

Impact of Government Health Expenditure, Environmental Quality and Medical Technology on Infant Mortality in Nigeria

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Abstract

This study examined the effects of government health expenditure, environmental degradation and medical technology on infant mortality rate (IMR) in Nigeria over the period 1985–2023, controlling for gross domestic product per capita and urbanization. The study was motivated by the persistent burden of infant mortality and the need to understand how health financing, environmental conditions and technological capacity are associated with infant survival. The study employed the Autoregressive Distributed Lag (ARDL) approach after the KPSS unit root test established a mixed order of integration, with the variables being either I(0) or I(1). The ARDL bounds test produced an F-statistic of 18.28348, exceeding the upper-bound critical value at the 5% significance level, providing evidence of a long-run relationship among the variables. The long-run results show that government health expenditure (LGHEX) has a negative but statistically insignificant coefficient, while environmental degradation (ENVDEG), proxied by carbon dioxide (CO₂) emissions, has a positive and significant coefficient, indicating that higher CO₂ emissions are associated with higher IMR. Medical technology (MEDTECH) has a positive but insignificant long-run coefficient, whereas urbanization significantly reduces IMR. Gross domestic product per capita (GDPPC) has a positive but insignificant long-run coefficient. In the short run, environmental degradation is positively associated with IMR, while medical technology produces significant mortality-reducing effects after several lags. The error correction coefficient of -0.189468 indicates that approximately 18.95% of short-run disequilibrium is corrected annually towards the long-run equilibrium. The study concludes that reducing IMR in Nigeria requires more efficient health expenditure, reduction of environmental degradation, strengthened medical technology and improved access to healthcare services.

Keywords: Infant mortality, government health expenditure, environmental quality, medical technology, ARDL, Nigeria.

Introduction

Infant mortality remains an important indicator of population health, human capital development and health-system performance. Despite global improvements in child survival, low- and middle-income countries, particularly those in sub-Saharan Africa, continue to experience a disproportionate burden of infant and child deaths. Evidence shows that infant mortality is

associated with healthcare access, socioeconomic conditions, environmental exposure and the capacity of health systems to provide timely and effective interventions (WHO, 2024; UNICEF, WHO, & World Bank Group, 2024; UN IGME, 2024). Thus, health expenditure alone may not sufficiently explain variations in infant mortality because functional health facilities, skilled personnel, medicines, safe environmental conditions and appropriate medical technologies are also required to translate health resources into improved health outcomes (WHO, 2024; World Bank, 2024). Nigeria remains an important case because infant mortality remains substantial despite successive health-sector interventions. The 2024 Nigeria Demographic and Health Survey reports an infant mortality rate of 63 deaths per 1,000 live births, neonatal mortality of 41 deaths per 1,000 live births and under-five mortality of 110 deaths per 1,000 live births during the five years preceding the survey (NPC & ICF, 2025). These figures indicate that preventable deaths remain a major concern, particularly during the neonatal and early-infant periods. Existing evidence also links infant mortality in Nigeria to socioeconomic inequalities, healthcare access and rural-urban disparities (NPC & ICF, 2025; Samuel et al., 2024; WHO, 2024). This persistence raises questions about whether public health resources are adequate and effectively translated into accessible and quality healthcare services. Government health expenditure is a major mechanism through which governments support population health. It finances primary healthcare, maternal and newborn services, immunization, health personnel, medicines, diagnostic equipment and emergency care. However, increased spending does not automatically translate into better health outcomes because its effectiveness depends on allocation, implementation, institutional capacity and service quality (WHO, 2023; World Bank, 2024; OECD & WHO, 2024). Recent evidence indicates that healthcare spending can improve health outcomes when resources are efficiently converted into healthcare provision, although inefficient allocation and weak infrastructure may limit its effects (Effects of Healthcare Spending on Public Health Status, 2024; The Puzzle of Public Health Expenditure and Healthcare Outcomes, 2024). In Nigeria, inadequate financing, high out-of-pocket expenditure and weaknesses in service delivery continue to constrain healthcare access, with implications for infant survival (WHO, 2023; World Bank, 2024; FMoHSW, 2024).

Environmental degradation is another important factor associated with infant mortality. In this study, environmental degradation is measured by carbon dioxide (CO₂) emissions, with higher emissions representing greater environmental degradation. Infants are particularly vulnerable to environmental hazards, including air pollution, contaminated water, inadequate sanitation and other forms of environmental exposure, which can contribute to respiratory infections, diarrhoeal diseases, adverse birth outcomes and premature death. Recent studies establish significant relationships between air pollution and infant mortality (Luben et al., 2023), while long-term exposure to air pollutants may affect pregnancy, fetal development and neonatal health (Long-Term Exposure to Criteria Air Pollutants and Infant Mortality, 2025). In Nigeria, rapid urbanization, industrialization, biomass use, poor waste management and pollution associated with oil and gas activities contribute to environmental risks. Evidence from sub-Saharan Africa also indicates an association between environmental conditions and infant mortality (Aderounmu et al., 2023), while environmental contamination has been linked to neonatal and infant mortality (E-waste Exposure and Infant Mortality Evidence, 2025). Accordingly, higher CO₂ emissions in the empirical analysis represent greater environmental degradation rather than higher environmental quality.

