0.000***	-0.2497
$LnCO_2$	-0.0047	0.0207	-0.23	0.817	-0.0454
LnPUB					
0	0.0324	0.0118	2.74	0.006*	0.0092
1	-0.0797	0.0126	6.30	0.000***	0.0548
cons	13.200	0.3554	37.13	0.000***	12.5029

Note: The ***, ** and * indicate 1%, 5% and 10% significance levels respectively. Dependent variable is LnINF, Observation is 966, Prob > F is 0.0000.

Table 4 shows influence of private health expenditure thresholds on the infant mortality rate in Sub Saharan African region. The upper bound of the threshold is estimated as 3.551 percent while the lower bound is obtained as 3.530 percent in 95% confidence interval. The critical threshold value is estimated as 3.544 percent.

The private health expenditure coefficient in the lower regime exhibited a statistically significant negative effect. This implies that a decrease within newborn mortality rate is associated with a decrease in the amount of money spent on private health care that falls below the minimal threshold level of 3.530 percent. Within the lower regime, discovered that a statistically significant rise in private health spending of 1% leads to 0.080% drop in newborn mortality. This was demonstrated over the course of the study period. According to the findings of this research, the amount of money that individuals in the SSA region pay out of their own pockets for medical treatment has climbed to the point where it is sufficient to cover the minimum threshold for medical expenses. In addition, a negative association exists between the incidence of infant mortality and the sum of funds that is covered out of pocket for medical care.

Furthermore, at the upper range of private health expenditure, the coefficient outcome exhibited statistical significance and displayed a negative correlation with regards to infant mortality. A 1% rise in the cost of private health care is linked to a 0.057 percent decrease in newborn mortality in higher-regime settings. This suggests that regardless of the specific level of private health expenditure, whether it is lower or larger, there will be a considerable reduction in infant mortality.

Table 4. Threshold of Private Health Expenditure on Infant Mortality in SSA

Model		Threshold	Lower		Upper
TH-1		3.5443	3.5302		3.5519
	Coefficient	**Std.Error**	**t-Stat.**	**Prob.**	**95% Conf.**
LnEDU	-0.0123	0.0089	-1.37	0.170	-0.0298
LnIMM	-0.1855	0.0298	-6.22	0.000***	-0.2441
LnHIV	0.1686	0.0206	8.18	0.000***	0.1281
$LnCO_2$	-0.0007	0.0215	-0.04	0.971	-0.0431
LnURB	-0.8992	0.0679	-13.23	0.000***	-1.0326
LnPHE					
0	-0.0806	0.0262	-3.07	0.002*	0.1322
1	-0.0570	0.0231	-2.46	0.014**	0.1024
cons	13.3904	0.3785	35.37	0.000***	12.6474

Note: The ***, ** and * indicate 1%, 5% and 10% significance levels respectively. Dependent variable is LnINF, Observation is 966, Prob > F is 0.0000.

An observed correlation indicates that a higher rate of immunisation reduces child mortality by 0.185 percent within the specified region. Also, the research revealed a decrease in child mortality within the area has been associated with the coefficient of education (-0.0123). However, it is important to note that the observed probability did not exhibit statistical significance over the duration of the current research. During the duration of this study, it was observed that there was a positive correlation between the increase in literacy rate by 1 percent and a corresponding decrease in infant mortality by 0.0123 percent. Furthermore, it is seen that there is a marginal drop of 0.0007 percent in newborn mortality as

carbon dioxide emission increases by one percent. However, it is important to note that this decrease is not statistically significant.

The potential insignificance of carbon dioxide can be attributed to the theoretical notion that its emissions are not environmentally sustainable and may lead to a reduction in the oxygen-carrying capacity, particularly in maternal haemoglobin. Therefore, the outcome was in opposition to the anticipated outcome.

Table 5. Threshold of External Health Expenditure on Infant Mortality in SSA

Model		Threshold		Lower	Upper
TH-1		1.6256		1.5056	1.7464
	Coefficient	**Std.Error**	**t-Stat.**	**Prob.**	**95% Conf.**
LnEDU	-0.0123	0.0089	-1.39	0.166	-0.0298
LnIMM	-0.1809	0.0298	-6.05	0.000***	-0.2441
LnHIV	0.1499	0.0200	7.49	0.000***	0.1281
$LnCO_2$	0.0095	0.0200	0.45	0.656	-0.0431
LnEXHEP					
0	0.0666	0.0189	3.53	0.000***	0.1036
1	-0.0014	0.0005	-2.89	0.004*	-0.0024
cons	13.0945	0.3645	35.92	0.000***	12.3790

Note: The ***, ** and * indicate 1%, 5% and 10% significance levels respectively. Dependent variable is LnINF, Observation is 966, Prob > F is 0.0000.

