Received: 3 April 2023 | Revised: 24 May 2023 | Accepted: 29 May 2023 | Published online: 2 June 2023

RESEARCH ARTICLE

Green and Low-Carbon Economy
2024, Vol. 2(4) 299–309
DOI: 10.47852/bonviewGLCE3202929

BON VIEW PUBLISHING

Achieving Infant Mortality SDG 3 Target in South Asia and Sub-Saharan Africa: Does Carbon Emission Matter?

Stanley Emife Nwani[1,*] and **Julius Chibuzor Ujah**[1]

[1]*School of Management & Social Sciences, Pan-Atlantic University, Nigeria*

Abstract: This study is necessitated by the high rate of infant mortality in South Asia (SA) and Sub-Saharan Africa (SSA) and the need to enhance the chances of these regions achieving SGD 3. The endemic nature of infant mortality in these regions constitutes a threat to attaining the 2030 sustainable development goal (SDG) 3 target. This study examined whether carbon emission matters and how other socioeconomic factors militate against the attainment of the infant mortality target in SA and SSA for the period 1981–2019. The study analyzed annual panel series using the robust least squares estimator. The result revealed that carbon emission per capita is the most critical impediment to attaining the SDG 3 target (25 infant mortality rate per 1000 in 2030) in SA and SSA. Fortunately, an increment in per capita income would be the strategic action to attaining the infant mortality target in these regions, and it is imperative to promote maternal education through improvement in female school enrollment rates. While the South Asian economies could afford to rely on foreign direct investment (FDI) inflows in addition to the aforementioned strategies, the SSA countries should not strongly depend on FDI to address the menace of infant mortality, rather improved social spending that is devoid of corruption and other systemic encumbrances would be more productive in arresting infant mortality in this region. Also, policymakers in Sub-Saharan African economies are encouraged to rely less on FDI and are strongly advised to improve government social spending and to implement pollution abatement policies and environmental regulations in line with international treaties and best practices.

Keywords: infant mortality, carbon emission, foreign direct investment, income per capita, South Asia, Sub-Saharan Africa

The endemic nature of infant mortality in developing regions without comparative attention in the literature constitutes a threat to attaining the 2030 sustainable development goal (SDG) 3 target. Therefore, this public health concern in developing economies requires a multi-disciplinary approach from a social, economic, and environmental perspective.

1. Introduction

The millennium development goals initiative has evolved into the sustainable development goals (SDGs) as a global call for action to address the challenges related to health, environment, social, and economic issues. The SDGs aim to foster a partnership to achieve optimal health and education, promote sustainable economic growth, mitigate climate change, and conserve natural resources, such as oceans and forests. In addition, they are set to target sound health and well-being for people of all ages across all member states and regions by the year 2030. In specific terms, the World Health Organization targets zero incident of preventable demise of less than 5-year-old children and newborns.

It further aimed at reducing neonatal and under-5 death rates to a maximum of 12/1000 and 25/1000 live births, respectively, by 2030. Notably, the progress made toward achieving this goal has been positive, as indicated by a consistent decrease in global infant mortality rates (IMRs) over time. In particular, data from 1950 to 2021 show that infant mortality reduced from 146.687 deaths per 1000 live births to 27.334 deaths per 1000 live births, highlighting significant strides in promoting and ensuring the health and well-being of infants worldwide.

Although there has been an overall decrease in IMRs globally, a closer examination at the regional level highlights significant disparities. Specifically, Sub-Saharan Africa (SSA) and South Asia (SA) have been experiencing much higher IMRs than other regions such as the European Union, North America, OECD Members, East Asia and Pacific, Europe, and Central Asia, Latin America Caribbean, Middle East, and North Africa, and Arab World, as indicated by statistical evidence presented in Figure 1 [1].

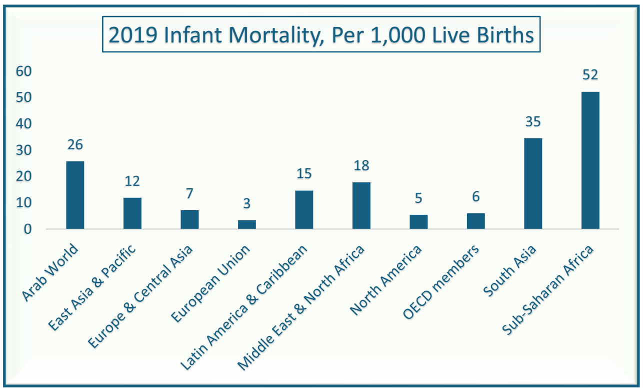
The World Bank [1] reports that the SSA region has been recording a slow decline in infant deaths, with the IMR dropping from 57.2 per 1000 live births in 2015 to 51.7 per 1000 live births in 2019. This raises questions about the factors responsible for the poor performance of this region in meeting infant mortality targets, given that the global average was 31.5 per 1000 live births in 2015 and 28.2 per 1000 live births in 2019.

IMRs are not solely attributable to poverty, as indicated by studies [2, 3] and World Development Indicators (WDI) data

*Corresponding author: Stanley Emife Nwani, School of Management & Social Sciences, Pan-Atlantic University, Nigeria. Email: snwani@pau.edu.ng

© The Author(s) 2023. Published by BON VIEW PUBLISHING PTE. LTD. This is an open access article under the CC BY License (https://creativecommons.org/licenses/by/4.0/).

Figure 1
Regional analysis of infant mortality rate



(2021) revealing a meager decline of 16.4% in poverty rates from 58.4% in 2000 to 42% in 2015. Rather, a plethora of factors, as suggested in health literature, are responsible for the slow rate of infant mortality reduction. Among these, maternal literacy and health have been identified as significant determinants of IMRs [4–8]. Globally, there was a 7.68% increase in maternal literacy rates between 2000 (75.344%) and 2019 (83.024%), while in SSA region, the rate increased by 12%, from 15% in 2000 to 27% in 2019, as per WDI data (2021).

Despite the horrendous challenge of infant mortality in SSA and SA, recent studies in these regions have shown little or no attention to this issue. Rather, studies in these areas have focused on factors such as profitability, financial development, trade, and export composition [9–12]. In addition, recent studies in these regions have not paid adequate attention to the significant roles of maternal literacy and income as mediators, as they have focused on pregnancy loss due to open fire [13] and how carbon emission affects infant mortality and energy consumption in Asia countries [14]. These gaps in empirical, methodological, and theoretical literature motivated this study. Specifically, previous studies on infant mortality determinants in SSA have focused more on economic and demographic variables [2, 3] and healthcare expenditure [15–19], while neglecting the considerable impact of environmental factors. Methodologically, earlier panel data studies on infant mortality did not employ comparative analysis between the worst-performing regions on infant mortality. Theoretically, this study extended Grossman's health stock theory to incorporate environmental factors as a determinant of health outcomes.

In SSA and SA, IMRs are influenced by several factors such as pollution, illiteracy, and poor economic growth and development. Air pollution, for instance, is a significant risk factor in these regions [20, 21]. However, according to Heft-Neal et al. [22], pollution is not caused solely by local economic activity, which is relatively low compared to developed regions. Instead, exposure to particulate matter 2.5 μm (PM2.5) driven by distant dust export from the Saharan across the region is a significant risk factor for infant mortality. This implies that the dust export from the Saharan region could be a critical cause of the high IMRs in SSA and SA.