Medical technology provides a further pathway through which healthcare systems may improve infant survival. Diagnostic equipment, neonatal incubators, laboratory systems, telemedicine and mobile-health technologies can improve the speed and quality of healthcare delivery, particularly where early diagnosis and treatment are critical (WHO, 2021; Digital Solutions for Community and Primary Health Workers, 2022; Integrating Digital Health Technologies into Healthcare Systems, 2025). However, the benefits of medical technology depend on electricity supply, skilled personnel, connectivity, maintenance and adequate financing. In Nigeria, evidence highlights considerable opportunities from digital health while identifying infrastructure, connectivity and human-capacity constraints (Onumajuru et al., 2024; Telemedicine Adoption and Prospects in Sub-Saharan Africa, 2025; Barriers and Facilitators of Telemedicine Provision in Nigeria, 2025). Medical technology should therefore be viewed as complementary to health-system investment rather than as an independent solution (WHO, 2024; World Bank, 2024). The combined relationship between government health expenditure, environmental degradation and medical technology provides a broader basis for understanding variations in infant mortality than considering each factor independently. Public expenditure can finance medical technologies, healthcare infrastructure and essential health services, while environmental degradation may increase exposure to health risks and consequently increase healthcare needs. Medical technology can, in turn, support the diagnosis and treatment of infant health conditions and improve the effectiveness of available health resources. However, the benefits of public health expenditure and medical technology may be constrained where environmental risks remain high or healthcare facilities lack the infrastructure and capacity required for effective utilisation (WHO, 2024; World Bank, 2024; OECD & WHO, 2024).

Despite the relevance of these factors, existing Nigerian studies have largely examined government health expenditure, environmental conditions and medical technology separately, leaving limited empirical evidence on their combined relationship with infant mortality over an extended time period. This constitutes an important empirical gap because the relationship between health expenditure and infant mortality may depend on the environmental conditions in which households live and the technological capacity available within the health system. Examining these variables within a common time-series framework can therefore provide a more integrated understanding of the factors associated with infant mortality in Nigeria. Against this background, this study examines the relationship between government health expenditure, environmental degradation and medical technology and infant mortality rate in Nigeria over the period 1985–2023, while controlling for gross domestic product per capita and urbanization. By integrating public financing, environmental conditions and technological capacity into a single empirical framework, the study seeks to provide evidence relevant to health-resource allocation, environmental-health interventions and medical technology investment. The findings are expected to contribute to Nigeria's efforts to reduce preventable infant deaths and advance Sustainable Development Goal 3.2 (WHO, 2024; UNICEF et al., 2024; World Bank, 2024).

Literature Review

Conceptual Review

Government health expenditure represents the financial resources committed by public authorities to the provision and improvement of healthcare services. In the broader public-finance literature, government expenditure constitutes an important mechanism through which the state provides

public goods, redistributes resources and pursues socioeconomic objectives (Musgrave & Musgrave, 1989; Rosen & Gayer, 2014; OECD, 2023). Within the health sector, such expenditure finances healthcare infrastructure, medical personnel, medicines, preventive programmes, maternal and child health services, diagnostic facilities and other interventions capable of improving population health. The effectiveness of health expenditure, however, depends not only on its magnitude but also on its composition, allocation and utilisation. Productive public spending can generate substantial social benefits when directed towards essential services and human-capital development, whereas inefficient allocation may weaken its expected impact on health outcomes (Barro, 1990; Devarajan et al., 1996; World Bank, 2024). Accordingly, this study conceptualises government health expenditure as public financial resources devoted specifically to the health sector and expects increased and effectively utilised expenditure to contribute to lower infant mortality. Environmental quality refers broadly to the condition of the physical and ecological environment and its capacity to support human health and socioeconomic activities. It encompasses air, water and land quality, sanitation, waste management and broader ecological conditions (WHO, 2024; UNEP, 2024; Field & Field, 2021). Poor environmental conditions can adversely affect infant survival through exposure to air pollution, contaminated water, inadequate sanitation and other environmental hazards. Infants are particularly vulnerable to these hazards because their physiological and immune systems are still developing. Recent empirical evidence indicates that exposure to air pollutants is associated with increased infant mortality, while evidence from sub-Saharan Africa identifies environmental degradation as an important factor associated with child survival (Luben et al., 2023; Aderounmu et al., 2023; WHO, 2024).

For the purpose of the present study, environmental degradation (ENVDEG) is used as the empirical measure of adverse environmental conditions and is proxied by carbon dioxide (CO₂) emissions. Higher CO₂ emissions indicate greater environmental degradation and are therefore interpreted as poorer environmental conditions. Accordingly, the study does not treat CO₂ emissions as a direct measure of environmental quality; rather, CO₂ emissions provide an empirical indicator of environmental degradation. This distinction is important for interpreting the estimated coefficient: a positive coefficient on ENVDEG indicates that higher CO₂ emissions, representing greater environmental degradation, are associated with higher infant mortality rate (IMR). Medical technology encompasses the application of scientific knowledge, equipment, procedures and digital innovations to prevent, diagnose, monitor and treat diseases. It includes diagnostic technologies, therapeutic equipment, monitoring devices and digital health technologies such as telemedicine, electronic health records and mobile-health applications (WHO, 2021; OECD, 2020; WHO, 2024). Medical technology can influence infant survival by facilitating early diagnosis, improving treatment accuracy, supporting neonatal monitoring and increasing access to healthcare services, particularly where geographical barriers constrain conventional service delivery. However, its effectiveness depends on complementary inputs such as electricity, trained personnel, maintenance facilities and adequate health financing. The conceptual review in the thesis similarly identifies medical technology as an important component of modern healthcare because technological advances can improve diagnosis, treatment and patient outcomes, although their benefits may be constrained by high costs and inadequate implementation capacity.