Table 5 presents threshold analysis for external health expenditure on infant mortality in Sub Saharan Africa. The upper bound of the threshold is estimated as 1.7464 percent while the lower bound is obtained as 1.5056 percent in 95% confidence interval. The critical threshold value is estimated as 1.6256 percent.

There exists a significant positive correlation between the coefficient of external health expenditure at lower thresholds and infant mortality. This phenomenon can potentially be attributed to various factors, including widespread corruption in many Sub-Saharan African (SSA) countries. Corruption often impedes the effective allocation and utilization of external aid intended for health purposes. Consequently, higher levels of external health expenditure in such contexts have been associated with increased infant mortality rates.

Specifically, a 1% increase in health spending from external sources below the threshold level is statistically linked to a significant 0.066% rise in infant mortality.

Conversely, within higher threshold regimes, an inverse correlation coefficient of external health expenditure reveals a beneficial association with reduced infant mortality beyond the threshold expenditure level. A 1% increment in external health expenditure here leads to a statistically significant decrease of 0.001% in newborn mortality, indicating a substantial impact on reducing child mortality. This effect is statistically significant only within higher threshold regimes, contrasting with the findings from lower threshold regimes where such impacts were not observed.

Moreover, a marginal decrease of 0.012% in newborn mortality rates was noted with a 1% increase in literacy rates achieved through schooling. However, this decrease was not statistically significant in the current regional context. Additionally, a statistically significant reduction of 0.180% in newborn mortality was observed with a mere 1% rise in immunization rates. Conversely, a 0.09% increase in newborn mortality was associated with a 1% increase in carbon dioxide emissions, although this finding was not statistically significant.

4.3. Discussion

The findings from Table 3 indicate that there is a threshold for public health spending on infant mortality. The estimated threshold is 4.15 percent, below which improvements in infant mortality cannot be achieved, even if other health outcomes show positive results in the region. To make progress in reducing infant mortality, it is necessary for the government to improve the amount it spends on health care. In the lower regime of public expenditure on healthcare, there was a notable positive coefficient, indicating an increase in infant mortality rates. Conversely, in the higher regime, there was a substantial negative coefficient, suggesting a decrease in infant mortality rates. This implies that the enhancement of newborn death rates in SSA region is contingent upon the allocation of government funds at a higher level. This result is consistent with the research that was undertaken by Chakroun (2012), which employed the threshold detection technique proposed by Hansen (1999) providing the evidence that in Africa, there are nonlinear interactions that involve economic growth and health.

Similarly, Table 4 displays the findings regarding the connection between private health care costs and child mortality. The results indicate the existence of a threshold of 3.54 percent below through which health care spending possesses no substantial impact on lowering infant death within the region. The findings of

this study indicate a strong and unfavourable correlation between a decrease in private health expenditure and a drop in newborn death rates. Similarly, the outcome of increased levels of private expenditure exhibited a statistically significant negative impact. This finding suggests that regardless of the level of private health spending, there will be a substantial reduction in infant mortality. The results were consistent with the study conducted by Andreoni and Galmarini (2016), which included private health expenditure as a covariate. The decline in newborn death rates could potentially be linked to the specific circumstances or geographical area where individuals mostly rely on the out-of-pocket spendings as the primary means of funding health care.

The findings in Table 5 indicate that there is a threshold for external health expenditure in relation to child mortality. A threshold of 1.625 percent has been computed, which indicates that health expenditures that fall below this level do not possess a substantial effect on the decrease in infant deaths within the area. When compared to the highest threshold of 1.746 percent, the lower threshold that was seen was observed to be 1.505 percent. The coefficient of external health expense was demonstrated to have a positive value within the lower regime zone, which indicates that there is a direct association between the sum of money used on external health care and the rate of infant mortality. In spite of this, the higher authority presented evidence of a correlation that was not only obvious but also statistically significant and revealed a negative nature. Since this is the case, the only way to achieve the reduction in infant mortality is through increased levels of governance. This study is comparable to the research that was carried out by Rana, Alan, and Gow (2018). In that study, the researchers evaluated the association between health outcomes and health costs in 161 countries with varying economic situation, including both developed and developing nations, between the years 1995 and 2014. For this purpose, an autoregressive distributed lag panel (PARDL) methodology was used in this investigation. According to the results of the investigation, it appears to be a more substantial connection between the sum of money utilised for external health care and the outcomes of health care costs in low-income nations as opposed to high income ones.