Inadequate economic growth and maternal illiteracy are other factors that contribute to the high IMR [23–26]. Benshaul-Tolonen [27] reported a decline of over 50% in infant mortality with a concurrent swift rise in economic growth. Similarly, other studies found an adverse relationship between growth and infant death rate [26, 28, 29]. Nonetheless, the question remains whether industrial development results in trade-offs that could either improve or harm health and well-being, such as reducing infant mortality or exposing people to harmful pollution. Benshaul-Tolonen [27] and Osawe [26] suggested that African and Asian governments should prioritize economic growth and development and invest more in quality healthcare services and education to achieve a rapid fall in IMRs. One of the sources of the investible funds to drive down infant death is the inflow of foreign direct investment (FDI).

FDI is a long-term transnational investment [30]. It is a crucial variable that influences infant mortality especially in less-developing economies by complementing domestic investment attracting foreign technology and spurring development [31]. Interestingly, since the spillover effect of technology transfer is notable in emerging economies, then, the positive impact of FDI on health outcome is more pronounced in the developing economies than in their developed counterparts [32, 33]. Another channel through which FDI affects health is through employment, improved working conditions, wages, and growth. These factors enhance patients ability to pay, which is a crucial determinant of healthcare in the developing countries [34].

Despite the above contributions, the impact of FDI on development indicators such as infant mortality remains inconclusive. Considerable studies suggest that FDI may be associated with the reduction of infant mortality in Africa [32, 35–41]. This is because an increase in FDI impacts the level of per capita income, resulting in improved access to healthcare and, subsequently, enhanced health indicators. However, on the other hand, FDI may also contribute to infant mortality [42, 43] or have no significant effect on infant mortality [44]. For instance, Burns et al. [34] revealed that a 1% increase in FDI as a share of GDP led to a 0.08% decline in mortality rates of adults, while for child mortality there was no evidence of a significant linkage.

This study analyzed the factors responsible for the comparatively elevated infant mortality in SSA and SA and the degree of their influences to ensure a decline in infant in line with the SDGs target. In particular, this study examined whether carbon emission matters and how other socioeconomic factors behave toward achieving this goal in SA and SSA countries.

2. Literature Review

Pollution and its relationship with infant mortality have been widely studied in various economies. Although there is general agreement regarding the connection between pollution and infant mortality, the size of its effect continues to be a subject of debate. Given the significance of policy implications and potential benefits, resolving these controversies is critical. To adequately determine the size of the effect, prior studies did not account for growth episodes and literacy rates simultaneously in their analyses of how pollution and infant death are related.

An illustration of this can be observed in the study conducted by Greenstone and Hanna [45], which employed a difference-in-differences approach to examine the effect of environmental regulation on air pollution and infant mortality in India. Their research revealed that government intervention in air pollution had a direct correlation with a significant reduction in IMRs, indicating a clear relationship between air pollution and infant mortality. Similarly, Cesur et al. [46] found that the adoption of natural gas usage by residents in a city in Turkey resulted in a substantial decline in IMRs. Specifically, a 1% rise in natural gas subscriptions by residents, indicating a decrease in air pollution, resulted in a 4% decrease in IMRs.

Similarly, Goyal et al. [47] analyzed the association between neonatal mortality and pollution across 43 low- and middle-income countries spanning the period from 1998 to 2014. Their regression analysis on a pool of data revealed that exposure to carbonaceous PM2.5–10.9 μg/m^3, a type of air pollution, was responsible for 50% of infant deaths within the first 28 days of birth, indicating a direct correlation between pollution and infant mortality. Furthermore, Anwar et al. [48] utilized a fixed effect model (FEM) to examine panel data from 12 highly vulnerable Asian countries between 2000 and 2017 and discovered a positive correlation between air pollution, temperature, and infant mortality. The findings indicated that severe respiratory infections resulting from air pollution had negatively impacted income and education, while also leading to a higher population density due to the deaths of infants. This implies that air pollution can cause a decrease in the infant population, which in turn negatively affects the standard of living due to low income and education.

In analyzing the impact of rising industrial pollution on infant mortality, Tavassoli et al. [49] used full-count decennial censuses to determine that the IMR in the USA increased significantly during the late 19th and early 20th centuries due to a rise in industrial activities and subsequent pollution. This indicates a positive relationship between pollution and infant mortality. Looking at African economies, Heft-Neal et al. [20] concluded that a 1% increase in air pollution leads to a 14% increase in infant mortality in Africa. However, Heft-Neal et al. [22] estimated the impact of air pollution on infant mortality at 24%.

Several studies have examined the relationship between health and education expenditure and infant mortality. Alemu [16] utilized a FEM to analyze this relationship and found that a 1% increase in education expenditure and health expenditure as a ratio to the gross domestic product resulted in a 3.2 and 2.5 per 1000 live births decrease in IMRs, respectively. van Malderen et al. [50] and Abbuy [51] both found that maternal literacy had a significant negative effect on infant mortality in SSA and WAEMU countries, respectively. Similarly, Zewdie and Adjiwanou [52] found that maternal education was negatively associated with infant mortality in South Africa, with an increase in women's participation in education leading to a 21% reduction in the odds of infant death. Bado and Sathiya Susuman [53] discovered that government policies on maternal education have contributed to the steady decline in IMRs over the past two decades in selected SSA countries by increasing maternal awareness about child healthcare and hygiene. These studies suggest that improving maternal literacy and increasing health and education expenditure are crucial steps toward reducing IMRs. Moreover, government healthcare expenditure has also been linked to a reduction in IMRs in Nigeria, as demonstrated by Matthew et al. [54], who used the fully modified ordinary least square method, Lu et al. [55], and Edeme et al. [17] who found public health expenditure to be a significant determinant of IMRs.

Furthermore, Bernet et al. [56] conducted a study in Florida that confirms previous research conducted in SSA countries, demonstrating a positive correlation between the effectiveness of public health spending and infant mortality. Their findings revealed that an increase of 10% in targeted public health spending per infant resulted in a 2.07% reduction in IMRs. Also, the study found that targeted spending was more effective in reducing infant deaths among black infants than white infants. Langnel and Buracom [19] conducted a study that explored the effect of health expenditure on infant mortality across 32 SSA countries between 2000 and 2015. Their results showed that although health expenditure did not directly impact infant mortality, the coefficient of the interaction between health expenditure and infant mortality was significant, demonstrating a negative relationship between the two.

Female literacy has been found to have a significant negative relationship with an IMR in South Asian countries, as demonstrated by Maqsood et al. [57]. This is in line with the findings of Naz and Patel [58] who used the Cox proportional hazards model to analyze infant mortality in Sierra Leone, and Tagoe et al. [59], who used a predictive model. Kiross et al. [18] also found attending primary or higher education to be associated with a decrease in the likelihood of infant mortality in Ethiopia. In addition, Shapiro and Tenikue [60] found that increased women's education attainment can lead to a significant decrease in IMRs in high-risk areas such as SSA.

Popoola [61] conducted a study on selected SSA countries to investigate the main factors contributing to infant deaths. Their findings showed that the quality and availability of water supplies and sanitation facilities have a negative and statistically significant effect on newborn deaths, while pollution levels have a positive and statistically significant effect. Alemu [16] also investigated the impact of access to improved sanitation on infant mortality in Africa using the FEM. They found that access to improved sanitation, including clean water, was significantly and negatively associated with IMRs in SSA. Kalbessa [62] similarly found that water and sanitation have a significant effect on decreasing infant mortality in the SSA region. Pickering et al. [63] identified a strong correlation between access to improved water supply and sanitation facilities and child health in Mali.