Infant mortality represents the probability of a child dying before reaching one year of age, conventionally expressed per 1,000 live births. It is an important indicator of population health

because infant survival is influenced by healthcare availability, socioeconomic circumstances, environmental conditions, nutrition and the effectiveness of public-health interventions (WHO, 2024; UNICEF, 2025; UN IGME, 2024). The conceptual relationship among the variables suggests that government health expenditure, environmental quality and medical technology can influence infant mortality through different but interconnected channels. Greater health expenditure can improve access to healthcare and essential services; better environmental quality can reduce exposure to disease-producing pollutants and unsafe living conditions; while improved medical technology can strengthen the capacity of health facilities to diagnose and treat infant illnesses promptly. Conversely, inadequate health financing, environmental degradation and limited technological capacity may reinforce infant mortality risks. The study therefore conceptualises infant mortality as the dependent health outcome, while government health expenditure, environmental quality and medical technology constitute the principal explanatory variables. This integrated conceptualisation provides the basis for empirically examining whether improvements in public health financing, environmental conditions and technological capacity contribute to reducing infant mortality in Nigeria.

Theoretical Review

Grossman Model of Health Demand

The Grossman Model of Health Demand, developed by Michael Grossman in 1972, presents a theoretical framework that views health as both consumption good and an investment good. In this model, individuals are seen as producers of their own health, not just passive consumers of healthcare. Health is conceptualized as a durable capital stock that produces an output healthy time which individuals value. This capital stock depreciates with age but can be increased or maintained through investment in health-related activities, such as medical care, exercise, nutrition, and environmental improvements (Grossman, 1972). According to the model, individuals demand health not only for the direct utility it provides (feeling well) but also because good health enables them to work and earn income, thus indirectly increasing their productivity and economic well-being. The model further assumes that individuals make rational decisions on how much to invest in their health, weighing the costs (health expenditure, time spent seeking care) against the expected benefits (reduced mortality, improved quality of life, increased longevity). In the background of Nigeria, the Grossman model underscores the importance of public and private investments in health as a way to maintain and improve the population's health capital. It also supports the idea that government expenditure on environmental quality and medical technology is crucial for enhancing health outcomes and reducing mortality. Moreover, the model implies that low-income populations may underinvest in health due to budget constraints, poor education, or lack of access to healthcare factors that are all highly relevant to Nigeria's health landscape.

Grossman (1972) created the theoretical health production function:

[illegible]

Where H is a measure of individual health output and X is a vector of individual inputs to the health production function F , including nutrient intake, income, consumption of public goods,

education, time spent on health-related procedures, initial individual endowments like genetic makeup, and community endowments like the environment. This theoretical health production function model analyses micro-level health production and extends it to macro level.

Empirical Review

Empirical studies have established that infant mortality is influenced by a combination of health-sector financing, environmental conditions and technological capacity. However, the direction and magnitude of these effects vary across countries because of differences in healthcare systems, institutional quality, socioeconomic conditions and access to technology. Recent evidence increasingly supports a multidimensional approach to infant mortality rather than attributing changes in child survival to healthcare expenditure alone. For example, Luben et al. (2023), using systematic review and meta-analysis techniques, found a positive association between exposure to major air pollutants and infant mortality, indicating that environmental conditions constitute an important determinant of early-life survival. Similarly, Aderounmu et al. (2023), examining selected sub-Saharan African countries, reported that environmental degradation was associated with higher infant mortality, although the magnitude of the relationship varied across countries. More recently, Samuel et al. (2024) demonstrated that socioeconomic and demographic characteristics remain important predictors of under-five mortality in Nigeria, reinforcing the argument that child survival reflects several interacting factors rather than a single health-sector variable. The relationship between government health expenditure and infant mortality has also received considerable empirical attention. Anyanwu and Erhijakpor (2009), using data from 47 African countries, found that higher health expenditure was associated with reductions in infant and under-five mortality, suggesting that public investment in healthcare can generate significant improvements in child survival. In the Nigerian context, Orji et al. (2020) found that public health expenditure contributed to improvements in health outcomes, although the effectiveness of expenditure was influenced by broader economic and institutional conditions. More recently, Wosowei et al. (2025) examined government healthcare expenditure and infant mortality in Nigeria and reported an inverse relationship between healthcare expenditure and infant mortality, suggesting that increases in public health investment can contribute to reducing infant deaths. These findings are consistent with the broader argument that public expenditure can improve access to healthcare facilities, medicines, skilled personnel and preventive services. Nevertheless, the mixed effectiveness of government expenditure across developing countries suggests that the quantity of spending may be less important than the efficiency and composition of expenditure.

Environmental factors have received increasing attention in the recent infant-mortality literature. Luben et al. (2023) conducted a systematic review and meta-analysis and established that short-term exposure to air pollution was associated with increased infant mortality. Their findings are particularly important because they demonstrate that environmental exposure can affect infant survival even over relatively short periods. Similarly, Aderounmu et al. (2023) found that environmental quality significantly influenced infant mortality in selected sub-Saharan African countries, thereby demonstrating the relevance of environmental conditions within the African development context. Evidence from WHO (2024) further indicates that air pollution, unsafe water, inadequate sanitation and other environmental hazards remain important contributors to premature deaths, particularly among vulnerable populations. However, much of the existing empirical literature has concentrated on specific pollutants or broad environmental-health

relationships, with relatively limited evidence examining environmental quality alongside government health expenditure and medical technology within a single Nigerian model.