5. Conclusion

The findings of the investigation show that a strong correlation exists between health care spending and infant mortality in the region. The analysis primarily emphasises the lower range of public and external health expenditure in relation to the benchmark, with a threshold of 4.16 and 1.74 respectively needed to effectively decrease infant death in sub-

Saharan Africa. Hence, it is imperative for the government to boost the financial commitments to the health care sector so as to decrease the minimum level of healthcare expenditure required to mitigate infant mortality. The differences in threshold results pertaining to private, public, and external health expenditures stem from their distinct funding systems, objectives, and approaches to administration. The contrasts noted above have implications for the financial responsibilities individuals have, their ability to obtain healthcare services and their evaluation of the level of care provided or they receive, and the general sustainability of the health system. Policymakers must carefully consider these discrepancies when developing and implementing healthcare policies to ensure equitable and unbiased access to healthcare services and positive health outcomes for all demographic groups.

References

Akinkugbe, O., & Mohanoe, M. (2009). Public health expenditure as a determinant of health status in Lesotho. Social Work in Public Health, 24(1), 131-147.

Akinlo, A.E., & Sulola, A.O. (2018). Health care expenditure and infant mortality in Sub Saharan Africa. Journal of Policy Modeling, 41(1), 168–178.

Andreoni, V., & Galmarini, S. (2016). Drivers in CO2 emissions variation: A decomposition analysis for 33 world countries. Energy, 103, 27-37.

Aregbeshola, B.S., & Khan, S.M. (2018). Out-of-pocket payments, catastrophic health expenditure and poverty among households in Nigeria. International Journal of Health Policy and Management, 7(9), 798–806.

Bairoliya, N. (2018). Causes of death and infant mortality rates among full-term births in the United States between 2010 and 2012. Journal of Plus Medicine, 15(3), 21-36.

Barroy, H., Sparkes, S., & Dale, E. (2016). Assessing fiscal space for health in low and middle-income countries: A review of the evidence. WHO Health Financing Working Paper No. 3. Retrieved from https://doi.org/(WHO/HIS/HGF/HFWorkingPaper/16.3)

Barroy, H., Kutzin, J., & Tandon, A. (2017). Assessing fiscal space for health in the SDG era: A different story. Health Systems & Reform, 4, 4–7. https://www.tandfonline.com/doi/citedby/10.1080/23288604.2017.1395503?scroll=top&needAccess=true

Belli, P.C., Bustreo, F., & Preker, A. (2005). Investing in children's health: What are the economic benefits? World Health Organization Bulletin, 77-84.

Bick, A. (2010). Threshold effects of inflation on economic growth in developing countries. Economics Letters, 108, 126–129. https://doi.org/10.1016/j.econlet.2010.04.040

Chakroun, M. (2009). Health care expenditure and GDP: An international panel smooth transition approach. MPRA Paper No. 14322.

Charfeddine, L., & Mrabet, Z. (2017). The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. Renewable and Sustainable Energy Reviews, 76, 138–154. https://doi.org/10.1016/j.rser.2017.03.031

Danladi, G. (2021). An empirical analysis of the impact of government health expenditure on the performance of the health sector of Nigeria. International Journal of Social Sciences and Economic Review, 3(3), 35–44.

Ebru, T. (2012). The relationship between health and growth in Eurasian Economic Union. Eurasian Journal of Economics and Finance, 5(4), 31-44.

Goodness, C.A., & Prosper, E. (2017). Effect of economic growth on CO2 emissions in developing countries: Evidence from a dynamic panel threshold model. Cogent Economics & Finance, 5(1), 1-22.

Kiross, G.T., Chojenta, C., Barker, D., & Loxton, D. (2020). The effects of health expenditure on infant mortality in Sub-Saharan Africa: Evidence from Panel Data Analysis. Health Economics Review, 10(5), 1-9.

Kur, K., Ogbonna, E.A., & Eze, A.A. (2020). Health expenditure and economic growth nexus in Nigeria: Does institutional quality matter? Journal of Economics and Allied Research, 4(4), 44-62.

Kurt, S. (2015). Government health expenditures and economic growth: A federal-run approach for the case of Turkey. International Journal of Economics and Financial Issues, 5(2), 441–447.