Despite the abundance of studies conducted on the topic, the empirical evidence concerning the relationship between CO_2 emissions and infant mortality remains inconclusive. Some studies, such as those by Erdoğan et al. [64], Matthew et al. [54], and Jerumeh et al. [65], have indicated a positive association between CO_2 emissions and infant mortality. However, other studies, including those by Ahmad et al. [66], Bayati et al. [67], and Yang and Liu [68] have contradicted these findings by either reporting a negative correlation or no significant relationship at all.

Aliyu and Ismail [69] conducted a study that utilized data from 35 African countries to explore the impacts of PM10 and carbon dioxide emissions on human mortality. Their results indicated that both PM10 and carbon dioxide levels had a significant impact on the increase in mortality rates of infants, children under-5 years old, and adults. In a similar vein, Heft-Neal et al. [20] investigated the relationship between air quality and infant mortality in Africa and found that higher concentrations of PM2.5 were positively associated with IMRs. Specifically, a 10 μg/m^3 increase in PM2.5 concentrations was linked to a 9% increase in IMRs. Furthermore, Hill et al. [70] explored the negative effects of air pollution on health in the USA from 2000 to 2010 while taking income inequality into account. They discovered that areas with higher income inequality had a more substantial negative effect of air pollution on life expectancy.

Matthew et al. [54] utilized time-series data from 1985 to 2016 to investigate the association between greenhouse gas (GHG) emissions, including CO_2, and health outcomes in Nigeria. They employed the autoregressive distributed lag (ARDL) economic approach to co-integration and discovered that an increase in GHG emissions reduces life expectancy by 0.0422% for every 1% increase, leading to a significant rise in infant mortality by 146.6%. The study findings suggest that implementing measures to reduce CO_2 emissions can have a positive impact on health outcomes.

Erdoğan et al. [64] established a long-term co-integration relationship between carbon emissions and health indicators. Their study revealed that this relationship harmed life expectancy, with a negative effect observed. Another study by Mohamoud et al. [3] examined the causal relationship between human development, healthy life expectancy, and carbon dioxide emissions in the top 10 countries in terms of carbon dioxide emissions between 1991 and 2014. The outcomes of the research exhibited a robust association between the human development index, healthy life expectancy, and carbon dioxide emissions in most countries studied. Jerumeh et al. [65] conducted a study aimed at assessing the influence of carbon dioxide emissions on life expectancy using data collected from Nigeria over the period between 1971 and 2011. The findings showed that a negative relationship existed, which consequently contributed to an increase in IMRs.

Fotourehchi [71] conducted a research study that aimed to examine the impact of PM10 and carbon dioxide emissions on infant mortality and life expectancy at birth in 60 developing nations between 1990 and 2010. The study results revealed that the positive impact of socioeconomic improvements on health was negated by pollutants such as PM10 and carbon dioxide emissions. The study also showed that pollutants have weaker effects on health than socioeconomic conditions, but their negative impact cannot be overlooked in health policy implementation. As such, to realize the benefits of high socioeconomic levels on health, it is crucial to consider the influence of pollutants and implement policies that address their negative impact.

The empirical analyses of the reviewed studies did not include controls for the roles of adult female literacy and income per capita. Earlier studies have shown that the female literacy rate is a critical socioeconomic factor in determining infant mortality [72–75], while economic growth has been reported to significantly impact infant mortality indicators globally [23, 76, 77].

The research gaps are that recent studies in these regions have shown little or no attention to the horrendous challenge of infant mortality in SSA and SA. Rather, studies in these areas have focused on factors such as profitability, financial development, trade, and export composition [9–12]. In addition, recent studies in these regions have not paid adequate attention to the significant roles of maternal literacy and income as mediators, as they have focused on pregnancy loss due to open fire [13] and the mediating role of carbon emission in infant mortality and energy consumption nexus in Asia [14]. These gaps in empirical, methodological, and theoretical literature informed the motivation for this study. Specifically, previous studies on infant mortality determinants in SSA have focused more on economic and demographic variables [2, 3] and healthcare expenditure [15–19], while neglecting the considerable impact of environmental factors. Methodologically, earlier panel data studies on infant mortality did not employ comparative analysis between the worst-performing regions on infant mortality. Theoretically, this study extended Grossman's health stock theory to incorporate environmental factors as a determinant of health outcomes.

A diagrammatic conceptual framework presenting the nexus among environmental, social, and economic factors that determine infant mortality is shown in Figure 2.

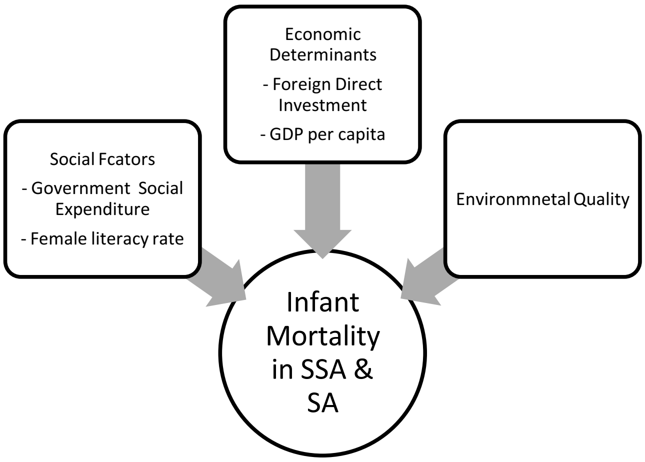
2.1. Theoretical framework

The research is based on the principles of the Grossman's demand for health theory, which was introduced by Grossman in 1972. This theory posits that the quality of health outcomes is dependent on various factors such as health expenditure, the cost of medical care, education, and other variables that impact the quality of health. Accordingly, Grossman [78] has formulated a theoretical model, as presented below.

$$H_O = h(iH_{i-1}, \ldots, nH_n, Z_{i-1}, \ldots, Z_n) \tag{1}$$

where H_O represents the current level of a specific health outcome, such as infant mortality. The symbol h indicates the functional relationship between the current outcome and other variables. H_{i-1} is the lagged value of the health outcome, while i is the coefficient that shows how much the variables influence the outcome per unit. Z_{i-1} represents the lags of other factors that affect health outcomes.

Figure 2
Infant mortality



The variable H_O represents the infant mortality rate (IFM), while the variable Z_{i-1} is composed of several factors, namely environmental pollution (measured by CO emissions), FDI, government social expenditure (GSEXP), per capita income (GDPPC), and female school enrollment rate (FSR), which is considered a proxy for maternal literacy.