Medical technology has also emerged as an increasingly important determinant of healthcare outcomes. Onumajuru et al. (2024), in a scoping review of digital health utilisation in Nigeria, found that digital technologies have considerable potential to improve healthcare access, information management, communication and service delivery, although infrastructure and implementation constraints remain significant. Similarly, recent evidence on telemedicine in sub-Saharan Africa indicates that technology-enabled healthcare can reduce geographical barriers and improve access to medical services, particularly for populations underserved by conventional healthcare systems. WHO (2021) also emphasises that digital health technologies can strengthen health-system efficiency, improve continuity of care and support clinical decision-making when appropriately integrated into existing healthcare structures. Nevertheless, empirical evidence directly linking medical technology to population-level infant mortality remains relatively limited, particularly in Nigeria. Existing studies have tended to examine technology in relation to healthcare utilisation, maternal healthcare or service delivery rather than its direct association with infant mortality. Some studies have attempted to integrate economic, environmental and health-related determinants of mortality. Aderounmu et al. (2023) examined environmental quality, infant mortality and economic growth in sub-Saharan Africa and demonstrated that environmental conditions form part of the broader economic-health relationship. Similarly, Samuel et al. (2024) showed that infant and child mortality in Nigeria is influenced by several socioeconomic and demographic characteristics, highlighting the inadequacy of explanations based on a single determinant. However, these studies did not simultaneously incorporate government health expenditure and medical technology into the analysis of infant mortality. Consequently, although the literature provides evidence supporting the individual relevance of public health expenditure, environmental quality and technological development, there remains insufficient evidence on their joint effects within the Nigerian context. The empirical literature reveals three important gaps. First, most previous Nigerian studies have examined government health expenditure and mortality without adequately accounting for environmental conditions and technological development. Second, studies on environmental quality have largely focused on pollution and mortality without considering whether public healthcare resources and medical technology can moderate or offset environmental health risks. Third, research on medical technology in Nigeria has concentrated mainly on healthcare access, digital-health adoption and service delivery, with limited empirical evidence linking technological development directly to infant mortality. Thus, existing studies provide useful but fragmented evidence.

This study addresses these gaps by examining government health expenditure, environmental quality and medical technology simultaneously as determinants of infant mortality in Nigeria. The approach is important because these variables operate through interconnected channels: government health expenditure can finance medical technologies and healthcare infrastructure; environmental degradation can increase the incidence of infant diseases; and medical technology can improve the capacity of healthcare facilities to diagnose and treat such conditions. The study therefore extends the existing literature by providing an integrated macroeconomic assessment of the determinants of infant mortality in Nigeria and by identifying whether improvements in public

health financing, environmental conditions and technological capacity are associated with better infant survival outcomes.

Methodology

Theoretical Framework

This section establishes the basic connection between dependent and the independent variables in order to have justified and testable hypotheses. It also considered the conceptualized variables that are relevant to this study.

Grossman (1972) model of demand for health

The theoretical framework of this study is based on the Grossman (1972) model of demand for health. According to Grossman (1972), gross investments in health capital are brought about by households' production functions of healthcare. The direct health production inputs are expenditure on medical care, housing, exercise and diet. The household health production function is also dependent on other environmental and socio-economic variables with the most relevant being the level of education which influences efficiency of production process. Grossman (1972) in his model of demand for health outlines that the health of individuals is not exogenous and instead depends partly on the number of resources allocated towards its production.

Utility of a household is a function of his health and consumption of other goods, given as; $U = (\phi_0 H_0, \dots, \phi_n H_n, Z_0, \dots, Z_n)$ ----- 2

Where H_0 is health stock inherited, H_i is health stock in the i^{th} time period, ϕ is the service flow per unit stock, $\phi_i H_i$ is an individual's total consumption of health services and Z_i is an individual's total consumption of other commodities in the i^{th} time period. Consumers produce gross investment into health according to a household function given as;

$$I_i = (M_i, TH_i, E_i) \text{ ----- } 3$$

Where M_i is medical care sought; TH_i are time inputs; E_i is exogenous stock of knowledge. The production function is assumed to be homogenous of degree one in both the goods and time inputs.

Health production function is then specified as;

$$H = (X) \text{ ----- } 4$$

Where H is a measure of individual health output and X is a vector of individual inputs to the health production function F , including nutrient intake, income, consumption of public goods, education, time spent on health-related procedures, initial individual endowments like genetic makeup, and community endowments like the environment. This theoretical health production function model analyses micro-level health production and extends it to macro level. Oluwatoyin, Adegboye, and Fasina (2015) used per capita variables to represent the vector X and regrouped it into sub-sectorial vectors of economic, social, and environmental factors:

$$H = (Y, S, V) \text{-----} 5$$

Where Y is a vector of per capita economic variables, S is a vector of per capita social variables and V is a vector of per capita environmental factors. It follows from the above that an individual health output is influence by economic, social, and environmental factors.