Modibbo, H.U., & Saidu, A.M. (2020). Health expenditure and economic growth nexus: A Generalized Method of Moment approach for the case of selected African countries. Lapai Journal of Economics, 4(1), 12-30.

Moran, N., & Moodley, J. (2012). The effect of HIV infection on maternal health and mortality. International Journal of Gynaecology and Obstetrics, 119, 526–529.

Munteh, P., & Fonchin, A. (2020). Public health expenditure and child mortality rate as determinants of full immunization coverage and poverty rates in Cameroon. ARC Journal of Clinical Case Reports, 6(1), 17–30.

Novignon, J., & Lawanson, A.O. (2017). Health expenditure and child health outcomes in Sub-Saharan Africa. African Review of Economics and Finance, 9(1), 96-141.

Novignon, J., Olakojo, S.A., & Nonvignon, J. (2012). The effects of public and private health care expenditure on health status in Sub-Saharan Africa: New evidence from panel data analysis. Health Economics Review, 2, 22.

Onoka, C.A., Onwujekwe, O.E., Hanson, K., & Uzochukwu, B.S. (2011). Examining catastrophic health expenditures at variable thresholds using household consumption expenditure diaries. Tropical Medicine and International Health, 16(10), 1334–1341.

Onwujekwe, O., Uzochukwu, B., & Kirigia, J. (2011). Basis for effective community-based health insurance schemes: Investigating inequities in catastrophic out-of-pocket health expenditures, affordability and altruism. African Journal of Health Economics, 4(1), 1-11.

Organization, W.H. (2016). World health statistics 2016: Monitoring health for the SDGs sustainable development goals. Geneva: World Health Organization.

Organization, W.H. (2017). World health statistics 2017. Geneva: World Health Organization.

Ouedraogo, I., Dianda, I., & Adeyele, I.T. (2020). Institutional quality and health outcomes in Sub Saharan Africa. Research in Applied Economics Africa, 12(4), 22-45.

Paudel, D.R. (2019). Catastrophic health expenditure: An experience from health insurance program in Nepal. Emerging Science Journal, 3(5), 1-14.

Phimphanthavong, H. (2013). The impacts of economic growth on environmental conditions in Laos. International Journal of Business Management and Economic Research, 4, 766–774.

Piabuo, G., & Tieguhong, N. (2017). Health expenditure and economic growth - A review of the literature and an analysis between the Economic Community for Central African States (CEMAC) and selected African countries. Health Economics Review, 7(23), 76-91.

Raghupathi, V., & Raghupathi, W. (2020). Healthcare expenditure and economic performance. Frontiers in Public Health, 8(156), 1-15.

Rahman, M.M., Khanam, R., & Rahman, M. (2018). Health care expenditure and health outcome nexus: New evidence from the SAARC-ASEAN region. Globalization and Health, 14(11), 1-113.

Rana, R.H., Alam, K., & Gow, J. (2018). Development of a richer measure of health outcomes incorporating the impacts of income inequality, ethnic diversity, and ICT development on health. Global Health, 14, 72.

Salahuddin, M., Gow, J., & Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust? Renewable and Sustainable Energy Reviews, 51, 317–326. https://doi.org/10.1016/j.rser.2015.06.005

Sarpong, B., & Owoo, N.S. (2018). Health and economic growth nexus: Evidence from selected Sub-Saharan African (SSA) countries. Global Business Review, 4(4), 34-46.

Seo, M.H., & Shin, Y. (2016). Dynamic panels with threshold effect and endogeneity. Journal of Econometrics, 195(2), 169-186.

Tobias, A., Armstrong, B., Zuza, I., Gasparrini, A., Linares, C. & Diaz, J. (2012). Mortality on Extreme Heat Days Using Official Thresholds in Spain: A Multi-City Time Series Analysis, BMC Public Health, 12(133), 1-9.

Umar, D.I. (2017). Education outcomes, health outcomes and economic growth in Nigeria (1980–2013). Journal Soc. Econ. Dev, 19(2), 227–244.

UNICEF, (2020). Water Sanitation and Hygiene (WASH). New York, USA.

WHO (2016). World health statistics. Geneva: World Health Organization.

WHO (2017). World health statistics. Geneva: World Health Organization.

Yang, X., (2020. Health expenditure, human capital, and economic growth: an empirical study of developing countries. International Journal of Health Economics and Management, 20(2), 163-176.