The inclusion of the aforementioned variables in Grossman's theoretical framework is supported by previous research. For instance, the impact of CO emissions on health outcomes has been justified by several studies, such as Arceo et al. [79], Cesur et al. [46], Lee et al. [80], Gouveia et al. [81], Goyal et al. [47], Pullabhotla [82], and Yin et al. [83]. In addition, Nagel et al. [32] have provided evidence for the influence of FDI, while Sede and Ohemeng [84] have rationalized the relationship between government social expenditure, per capita income, and school enrollment rate (represented by FSR in the model) and health outcomes. Consequently, Equation (1) is transformed into Equation (2) with the inclusion of pertinent control variables, which has important theoretical implications. Moreover, the environmental Kuznets curve and pollution haven theories have provided further theoretical justifications for the proposed model.

$$IFM_t = f(CO_t, FDI_t, GSEXP_t, GDPPC_t, FSR_t) \tag{2}$$

The econometric models employed in this study are derived from the theoretical framework presented in Equation (2). The first model seeks to determine the individual effects of socioeconomic and environmental factors on infant mortality, while the second model captures the joint effect of environmental and economic factors on infant mortality. The model specification in this study represents an improvement over earlier econometric models, such as those estimated by Anwar et al. [48], Heft-Neal et al. [22], and Goyal et al. [47]. Previous studies neglected to account for the impact of environmental pollution and its interaction with socioeconomic variables in achieving the United Nations SDG 3 of promoting good health and well-being and reducing IMRs.

$$IFM_t = \beta_0 + \beta_1 CO_t + \beta_2 FDI_t + \beta_3 GSEXP_t + \beta_4 GDPPC_t + \beta_5 FSR_t + \mu_t \tag{3}$$

where IFM_{it} represents infant mortality rate, CO depicts carbon emission (a proxy for environmental pollution), FDI captures foreign direct investment, GSEXP is the government social expenditure on health and education, GDPPC represents gross domestic product per capita, FSR represents female school enrollment rate (a proxy for female literacy rate), μ denotes the white noise variable, and t represents the time.

Although earlier studies [4–8, 72–75] have validated the significant impact of maternal and female literacy on IMRs, it is unclear as to whether the presence of carbon emission would worsen or reduce its effect on IMRs. Therefore, this study focused on the impact of carbon emission on infant mortality and controlled for other economic variables that included FDI, government social expenditure, and GDP per head to analyze a more robust model than earlier studies.

3. Research Methodology

3.1. Research design

This study employed an ex-post facto research design and utilized annual panel data from the WDI 2020 publications by the World Bank as indicated in Table 1. The data cover the period from 1981 to 2019 and focus on the SA and SSA regions. The study includes all economies in these regions that are recognized by the IDA and IBRD according to the WDI 2020.

3.2. Description of variables

Table 1
Description of variables

Variable	Description	Source
IFM	The infant mortality rate is determined by the number of infant deaths per 1000 live births	World Development Indicator (2021)
CO	Carbon emission per capita as a measure of air pollution and environmental quality	World Development Indicator (2021)
FDI	Foreign direct investment is measured in million of US$	World Development Indicator (2021)
GSEXP	Government social expenditure is the combination of health and education expenditure measured in US$. This variable captures health input	World Development Indicator (2021)
GDPPC	Gross domestic product per capita serves as an economic indicator to gauge the economic well-being of countries	World Development Indicator (2021)
FSR	Female school enrollment is a measure of female literacy	World Development Indicator (2021)

3.3. Results

Table 2 depicts the summary result of the descriptive statistics for these regions. The point estimate of the mean indicates that the average rate of infant mortality in SA and SSA is 50.67 and 69.26 per 1000 live births, respectively, between 1981 and 2019, which is the highest average combination of 59.96 per 1000 live births for any other two regions globally. Thus, infant mortality remains a significant socioeconomic and health challenge in both regions. More so, carbon emission per capita in metric tons stands at 1.1 mt and 0.79 mt for SA and SSA; the record is worrisome when compared with the 0.05 metric ton per capita global average. In addition, the female school enrollment rate, a proxy variable for maternal literacy, shows an average of 53.86% and 51.77%, respectively, which implies maternal illiteracy of 46.14% and 48.23% for SA and SSA, the highest amongst other regions of the world. Beyond these, the preliminary result further reveals that income is low in these regions, per capita income, current domestic government expenditure on health is weak and grossly inadequate, and FDI into the health sector, as a ratio of GDP, is also weak at 1.52% and 2.50%, respectively, for SA and SSA. These appalling socioeconomic conditions in SA and SSA economies are necessary conditions to believe that the lack of obvious improvement in IMRs requires comparative empirical attention, which this study provided. Also, the Jarque-Bera statistics with non-statistically significant p-values support the non-normality characteristics of the variables.

As indicated in Table 3, the correlational analysis and results revealed the orthogonal relationship among the variables in the empirical model. The correlation coefficients imply a minimal level of multicollinearity among the explanatory variables. Specifically, the correlation matrix estimates reveal that the IMR has a negative relation with carbon emission, FDI, income per capita, and government social expenditure in both regions. However, while the female enrollment rate is inversely related to infant mortality in SA, a direct relationship was observed for SSA.

Table 4 depicts the regression estimates of the determining factors of infant mortality in SA and SSA countries, respectively. The use of the robust least square estimator is rationalized by its ability to capture and model more complex socioeconomic interactions using available data with minimal errors [85]. Alternative estimation techniques include the panel least square, dynamic least square, and panel ARDL estimator, which do not minimize errors in estimates as much as the robust lease square.

These estimates for both regions are not reinforcing. This claim is reflected in the significant difference in the factors that accounted for the scourge of infant mortality in these regions. For SA, the results indicated that the IMR is significantly impacted by carbon emission, FDI, maternal literacy, income per capita, and government social expenditure. Specifically, carbon emission, a proxy for environmental pollution, had a strong positive impact on infant mortality. By implication, as environmental quality degrades, infant death increases in SA. The estimate is such that for every metric ton increase in carbon emission, infant mortality increases by 8.83 deaths per 1000 live births per annum.

However, in the SSA region, carbon emission is not a significant determinant of infant mortality as revealed by the regression estimate. This outcome is consistent with the pre-test estimation result that indicated a higher environmental degradation level in SA compared to the SSA region where economic activities that emit carbon particles are at a low ebb. The result is further justified by the fact that rising carbon emissions due to economic expansion and foreign capital inflows without concerns for strong regulations are the key reasons for the significant infant mortality impact of the environmental variable in SA as earlier documented by existing studies in the literature [45–47].

Table 2
Comparative presentation of summary statistics

South Asia (SA)	IFM	GSEXP	GDPPC	FDI	FSR	CO	Sub-Saharan Africa(SSA) IFM	GSEXP	FDI	CO	FSR	GDPPC
Mean	50.6704	35.5486	3859.089	1.52024	53.8620	1.10099	69.2635	53.8823	2.50225	0.7933	51.7719	2997.801
Median	50.2915	33.5926	3737.928	1.42055	52.7036	1.10291	67.2396	56.6631	2.57177	0.7987	50.2608	3058.756
Maximum	68.6753	68.1773	6218.554	3.34908	63.7202	1.52665	91.0797	70.5413	4.08506	0.8381	58.3170	3871.541
Minimum	34.4805	19.4091	2080.162	0.60944	44.9304	0.77317	53.0172	31.5233	1.68783	0.7171	46.8165	1965.719
Std. dev.	10.6919	15.3627	1292.753	0.67212	6.25361	0.26134	12.0309	13.0936	0.60319	0.0297	3.7240	633.625
Skewness	0.10769	0.68826	0.20934	0.93858	0.15503	0.12429	0.3619	−0.4060	0.71969	−0.7374	0.4604	−0.2529
Kurtosis	1.80240	2.34901	1.856691	3.93607	1.60189	1.56126	1.8793	1.8930	3.6133	3.2898	1.7869	1.7051
Jarque–Bera	1.17216	1.83556	1.17361	3.48330	1.62358	1.68765	1.4091	1.4922	1.9380	1.7882	1.8364	1.5299
Probability	0.55650	0.39940	0.55610	0.17523	0.44406	0.43006	0.4943	0.4742	0.3795	0.4089	0.3992	0.4653
Sum	962.738	675.423	73,322.69	28.8846	1023.37	20.9187	1316.00	1023.76	47.54	15.07	983.66	56958.2
Sum sq. dev.	2057.70	4248.24	30081783	8.1313	703.937	1.22936	2605.36	3085.98	6.549	0.015	249.627	7226657

In congruence with the foregoing argument, the estimate also reveals an inverse relationship between FDI in health and infant mortality in the SA region. The estimated coefficient is such that for every 1% increase in FDI inflow into the health sector, the IMR declines significantly by 0.709 deaths per 1000 live births at a 5% significance level. But, in SSA, a direct relationship was observed between FDI and IMR. The estimated coefficient of 0.5454 implies that FDI contributes to the high rate of infant mortality in the region. Although FDI is significantly attracted to the SSA than the SA region, its misallocation, weak regulation, and a lack of environmental impact assessment are fundamental reasons for its adverse effects on infant mortality in SSA, an empirical finding spectacle that agrees with Bugelli et al. [86].