Models Specification

The study adapted and modified the model of Omirin and Idris (2023) who examined the impact of government health expenditure on child mortality. The adapted model is specified as:

$$CMT = (f \text{ CGHE, RGHE, MTL}) \quad 6$$

Where; Where CMT is the child mortality rate. CGHE is capital government health expenditure, RGHE is recurrent government health expenditure MTL is maternal literacy. However, in line with objective one, the study modified the model by replacing child mortality with maternal mortality rate as a dependent variable. Also, the study used medical technology and environmental quality as independents variables in the model. Urbanization and Gross Domestic Product per capital are considered as control variables in the model. Arising from the above, the functional form of Model 1 is written as:

$$IMR_t = \beta_0 + \beta_1 GHEX_t + \beta_2 ENVDEG_t + \beta_3 MEDTECH_t + \beta_4 GDPPC_t + \beta_5 URB_t + \mu_t \text{---} 7$$

Where: IMR is infant mortality rate; GHEX = Government health expenditure; ENVDEG = Environmental degradation, proxied by carbon dioxide (CO₂) emissions; MEDTECH = Medical technology, proxied by physicians per 1,000 people; GDPPC = Gross domestic product per capita; URB = Urbanization; β_0 is the intercept of the model; β_1 - β_5 are the parameters to be estimated; and μ_t is the error term. Based on theoretical and empirical literature, the expected signs of the coefficients are as follows. Government health expenditure (GHEX) is expected to have a negative relationship with infant mortality rate (IMR) because higher public spending on health can improve access to healthcare services, immunization, and maternal and child health interventions, thereby reducing infant deaths. Environmental degradation (ENVDEG), proxied by carbon dioxide (CO₂) emissions, is expected to have a positive relationship with IMR because higher CO₂ emissions indicate greater environmental degradation and pollution, which may worsen respiratory and other health conditions affecting infants. Medical technology (MEDTECH), proxied by physicians per 1,000 people, is expected to have a negative effect on IMR since improved availability of medical personnel can enhance healthcare delivery and increase the chances of infant survival. Gross domestic product per capita (GDPPC) is also expected to exert a negative influence on IMR, as higher income levels can improve household welfare, nutrition, and access to quality healthcare services. Lastly, urbanization (URB) is expected to have a negative relationship with IMR, in line with the argument that urban areas generally provide better access to healthcare infrastructure and services, although the effect may vary depending on the quality of urban living conditions.

$$\begin{aligned} \Delta IMR_t = & \beta_0 + \beta_1 IMR_{t-1} + \beta_3 GHEX_{t-1} + \beta_4 ENVQ_{t-1} + \beta_5 MEDTECH_{t-1} \\ & + \beta_6 GDPPC_{t-1} + \beta_7 URB_{t-1} + \sum_{i=0}^m \beta_1 \Delta MMR_{t-i} + \sum_{i=0}^p \beta_8 \Delta GHEX_{t-i} \\ & + \sum_{i=0}^p \beta_3 \Delta ENVQ_{t-i} + \sum_{i=0}^p \beta_4 \Delta MEDTECH_{t-i} + \sum_{i=0}^p \beta_5 \Delta DPCC_{t-i} \\ & + \sum_{i=0}^p \beta_6 \Delta URB_{t-i} + \mu_{1t} - - - -3.18 \end{aligned}$$

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Where; *IMR* is Infant mortality rate, *GHEX* is Government health expenditure, *ENVDEG* is Environmental quality, *MEDTECH* is Medical Technology, *GDPPC* is Gross domestic product per capita, *URB* is Urbanization, β_0 is the intercept of the model, β_1 - β_5 are the parameters to be estimated, and μ_t is the error term.

Results and Discussion

Descriptive Analysis

Table 1.Descriptive Statistics of the Variables

Variable	Mean	Maximum	Minimum	Standard Deviation
GHEX	117.499	437.520	0.040	144.132
ENVDEG	0.648	0.860	0.400	0.121
MEDTECH	0.311	0.776	0.185	0.132
URB	39.199	54.280	25.640	8.644
GDPPC	1885.665	2585.734	1390.469	439.204
IMR	86.487	105.900	60.100	16.499

Source: Author's Computation using EViews (2026)

Government health expenditure (GHEX) recorded a mean of ₦117.50 billion, ranging from ₦0.04 billion to ₦437.52 billion, with a standard deviation of 144.13, indicating substantial fluctuations in public health spending over the study period, particularly between periods of fiscal constraint and increased government investment in healthcare. Environmental degradation (ENVDEG), measured by carbon dioxide emissions per capita, had a mean of 0.648 metric tons, with values ranging from 0.400 to 0.860 and a standard deviation of 0.121, indicating relatively limited variation in emissions over time. Medical technology (MEDTECH), measured by physicians per 1,000 population, recorded a mean of 0.311, ranging from 0.185 to 0.776, with a standard deviation of 0.132, reflecting gradual improvements but continued limitations in physician availability. Urbanization (URB) averaged 39.20%, ranging from 25.64% to 54.28%, with a standard deviation of 8.64, indicating a steady increase in the proportion of the population living in urban areas. GDP per capita (GDPPC) averaged US\$1,885.67, with a minimum of US\$1,390.47 and a maximum of US\$2,585.73 and a standard deviation of 439.20, reflecting fluctuations in economic performance. Finally, infant mortality rate (IMR) averaged 86.49 deaths per 1,000 live births, ranging from 60.10 to 105.90, with a standard deviation of 16.50, indicating a general improvement in infant survival over the study period despite persistent mortality challenges

Correlation Matrix Analysis

Table 2 Correlation Matrix of Study Variables

<u>Variable</u>	<u>GHEX</u>	<u>ENVQ</u>	<u>MEDTECH</u>	<u>MMR</u>	<u>URB</u>	<u>GDPPC</u>	<u>IMR</u>
GHEX	1.0000						
ENVDEG	-0.1776	1.0000					
MEDTECH	0.6922	-0.0704	1.0000				
URB	0.9267	-0.1780	0.7660	-0.9345	1.0000		
GDPPC	0.8116	-0.2358	0.8584	-0.8646	0.9051	1.0000	
IMR	-0.8978	0.1617	-0.8189	0.9106	-0.9140	-0.9407	1.0000

Source: Author's Computation using EViews (2026)

The correlation matrix indicates the direction and strength of relationships among the study variables. Government health expenditure (GHEX) is strongly and positively correlated with medical technology (MEDTECH) ($r = 0.6922$), urbanization (URB) ($r = 0.9267$), and GDP per capita (GDPPC) ($r = 0.8116$), while showing strong negative relationships with infant mortality (IMR) ($r = -0.8978$), suggesting that increased health expenditure is associated with improved healthcare capacity, economic development and lower infant mortality. Environmental degradation (ENVDEG) exhibits generally weak relationships with the other variables, indicating limited linear association. Medical technology is positively correlated with GDPPC ($r = 0.8584$) and URB ($r = 0.7660$), but negatively correlated with IMR ($r = -0.8189$), suggesting that greater healthcare capacity is associated with improved infant survival. Urbanization and GDPPC are strongly positively correlated ($r = 0.9051$), while both are negatively associated with IMR, indicating that socioeconomic development and improved access to urban services are associated with lower infant mortality. Overall, the correlation results suggest that higher public health expenditure, greater medical technology, urbanization and economic development are associated with improved infant health outcomes.

Unit Root Test

Table 3 KPSS Unit Root Test Results (5% Critical Level)

Variable	Level	First Difference	Order of Integration	Test Statistic	5% Critical Value	Test Statistic	5% Critical Value
ENVDEG	0.115496	0.146	—	—	—	—	I(0)
LIMR	0.130516	0.146	—	—	—	—	I(0)
MEDTECH	—	—	0.117740	0.463	0.463	0.463	I(1)
LGHEX	—	—	0.460579	0.463	0.463	0.463	I(1)
LGDDPPC	—	—	0.145318	0.463	0.463	0.463	I(1)
URB	—	—	0.245230	0.463	0.463	0.463	I(1)

Source: Author's Computation using EViews (2026)

The KPSS unit root test results in Table 4.4 indicate that the variables have mixed orders of integration. Environmental degradation (ENVDEG) and infant mortality (LIMR) are stationary at level, indicating I(0), while government health expenditure (LGHEX), GDP per capita (LGDPGC), urbanization (URB), and medical technology (MEDTECH) become stationary after first differencing, indicating I(1).

Lag Length Selection and ARDL Model Specification

The appropriate lag structure was determined before estimating the Autoregressive Distributed Lag (ARDL) model. The lag length selection procedure was conducted using the Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). The results are presented in Table 4.11. The results indicate that lag 4 provides the preferred maximum lag order for the model. Specifically, the FPE, AIC, Schwarz Criterion and Hannan-Quinn Criterion attain their minimum values at lag 4, while the LR statistic also supports the selection of lag 4. The lag-order selection procedure therefore establishes four as the maximum lag length considered in the subsequent ARDL estimation. This approach allows the model to capture sufficient dynamic effects while avoiding the use of an unnecessarily long lag structure.

Table 4. Lag Order Selection Criteria

Endogenous Variables: LIMR, LGHEX, ENVDEG, MEDTECH, URB, LGDDPPC
Sample: 1985 2023

Lag	LogL	LR	FPE	AIC	SC	HQ
0	132.3314	NA	2.95e-11	-7.218938	-6.952307	-7.126897
1	436.7924	487.1376	6.64e-18	-22.55957	-20.69315	-21.91528
2	534.2450	122.5118	2.40e-19	-26.07114	-22.60494	-24.87461
3	634.4660	91.63062	1.07e-20	-29.74091	-24.67492	-27.99214
4	711.3512	43.93443	4.17e-21*	-32.07721*	-25.41144*	-29.77619*

Source: Author's Computation using Eviews (2026)

Following the determination of the maximum lag order, the ARDL model was estimated by allowing the lag length of each variable to be selected according to the model selection criterion used in EViews. Thus, the maximum lag order of four does not imply that every variable enters the final ARDL model with four lags. Rather, the final specification permits different lag lengths for the dependent and explanatory variables, subject to the maximum lag of four.

ARDL Bound Test

The ARDL bounds test is used to determine whether a long-run equilibrium relationship exists among the variables in the model regardless of their order of integration. It provides a joint significance test of the lagged level variables to confirm cointegration within a single equation framework.

Table 5. ARDL Bounds Test for Cointegration
Dependent Variable: LIMR

Test Statistic	Value	Significance	I(0)	I(1)
F-statistic	18.28348	10%	2.08	3.00
		5%	2.39	3.38
		1%	3.06	4.15

Source: Author's Computation using EViews (2026)

The ARDL bounds testing results in Table 5 provide evidence of a long-run relationship (cointegration) among government health expenditure, environmental degradation, medical technology, GDP per capita, urbanization and infant mortality in Nigeria. The computed F-statistic of 18.28348 exceeds the upper-bound critical value of 4.15 at the 1% significance level, leading to the rejection of the null hypothesis of no long-run relationship. This provides strong evidence that the variables are cointegrated and move together in the long run. Thus, changes in government health expenditure, environmental degradation, medical technology and socioeconomic conditions are associated with long-run changes in infant mortality. However, the bounds test establishes the existence of a long-run level relationship among the variables and does not, by itself, establish causality. The finding is consistent with previous studies that identify long-run relationships between environmental conditions, socioeconomic development, healthcare expenditure, technology and health outcomes (Weihong et al., 2020; Taghizadeh-Hesary et al., 2020; Beyene & Kotosz, 2021; Bogale et al., 2024).