Nevertheless, there exists a conflicting empirical disposition on how government social expenditure influenced infant mortality in SA and SSA. In SA, estimates revealed that the 1% significance level, government social expenditure accentuates the infant mortality scourge in the SA region. Conversely, the result for the SSA region indicated that GSEXP ameliorates the scourge of infant mortality, but not significantly. The evidence that government social expenditure reduces infant mortality in SSA, but does not in SA is in concord with the summary statistics which showed a higher average of $53.88 million for SSA and $35.54 million for SA. The estimates for SA did not in conformity with theoretical expectations. Thus, government expenditure on the social sector worsens infant mortality in SA. Although, in SSA, the a priori expectation of a positive relationship was obtained, the estimate was not statistically significant. Thus, in this region, weak health infrastructure and poor human capital, slow technological advancement [87], and corruption in public expenditure are the essential reasons for government expenditure to have had a strong positive and weak negative impact on infant mortality in SSA and SSA, respectively.

Besides, income per capita has a significant negative relationship with the IMR in both regions. The results implied that the IMR is significantly addressed by rising income per head. The result further shows that efforts toward curbing the menace of infant mortality in these regions should strategically focus on improving income per capita.

Finally, the maternal literacy rate proxy by female school enrollment rate had a notable negative impact on infant mortality in SA, but its impact on infant mortality in the SSA region was not statistically significant. Despite the contentious positions of our findings, what is obvious is that maternal literacy has a significant impact on infant mortality in SA and an insignificant effect on infant mortality in SSA. This shred of empirical evidence is supported by the high rate (46% SA and 49% SSA) of maternal illiteracy in both regions investigated by the study.

In addition, the model fitness is significantly high, with 99% changes in IMR accounted for by variations in the exogenous variables in the model for both regions. Key findings from the study summarized that environmental, social, and economic conditions are critical factors to be considered if the attainment of the infant mortality target of the SDGs in SA and SSA countries would be realized. In specific terms, in both regions, exposure to a hostile environment is the most critical variable with the highest impact size, and the pursuant of higher GDP per capita is another panacea to the scourge of infant mortality in these regions.

Table 3
Correlation matrix in South Asia and Sub-Saharan Africa

Variable	IFM	GSEXP	GDPPC	FSR	FDI	CO
IFM	1.0000	−0.9910	−0.9965	0.2735	−0.8961	−0.1791
GSEXP	−0.9501	1.0000	0.9896	−0.2431	0.8885	0.1808
GDPPC	−0.9912	0.9799	1.0000	−0.2725	0.8993	0.1491
FSR	−0.3597	0.2048	0.3012	1.0000	−0.4485	0.2435
FDI	−0.9870	0.9694	0.9900	0.2525	1.0000	−0.0668
CO	−0.9869	0.9688	0.9932	0.2926	0.9915	1.0000

Note: Yellow for Sub-Saharan Africa; green for South Asia; red for joint estimates

Table 4
Regression estimates of the determinants of infant mortality in South Asia and Sub-Saharan Africa

	Dependent variable: infant mortality rate	
Predictor	South Asia (SA)	Sub-Saharan Africa (SSA)
GSEXP	0.310690 (0.0004***)	−0.183088 (0.1892)
GDPPC	−0.009692 (0.0001***)	−0.014638 (0.0001***)
FSR	−0.790618 (0.0057***)	−0.071704 (0.3310)
FDI	−0.709201 (0.0494**)	0.545422 (0.6994)
CO	8.833562 (0.0000***)	−13.35061 (0.1793)
C	110.9647 (0.0000***)	136.6645 (0.0000***)
R-squared	0.9967	0.9950
Adjusted R-squared	0.9955	0.9931

4. Conclusion and Recommendations

The study examined the role of carbon emission in the attainment of the SDGs infant mortality target in SA and SSA countries between 1981 and 2019. The study is motivated by the high rate of infant mortality in these regions, which requires concerted efforts and policy direction to enable these regions to achieve SDGs. The study concluded that carbon emission has a positive effect on the IMR, while per capita income and female literacy had negative impact on infant mortality.

The conclusion implies that carbon emission is the most critical impediment to attaining SDG 3 target (25 IMR per 1000 in 2030) in SA and SSA. Fortunately, an increment in per capita income would be the strategic action to attain the infant mortality target in these regions. The study further concludes that it is imperative to promote maternal education by improving female school enrollment rate and access to affordable quality education.

More so, the government in Sub-Saharan African regions should not rely on public social expenditure as the panacea to the menace of infant death. Rather than having the SDGs office under the presidency for improved financing, the empirical evidence suggests that bold economic policies that could amplify per capita income, reduce environmental pollution, and encourage female education are the way forward. Also, while the South Asian economies could afford to rely on FDI inflows in addition to the aforementioned strategies, unfortunately, SSA countries should not depend so much on FDI to address the menace of infant mortality, rather improved social spending that is devoid of corruption and other systemic encumbrances would be more productive in arresting infant mortality in the region.

Thus, to actualize the 2030 target, SDG 3 target on infant mortality in SA and SSA, the study proposed the following policy pathways:

1) Based on the result of this study, it is imperative for South Asian and Sub-Saharan African policymakers to not depend on public spending on social sectors as the panacea to addressing the scourge of infant mortality. Rather, the strategic action should be a profound economic and political will to improve per capita income by enhancing economic growth and development that is mindful of carbon emissions.
2) Also, policymakers have to devise ways to encourage female literacy, which requires accessibility, affordability, safety, and quality of education. This would assist present and potential mothers to play their roles in the war against infant mortality in Africa and Asia at large.

Moreover, there exists evidence of pollution haven for SA and SSA countries based on the observed effects of carbon emission and FDI on infant mortality. Thus, policymakers in SSA economies are encouraged to rely less on FDI in health sector financing and strongly advised to implement pollution abatement policies and environmental regulations in line with international treaties and best practices.

Going forward, future studies could analyze the determinants of infant mortality from the perspective of entire developing countries, which would generate more robust empirical evidence to aid generalization.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data available on request from the corresponding author upon reasonable request.

Author Contribution Statement

Stanley Emife Nwani: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Supervision, Project administration. **Julius Chibuzor Ujah:** Conceptualization, Validation, Investigation, Writing – original draft, Writing – review & editing, Visualization.

References

[1] World Bank. (2021). *Mortality rate, infant (per 1,000 live births) – South Africa*. Retrieved from: https://data.worldbank.org/indicator/SP.DYN.IMRT.IN?locations=ZA

[2] Alimi, A. S. (2018). Foreign aid and poverty level: Does public investment matter in Sub-Saharan African countries? *Global Journal of Management and Business Research*, *18*(1), 1–10.