Long Run Estimation

The long-run estimation in the ARDL framework is used to determine the equilibrium relationship between the government health expenditure, environmental quality, and medical technology on infant mortality. It shows the persistent effects of the independent variables on the dependent variable after all short-run adjustments have fully occurred

Table 6: Long-Run ARDL Results
Dependent Variable: LIMR

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LGHEX	-0.015480	0.010641	-1.454797	0.1797
ENVDEG	0.053707	0.009763	5.500943	0.0004
MEDTECH	0.050718	0.041438	1.223942	0.2520
URB	-0.009288	0.000361	-25.75226	0.0000
LGDDPPC	0.110971	0.059534	1.863991	0.0952
C	1.936355	0.185643	10.43055	0.0000

Source: Author's Computation using EViews (2026)

The long-run ARDL results in Table 6 show that government health expenditure (LGHEX) has a negative but insignificant coefficient (-0.015480), indicating a potential reduction in infant mortality, although the effect is not statistically established. This contrasts with Dinga et al. (2024) and Onwunali et al. (2024), who reported significant mortality-reducing effects of health expenditure. Environmental degradation (ENVDEG), measured by carbon dioxide (CO₂)

emissions, has a positive and significant coefficient (0.053707), indicating that higher CO₂ emissions are associated with higher infant mortality in the long run. This result implies that worsening environmental conditions, as reflected by increased CO₂ emissions, are associated with adverse infant health outcomes and higher infant mortality. The finding contrasts with the results reported by Taghizadeh-Hesary et al. (2020) and Chuks (2022). Medical technology (MEDTECH) is positive but insignificant (0.050718), indicating no significant long-run effect, consistent with Ayeyi et al. (2020) and Bogale et al. (2024), who emphasised that technology requires adequate infrastructure and institutional support. Urbanization (URB) has a negative and significant coefficient (-0.009288), implying that urban development reduces infant mortality through improved access to healthcare and social services. Finally, GDP per capita (LGDDPPC) is positive but insignificant (0.110971), suggesting that income growth alone does not significantly improve infant survival, possibly because economic gains are not evenly translated into healthcare access and living conditions.

Short Run Estimation

The short-run estimation in the ARDL framework captures the immediate and dynamic effects of changes in the government health expenditure, environmental quality, and medical technology on infant mortality. It also shows how the system adjusts back to long-run equilibrium after short-run shocks through the error correction mechanism.

Table 7: Short-Run ARDL Result

Dependent Variable: D(LIMR)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LIMR(-1))	0.457112	0.108315	4.220208	0.0022
D(LIMR(-2))	0.202666	0.099401	2.038864	0.0719
D(LGHEX)	0.001018	0.000469	2.171191	0.0580
D(LGHEX(-1))	0.001441	0.000238	6.044627	0.0002
D(LGHEX(-2))	0.001541	0.000244	6.324952	0.0001
D(LGHEX(-3))	0.001073	0.000184	5.842543	0.0002
D(ENVDEG)	0.006534	0.000791	8.260587	0.0000
D(MEDTECH)	0.000343	0.000710	0.482500	0.6410
D(MEDTECH(-1))	-0.008941	0.000817	-10.94663	0.0000
D(MEDTECH(-2))	-0.004610	0.000914	-5.044867	0.0007
D(MEDTECH(-3))	-0.003340	0.000796	-4.193736	0.0023
D(URB)	-0.002827	0.000838	-3.374773	0.0082
D(URB(-1))	-0.001000	0.000976	-1.024722	0.3322
D(URB(-2))	0.000682	0.001931	0.353017	0.7322
D(URB(-3))	-0.009429	0.001535	-6.141105	0.0002
D(LGDDPPC)	-0.015662	0.005338	-2.934315	0.0166
D(LGDDPPC(-1))	-0.037012	0.007113	-5.203564	0.0006
D(LGDDPPC(-2))	0.013652	0.004525	3.017306	0.0145
D(LGDDPPC(-3))	-0.014400	0.004516	-3.188551	0.0110
CointEq(-1)	-0.189468	0.012973	-14.60504	0.0000

Source: Author's Computation using EViews (2026)

The short-run ARDL results in Table 7 show that the error correction term, CointEq(-1), is negative and significant (-0.189468), indicating that about 18.95% of short-run deviations are corrected towards long-run equilibrium each period. Government health expenditure

(LGHEX) has an insignificant contemporaneous effect but significant positive lagged effects. The positive lagged coefficients should not be interpreted as evidence that higher government health expenditure causes infant mortality to increase. Rather, the result may reflect the possibility that rising infant mortality and increasing health needs generate additional government health expenditure, particularly in response to urgent or emerging health challenges. The positive lagged effects may also reflect delays in the implementation of health programmes, expenditure allocation and institutional processes before health spending translates into improved health outcomes. Thus, the short-run relationship between government health expenditure and infant mortality may capture the timing and responsiveness of public health spending rather than a direct adverse effect of expenditure on infant survival. This finding differs from Dinga et al. (2024) and Onwunali et al. (2024), who reported mortality-reducing effects of health expenditure. Environmental degradation (ENVDEG), proxied by carbon dioxide (CO₂) emissions, has a positive and significant short-run effect (0.006534), indicating that increases in environmental degradation are associated with higher infant mortality. This finding suggests that worsening environmental conditions, as reflected by higher CO₂ emissions, may adversely affect infant health and survival, differing from the findings of Taghizadeh-Hesary et al. (2020) and Chuks (2022). Medical technology (MEDTECH) has a positive but statistically insignificant long-run coefficient (0.050718), while its current short-run effect is insignificant and its coefficients at the first three lags are negative and significant. The negative lagged short-run effects suggest that the mortality-reducing benefits of medical technology may emerge gradually rather than immediately. However, the positive and insignificant long-run coefficient should be interpreted cautiously because the expected negative relationship between medical technology and infant mortality is not supported in the long-run estimates. One possible explanation is that medical technologies may be concentrated in urban or specialised health facilities that serve populations with more severe or high-risk health conditions. Technology adoption may also occur in response to existing health problems, creating a reverse-causality mechanism in which greater health needs lead to increased adoption of medical technologies. In addition, inadequate maintenance, unreliable electricity supply and other infrastructural constraints may limit the effective use of medical technologies. Uneven access to technologically equipped health facilities may further reduce their population-wide effect on infant survival. Therefore, the positive long-run coefficient should not be interpreted as evidence that medical technology increases infant mortality; rather, it may reflect the uneven distribution, utilisation and institutional conditions surrounding medical technology in Nigeria. This interpretation is consistent with Ayeyi et al. (2020) and Bogale et al. (2024), who emphasised the importance of adequate infrastructure and institutional support for translating medical technology into improved health outcomes. Urbanization (URB) has significant negative effects contemporaneously and at the third lag, consistent with Sibanda et al. (2023), while GDP per capita (LGDPPC) generally reduces infant mortality in the short run, although its alternating lag effects indicate a dynamic relationship, broadly consistent with Momoh and Okwu (2022) and David et al. (2023).

Table 8: Diagnostic Tests for the ARDL Model

Diagnostic Test	Test Statistic	Value	Prob.	Decision
Breusch-Godfrey Test	LM F-statistic	0.656644	0.5942	No serial correlation
	Obs*R-squared	5.076439	0.1663	No serial correlation
Breusch-Pagan-Godfrey Test	F-statistic	1.593320	0.2374	No heteroskedasticity
	Obs*R-squared	28.54945	0.2832	No heteroskedasticity
	Scaled Explained SS	2.232048	1.0000	No heteroskedasticity
CUSUM Test	Plot	Within 5% bounds	—	Stable
CUSUM of Squares	Plot	Within 5% bounds	—	Stable

Source: Author's Computation using EViews (2026).

The diagnostic tests reported in Table 8 provide evidence that the estimated ARDL model satisfies the major post-estimation requirements. The Breusch-Godfrey LM test reports an F-statistic of 0.656644 with a probability value of 0.5942, while the corresponding Obs*R-squared statistic is 5.076439 with a probability value of 0.1663. These results indicate that the null hypothesis of no serial correlation cannot be rejected at the 5% significance level. Thus, there is no evidence of serial correlation in the model residuals. Similarly, the Breusch-Pagan-Godfrey test reports an F-statistic of 1.593320 with a probability value of 0.2374 and an Obs*R-squared statistic of 28.54945 with a probability value of 0.2832. The probability values exceed the 5% significance level, indicating that the null hypothesis of homoskedasticity cannot be rejected. The Scaled Explained SS statistic also has a probability value of 1.0000, providing no evidence of heteroskedasticity. The stability of the estimated coefficients was further assessed using the CUSUM and CUSUM of Squares tests. As reported in Table 7, both plots remain within the 5% critical bounds throughout the study period, indicating that the estimated parameters remain stable over the sample period. This suggests that there is no evidence of major structural instability in the estimated ARDL relationship.

Conclusion and Recommendations

This study examined the effects of government health expenditure, environmental quality and medical technology on infant mortality in Nigeria over the period 1985–2023, while controlling for GDP per capita and urbanization. The ARDL bounds test established the existence of a long-run relationship among the variables, with an F-statistic of 18.28348 exceeding the upper-bound critical value at the 1% level. The long-run estimates indicate that government health expenditure has a negative but statistically insignificant effect on infant mortality, suggesting that increases in public health spending alone may not be sufficient to generate substantial reductions in infant deaths. Environmental degradation, measured by CO₂ emissions, has a positive and statistically significant effect on infant mortality, confirming that worsening environmental conditions constitute an important threat to infant survival. Medical technology also has a positive but insignificant long-run effect, while urbanization has a significant negative effect on infant mortality. GDP per capita is positive but statistically insignificant in the long run. In the short run, the effects are more dynamic, with government health expenditure showing significant positive effects at some lags, environmental degradation increasing infant mortality, and medical technology producing significant mortality-reducing effects after several lags. The significant and negative error

correction coefficient of -0.189468 further confirms that approximately 18.95% of short-run disequilibrium is corrected towards long-run equilibrium each period.

Based on the findings, the study recommends that the Nigerian government should increase the efficiency and effectiveness of government health expenditure by directing a greater proportion of health resources towards primary healthcare, maternal and newborn services, immunisation, essential medicines, healthcare infrastructure and skilled health personnel, rather than focusing exclusively on increases in expenditure volumes. Given the significant positive relationship between environmental degradation and infant mortality, stronger environmental-health policies are also required, particularly measures aimed at reducing air pollution, improving waste management, strengthening sanitation and ensuring access to clean water. Investment in medical technology should be accompanied by reliable electricity, trained personnel, maintenance systems and adequate financing so that technological improvements can translate into better infant health outcomes. The government should also strengthen healthcare provision in underserved rural areas while promoting well-planned urban development, since urbanisation was found to have a significant mortality-reducing effect. Finally, health, environmental and economic policies should be implemented in an integrated manner because the results indicate that infant mortality is influenced by interconnected health, environmental and socioeconomic conditions rather than by a single factor.

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