[3] Mohamoud, Y. A., Kirby, R. S., & Ehrenthal, D. B. (2019). Poverty, urban-rural classification and term infant mortality: A population-based multilevel analysis. *BMC Pregnancy and Childbirth*, *19*, 40. https://doi.org/10.1186/s12884-019-2190-1

[4] Balogun, S. A., Yusuff, H. A., Yusuf, K. Q., Al-Shenqiti, A. M., Balogun, M. T., & Tettey, P. (2017). Maternal education and child immunization: The mediating roles of maternal literacy and socioeconomic status. *The Pan African Medical Journal*, *26*, 217. https://doi.org/10.11604/pamj.2017.26.217.11856

[5] Dey, S. (2017). Impacts of female literacy rate on infant mortality rate in Bangladesh: An econometric exercise. *The Millennium University Journal*, *2*(1), 44–53.

[6] Enlow, E., Gray, M. M., Wallace-Keeshen, S., D'Agostino, J. A., Abbasi, S., & Lorch, S. A. (2019). Health literacy of parents of very preterm infants at NICU admission and discharge: A prospective cohort study. *Journal of Perinatology*, *39*(6), 866–875. https://doi.org/10.1038/s41372-019-0340-y

[7] Imam, H. S. H., Chohan, F. A., Murtaza, M., Qamar, I., Zahra, F. T., Shahab, A., . . . , Ismail, W. (2017). How illiteracy affects the health of women and their children in PMC Colony F Block. *Annals of Punjab Medical College*, *11*(2), 94–99.

[8] Shrestha, V. (2019). Can basic maternal literacy skills improve infant health outcomes? Evidence from the education act in Nepal. *Journal of Human Capital*, *13*(3), 434–478. https://doi.org/10.1086/704320

[9] Munir, K., & Javed, Z. (2018). Export composition and economic growth: Evidence from South Asian countries. *South Asian Journal of Business Studies*, *7*(2), 225–240. https://doi.org/10.1108/SAJBS-10-2017-0117

[10] Saleem, H., Shabbir, M. S., & Bilal Khan, M. (2020). The short-run and long-run dynamics among FDI, trade openness and economic growth: Using a bootstrap ARDL test for co-integration in selected South Asian countries. *South Asian Journal of Business Studies*, *9*(2), 279–295. https://doi.org/10.1108/SAJBS-07-2019-0124

[11] Singhania, M., & Mehta, P. (2017). Working capital management and firms' profitability: Evidence from emerging Asian countries. *South Asian Journal of Business Studies*, *6*(1), 80–97. https://doi.org/10.1108/SAJBS-09-2015-0060

[12] Sinha, N., & Shastri, S. (2023). Does financial development matter for domestic investment? Empirical evidence from India. *South Asian Journal of Business Studies*, *12*(1), 104–126. https://doi.org/10.1108/SAJBS-09-2020-0332

[13] Xue, T., Geng, G., Han, Y., Wang, H., Li, J., Li, H. T., . . . , Zhu, T. (2021). Open fire exposure increases the risk of pregnancy loss in South Asia. *Nature Communications*, *12*(1), 3205. https://doi.org/10.1038/s41467-021-23529-7

[14] Adeleye, B. N., Azam, M., & Bekun, F. V. (2023). Infant mortality rate and nonrenewable energy consumption in Asia and the Pacific: The mediating role of carbon emissions. *Air Quality, Atmosphere & Health*, *16*(7), 1333–1344. https://doi.org/10.1007/s11869-023-01347-8

[15] Akinlo, A. E., & Sulola, A. O. (2019). Health care expenditure and infant mortality in Sub-Saharan Africa. *Journal of Policy Modeling*, *41*(1), 168–178. https://doi.org/10.1016/j.jpolmod.2018.09.001

[16] Alemu, A. M. (2017). To what extent does access to improved sanitation explain the observed differences in infant mortality in Africa? *African Journal of Primary Health Care and Family Medicine*, *9*(1), a1370. https://doi.org/10.4102/phcfm.v9i1.1370

[17] Edeme, R. K., Emecheta, C., & Omeje, M. O. (2017). Public health expenditure and health outcomes in Nigeria. *American Journal of Biomedical and Life Sciences*, *5*(5), 96–102. https://doi.org/10.11648/j.ajbls.20170505.13

[18] 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. https://doi.org/10.1186/s13561-020-00262-3

[19] Langnel, Z., & Buracom, P. (2020). Governance, health expenditure and infant mortality in Sub-Saharan Africa. *African Development Review*, *32*(4), 673–685. https://doi.org/10.1111/1467-8268.12470

[20] Heft-Neal, S., Burney, J., Bendavid, E., & Burke, M. (2018). Robust relationship between air quality and infant mortality in Africa. *Nature*, *559*(7713), 254–258. https://doi.org/10.1038/s41586-018-0263-3

[21] Shobande, O. A. (2020). The effects of energy use on infant mortality rates in Africa. *Environmental and Sustainability Indicators*, *5*, 100015. https://doi.org/10.1016/j.indic.2019.100015

[22] Heft-Neal, S., Burney, J., Bendavid, E., Voss, K. K., & Burke, M. (2020). Dust pollution from the Sahara and African infant mortality. *Nature Sustainability*, *3*(10), 863–871. https://doi.org/10.1038/s41893-020-0562-1

[23] Baird, S., Friedman, J., & Schady, N. (2011). Aggregate income shocks and infant mortality in the developing world. *The Review of Economics and Statistics*, *93*(3), 847–856. https://doi.org/10.1162/REST_a_00084

[24] Ester, P. V., Torres, A., Freire, J. M., Hernández, V., & Gil, Á. (2011). Factors associated to infant mortality in Sub-Saharan Africa. *Journal of Public Health in Africa*, *2*(2), e27. https://doi.org/10.4081/jphia.2011.e27

[25] Kiros, G. E., & Hogan, D. P. (2001). War, famine and excess child mortality in Africa: The role of parental education. *International Journal of Epidemiology*, *30*(3), 447–455. https://doi.org/10.1093/ije/30.3.447

[26] Osawe, O. W. (2014). Determinant of infant mortality rate: A panel data analysis of African countries. *Developing Country Studies*, *4*(18), 111–115.

[27] Benshaul-Tolonen, A. (2019). Local industrial shocks and infant mortality. *The Economic Journal*, *129*(620), 1561–1592. https://doi.org/10.1111/ecoj.12625

[28] Ferrarini, T., & Norström, T. (2010). Family policy, economic development and infant mortality: A longitudinal comparative

analysis. *International Journal of Social Welfare*, *19*, S89–S102. https://doi.org/10.1111/j.1468-2397.2010.00736.x
[29] Lu, Z. N., Chen, H., Hao, Y., Wang, J., Song, X., & Mok, T. M. (2017). The dynamic relationship between environmental pollution, economic development and public health: Evidence from China. *Journal of Cleaner Production*, *166*, 134–147. https://doi.org/10.1016/j.jclepro.2017.08.010
[30] World Bank. (n.d). *Foreign direct investment, net inflows (BoP, current US$)*. Retrieved from: https://data.worldbank.org/indicator/BX.KLT.DINV.CD.WD?view=chart
[31] Outreville, J. F. (2007). Foreign direct investment in the health care sector and most-favoured locations in developing countries. *The European Journal of Health Economics*, *8*(4), 305–312. https://doi.org/10.1007/s10198-006-0010-9
[32] Nagel, K., Herzer, D., & Nunnenkamp, P. (2015). How does FDI affect health? *International Economic Journal*, *29*(4), 655–679. https://doi.org/10.1080/10168737.2015.1103772
[33] Chintrakarn, P., Herzer, D., & Nunnenkamp, P. (2012). FDI and income inequality: Evidence from a panel of U.S. states. *Economic Inquiry*, *50*(3), 788–801. https://doi.org/10.1111/j.1465-7295.2011.00384.x
[34] Burns, D. K., Jones, A. P., Goryakin, Y., & Suhrcke, M. (2017). Is foreign direct investment good for health in low and middle income countries? An instrumental variable approach. *Social Science & Medicine*, *181*, 74–82. https://doi.org/10.1016/j.socscimed.2017.03.054
[35] Ayenagbo, K. (2022). Empirical analysis of the effect of foreign direct investment on health status in Sub-Saharan Africa: What role for governance? *Innovation Journal of Social Sciences & Economic Review*, *4*(3), 1–8. https://doi.org/10.36923/ijsser.v4i3.167
[36] Immurana, M. (2021). How does FDI influence health outcomes in Africa? *African Journal of Science, Technology, Innovation and Development*, *13*(5), 583–593. https://doi.org/10.1080/20421338.2020.1772952
[37] Immurana, M., Iddrisu, A. A., Owusu, S., & Yusif, H. M. (2023). Foreign direct investment and child health outcomes in Africa. *Cogent Economics & Finance*, *11*(1), 2164565. https://doi.org/10.1080/23322039.2022.2164565
[38] Okafor, J., & Ihayere, O. B. (2019). Foreign direct investment and the performance of health outcomes in Nigeria. *Amity Journal of Healthcare Management*, *4*(1), 15–31. http://dx.doi.org/10.13140/RG.2.2.24593.58721
[39] Salahuddin, M., Vink, N., Ralph, N., & Gow, J. (2020). Effects of economic growth, foreign direct investment and internet use on child health outcomes: Empirical evidence from South Africa. *Development Studies Research*, *7*(1), 1–17. https://doi.org/10.1080/21665095.2020.1717362
[40] Shahid, A., Siddique, H. M. A., & Liaqat, R. (2019). Human health and foreign direct investment nexus: Evidence from South Asia. *Asian Development Policy Review*, *7*(3), 209–218. https://doi.org/10.18488/journal.107.2019.73.209.218
[41] Siddique, F. K., Hasan, K., Chowdhury, S., Rahman, M., Raisa, T. S., & Zayed, N. M. (2021). The effect of foreign direct investment on public health: Empirical evidence from Bangladesh. *The Journal of Asian Finance, Economics and Business*, *8*(4), 83–91. https://doi.org/10.13106/jafeb.2021.vol8.no4.0083
[42] Jorgenson, A. K. (2009). Foreign direct investment and the environment, the mitigating influence of institutional and civil society factors, and relationships between industrial pollution and human health: A panel study of less-developed countries. *Organization & Environment*, *22*(2), 135–157. https://doi.org/10.1177/1086026609338163
[43] Shandra, J. M., Nobles, J. E., London, B., & Williamson, J. B. (2005). Multinational corporations, democracy and child mortality: A quantitative, cross-national analysis of developing countries. *Social Indicators Research*, *73*, 267–293. https://doi.org/10.1007/s11205-004-2009-x
[44] Mwabeza, J. A. (2018). *Foreign direct investment and child mortality: An empirical investigation in the case of Tanzania*. Master's Thesis, Istanbul University.
[45] Greenstone, M., & Hanna, R. (2014). Environmental regulations, air and water pollution, and infant mortality in India. *American Economic Review*, *104*(10), 3038–3072. https://doi.org/10.1257/aer.104.10.3038
[46] Cesur, R., Tekin, E., & Ulker, A. (2017). Air pollution and infant mortality: Evidence from the expansion of natural gas infrastructure. *The Economic Journal*, *127*(600), 330–362. https://doi.org/10.1111/ecoj.12285
[47] Goyal, N., Karra, M., & Canning, D. (2019). Early-life exposure to ambient fine particulate air pollution and infant mortality: Pooled evidence from 43 low-and middle-income countries. *International Journal of Epidemiology*, *48*(4), 1125–1141. https://doi.org/10.1093/ije/dyz090
[48] Anwar, A., Ayub, M., Khan, N., & Flahault, A. (2019). Nexus between air pollution and neonatal deaths: A case of Asian countries. *International Journal of Environmental Research and Public Health*, *16*(21), 4148. https://doi.org/10.3390/ijerph16214148
[49] Tavassoli, N., Noghanibehambari, H., Noghani, F., & Toranji, M. (2021). Upswing in industrial activity and infant mortality during late 19th century US. *arXiv Preprint:2101.02590*. https://doi.org/10.48550/arXiv.2101.02590
[50] van Malderen, C., Amouzou, A., Barros, A. J. D., Masquelier, B., van Oyen, H., & Speybroeck, N. (2019). Socioeconomic factors contributing to under-five mortality in Sub-Saharan Africa: A decomposition analysis. *BMC Public Health*, *19*, 1–19. https://doi.org/10.1186/s12889-019-7111-8
[51] Abbuy, K. E. (2018). Macroeconomic determinants of infant mortality in WAEMU Countries: Evidence from panel data analysis. MPRA Paper No. 89457. https://mpra.ub.uni-muenchen.de/89457/1/MPRA_paper_89457.pdf
[52] Zewdie, S. A., & Adjiwanou, V. (2017). Multilevel analysis of infant mortality and its risk factors in South Africa. *International Journal of Population Studies*, *3*(2), 43–56. https://doi.org/10.18063/ijps.v3i2.330
[53] Bado, A. R., & Sathiya Susuman, A. (2016). Women's education and health inequalities in under-five mortality in selected Sub-Saharan African countries, 1990–2015. *PLoS ONE*, *11*(7), e0159186. https://doi.org/10.1371/journal.pone.0159186
[54] Matthew, O., Osabohien, R., Fagbeminiyi, F., & Fasina, A. (2018). Greenhouse gas emissions and health outcomes in Nigeria: Empirical insight from Auto-regressive Distribution Lag technique. *International Journal of Energy Economics and Policy*, *8*(3), 43–50.
[55] Lu, Z., Bandara, J. S., & Paramati, S. R. (2020). Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies. *Australian Economic Papers*, *59*(1), 13–33. https://doi.org/10.1111/1467-8454.12167
[56] Bernet, P. M., Gumus, G., & Vishwasrao, S. (2018). Effectiveness of public health spending on infant mortality

in Florida, 2001–2014. *Social Science & Medicine*, *211*, 31–38.

[57] Maqsood, F., Baneen, U., & Maqsood, S. (2019). Impact of female literacy and female's labor force participation on infant mortality: Case of three South Asian countries. *Pakistan Journal of Social Sciences*, *39*(4), 1257–1264.

[58] Naz, L., & Patel, K. K. (2020). Determinants of infant mortality in Sierra Leone: Applying Cox proportional hazards model. *International Journal of Social Economics*, *47*(6), 711–726. https://doi.org/10.1108/IJSE-08-2019-0478.

[59] Tagoe, E. T., Agbadi, P., Nakua, E. K., Duodu, P. A., Nutor, J. J., & Aheto, J. M. K. (2020). A predictive model and socioeconomic and demographic determinants of under-five mortality in Sierra Leone. *Heliyon*, *6*(3), e03508. https://doi.org/10.1016/j.heliyon.2020.e03508

[60] Shapiro, D., & Tenikue, M. (2017). Women's education, infant and child mortality, and fertility decline in urban and rural sub-Saharan Africa. *Demographic Research*, *37*, 669–708.

[61] Popoola, O. T. (2019). An empirical analysis of infant mortality. *Journal of Economics and Management Sciences*, *2*(1), 27–32. https://doi.org/10.30560/jems.v2n1p27

[62] Kalbessa, C. D. (2018). *The impact of water and sanitation on childhood mortality in Sub-Saharan Africa*. Master's Thesis, KDI School.

[63] Pickering, A. J., Djebbari, H., Lopez, C., Coulibaly, M., & Alzua, M. L. (2015). Effect of a community-led sanitation intervention on child diarrhoea and child growth in rural Mali: A cluster-randomised controlled trial. *The Lancet Global Health*, *3*(11), e701–e711. https://doi.org/10.1016/S2214-109X(15)00144-8

[64] Erdoğan, S., Yıldırım, D. Ç., & Gedikli, A. (2019). The relationship between CO_2 emissions and health indicators: The case of Turkey. *Econometrics Letters*, *6*(1), 28–39.

[65] Jerumeh, T. R., Ogunnubi, C. S., & Yusuf, S. A. (2015). Industrial pollution and its attendant effects on public health in Nigeria. *Journal of Economics and Sustainable Development*, *6*(24), 164–175.

[66] Ahmad, M., Ur Rahman, Z., Hong, L., Khan, S., Khan, Z., & Naeem Khan, M. (2018). Impact of environmental quality variables and socio-economic factors on human health: Empirical evidence from China. *Pollution*, *4*(4), 571–579. https://doi.org/10.22059/poll.2018.252214.391

[67] Bayati, M., Akbarian, R., & Kavosi, Z. (2013). Determinants of life expectancy in eastern Mediterranean region: A health production function. *International Journal of Health Policy and Management*, *1*(1), 57–61. https://doi.org/10.15171/ijhpm.2013.09

[68] Yang, T., & Liu, W. (2018). Does air pollution affect public health and health inequality? Empirical evidence from China. *Journal of Cleaner Production*, *203*, 43–52. https://doi.org/10.1016/j.jclepro.2018.08.242

[69] Aliyu, A. J., & Ismail, N. W. (2016). The effects of air pollution on human mortality: Does gender difference matter in African countries?. *Environmental Science and Pollution Research*, *23*(21), 21288–21298. https://doi.org/10.1007/s11356-016-7253-5

[70] Hill, T. D., Jorgenson, A. K., Ore, P., Balistreri, K. S., & Clark, B. (2019). Air quality and life expectancy in the United States: An analysis of the moderating effect of income inequality. *SSM-Population Health*, *7*, 100346. https://doi.org/10.1016/j.ssmph.2018.100346

[71] Fotourehchi, Z. (2016). Health effects of air pollution: An empirical analysis for developing countries. *Atmospheric Pollution Research*, *7*(1), 201–206. https://doi.org/10.1016/j.apr.2015.08.011

[72] Abuqamar, M., Coomans, D., & Louckx, F. (2011). Correlation between socioeconomic differences and infant mortality in the Arab World (1990–2009). *International Journal of Sociology and Anthropology*, *3*(1), 15–21.

[73] Chowdhury, Q. H., Islam, R., & Hossain, K. (2010). Socio-economic determinants of neonatal, post neonatal, infant and child mortality. *International Journal of Sociology and Anthropology*, *2*(6), 118–125.

[74] Jain, G., & Bisen, V. (2012). Female literacy & its relevance with maternal and infant mortality rates. *International Journal of Management*, *3*(2), 65–79.

[75] Kapoor, S. (2010). Infant mortality rates in India: District level variations and correlations. In *6th Annual Conference on Growth and Development*, 16–18.

[76] Demetriou, I. C., & Tzitziris, P. (2017). Infant mortality and economic growth: Modeling by increasing returns and least squares. In *Proceedings of the World Congress on Engineering*, *2*, 1–6.

[77] Dhrifi, A. (2019). Health-care expenditures, economic growth and infant mortality: Evidence from developed and developing countries. *CEPAL Review*, *2018*(125), 69–91. https://doi.org/10.18356/02c1a26c-en

[78] Grossman, M. (2017). On the concept of health capital and the demand for health. In M. Grossman (Ed.), *Determinants of health: An economic perspective* (pp. 6–41). Columbia University Press. https://doi.org/10.7312/gros17812-004

[79] Arceo, E., Hanna, R., & Oliva, P. (2016). Does the effect of pollution on infant mortality differ between developing and developed countries? Evidence from Mexico City. *The Economic Journal*, *126*(591), 257–280. https://doi.org/10.1111/ecoj.12273

[80] Lee, S., Yoo, H., & Nam, M. (2018). Impact of the Clean Air Act on air pollution and infant health: Evidence from South Korea. *Economics Letters*, *168*, 98–101. https://doi.org/10.1016/j.econlet.2018.04.010

[81] Gouveia, N., Junger, W. L., Romieu, I., Cifuentes, L. A., de Leon, A. P., Vera, J., . . . , Tzintzun-Cervantes, G. (2018). Effects of air pollution on infant and children respiratory mortality in four large Latin-American cities. *Environmental Pollution*, *232*, 385–391. https://doi.org/10.1016/j.envpol.2017.08.125

[82] Pullabhotla, H. (2018). *Fires, wind, and smoke: Air pollution and infant mortality*. Retrieved from: https://www.dropbox.com/scl/fi/hsuifi3kxvbxko4htw5gb/Hemant_Pullabhotla_JMP.pdf?rlkey=l2vn18fdxu46tjc1ddag8p7n8&e=1&dl=0

[83] Yin, P., Brauer, M., Cohen, A. J., Wang, H., Li, J., Burnett, R. T., . . . , Murray, C. J. L. (2020). The effect of air pollution on deaths, disease burden, and life expectancy across China and its provinces, 1990–2017: An analysis for the Global Burden of Disease Study 2017. *The Lancet Planetary Health*, *4*(9), e386–e398. https://doi.org/10.1016/S2542-5196(20)30161-3

[84] Sede, P. I., & Ohemeng, W. (2015). Socio-economic determinants of life expectancy in Nigeria (1980–2011). *Health Economics Review*, *5*(1), 2. https://doi.org/10.1186/s13561-014-0037-z

[85] Hsiao, C. (2007). Panel data analysis—Advantages and challenges. *Test*, *16*(1), 1–22. https://doi.org/10.1007/s11749-007-0046-x

[86] Bugelli, A., Borgès Da Silva, R., Dowbor, L., & Sicotte, C. (2021). The determinants of infant mortality in Brazil, 2010–2020: A scoping review. *International Journal of Environmental Research and Public Health*, *18*(12), 6464. https://doi.org/10.3390/ijerph18126464

[87] Weil, D. N. (2014). Health and economic growth. In P. Aghion & S. N. Durlauf (Eds.), *Handbook of economic growth* (vol. 2, pp. 623–682). Elsevier. https://doi.org/10.1016/B978-0-444-53540-5.00003-3

How to Cite: Nwani, S. E., & Ujah, J. C. (2024). Achieving Infant Mortality SDG 3 Target in South Asia and Sub-Saharan Africa: Does Carbon Emission Matter? *Green and Low-Carbon Economy*, *2*(4), 299–309. https://doi.org/10.47852/bonviewGLCE3202929