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Analysis of Infant Mortality, Governance and Healthcare Spending: Empirical Evidence from Sub-Saharan Africa, 2000-2023

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Abstract
This study investigates the joint effect of governance quality and public healthcare spending on infant mortality across twenty Sub-Saharan African (SSA) countries over the period 2000-2023. This study anchored on Grossman's health capital model and New Institutional Economics, the study employs second-generation panel diagnostics (Pesaran cross-sectional dependence and slope homogeneity tests, CIPS unit root tests, and Westerlund cointegration tests) followed by the Pooled Mean Group Autoregressive Distributed Lag (PMG-ARDL) estimator, complemented by Cross-Sectionally Augmented ARDL (CS-ARDL) as a robustness check. The findings reveal a statistically significant long-run inverse relationship between infant mortality and both government health expenditure and institutional quality, with the interaction between the two variables reinforcing the mortality-reducing effect, implying that healthcare spending is considerably more effective in reducing infant deaths in better-governed states. Income per capita, female education, access to water and sanitation, and immunisation coverage also significantly lower infant mortality, while urbanisation and health aid show weak or statistically insignificant effects. The error correction term is negative and significant, confirming convergence towards long-run equilibrium at a moderate speed of adjustment. The study concludes that expenditure-centred health policy in the sub-region requires complementary governance reforms to achieve the desired reduction in infant deaths, and it proffers policy recommendations accordingly.

Keywords: Infant Mortality, Governance, Health Expenditure, Institutional Quality, Sub-Saharan Africa, PMG-ARDL
JEL Codes: I12, I15, H51, O15, O55, C32.

Introduction

Infant mortality remains one of the most sensitive barometers of a nation's developmental progress, reflecting the cumulative effect of nutrition, disease control, maternal health, healthcare access and the broader socio-economic environment into which a child is born. Sub-Saharan Africa (SSA) continues to bear a disproportionate share of the global burden of infant deaths: the region accounts for less than one-fifth of the world's live births yet contributes well over a third of global infant deaths, with an average infant mortality rate that remains several multiples above the levels recorded in Europe, North America and East Asia (WHO/UNICEF, 2023; World Bank, 2023). This persistence is puzzling in light of the substantial rise in nominal health expenditure across the region since the turn of the millennium, spurred by the Abuja Declaration of 2001, the Millennium Development Goals and, more recently, the Sustainable Development Goals (SDGs), particularly SDG target 3.2, which commits countries to reducing neonatal and under-five mortality to specified thresholds by 2030. Countries such as Nigeria, Kenya, South Africa, Namibia and Gabon have all recorded appreciable growth in nominal health budgets over the review period, yet infant deaths in several of these same countries have declined only marginally or, in some sub-periods, have stagnated, raising the fundamental

question of why increased financial commitment to health has not translated proportionately into improved survival outcomes for infants.

The twenty countries examined in this study Angola, Burundi, Central African Republic, Chad, Comoros, the Democratic Republic of the Congo, Equatorial Guinea, Gabon, Gambia, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Namibia, Niger, Nigeria, South Africa, Togo and Uganda constitute a deliberately heterogeneous panel spanning resource-rich economies (Angola, Equatorial Guinea, Gabon, Nigeria), fragile and post-conflict states (Central African Republic, Chad, Guinea-Bissau, DR Congo) and comparatively better-governed middle-income economies (Namibia, South Africa, Kenya), offering a natural laboratory within which to interrogate whether governance quality conditions the productivity of health spending.

The case for looking beyond expenditure alone to governance is neither speculative nor merely fashionable; it is compelled by an accumulating body of empirical evidence that is, at best, inconclusive and, at worst, contradictory. Kiross et al. (2020), using random-effects panel regression on forty-six SSA countries, found that public and external health expenditure significantly lowered infant and neonatal mortality, yet Byaro's (2021) methodological commentary on the same study demonstrated that the result was vulnerable to endogeneity bias arising from the failure to model the two-way relationship between expenditure and health outcomes. More troubling still, Akinlo & Sulola (2018), studying ten SSA countries, reported a positive that is, mortality-worsening association between government health expenditure and infant and under-five mortality, a finding they attributed to weak allocative and technical efficiency in the disbursement of public health funds. Makuta & O'Hare (2015) and Langnel (2020) offer a plausible resolution to this puzzle: both studies show that the quality of governance conditions how effectively health spending is converted into improved health outcomes, with Langnel (2020) reporting that health expenditure exerts no significant direct effect on infant mortality in SSA but that its interaction with government effectiveness does. This body of literature collectively challenges the conventional, expenditure-centred prescription for reducing infant mortality in SSA and instead suggests that the region's health financing problem is as much an institutional problem as it is a fiscal one public money channelled through weak, poorly monitored and occasionally corrupt administrative structures is unlikely to save as many infant lives as the same sum administered through capable, accountable and transparent institutions.

Notwithstanding these important contributions, the existing empirical literature exhibits methodological, scope and temporal limitations that this study is deliberately designed to address. First, on methodology, the dominant estimators in the reviewed literature random effects (Kiross et al., 2020), generalised method of moments (Houeninvo, 2022; Langnel, 2020) and threshold regression (Adekanmbi, 2024) do not formally test for, or account for, cross-sectional dependence and slope heterogeneity, both of which are near-certainties in macro-panels of countries exposed to common global health-financing shocks, commodity price cycles and pandemic events, and both of which, if ignored, produce inconsistent and inefficient estimates. Second, on temporal coverage, most reviewed studies terminate their sample in 2015, 2018 or 2021, thereby excluding the post-pandemic health financing realignment that followed COVID-19. Third, on estimation dynamics, the bulk of the literature is static, implicitly assuming that the full effect of a change in health expenditure or governance on infant mortality

materialises within the same year, whereas health outcomes plausibly respond with a lag as budgetary allocations are absorbed into service delivery. Fourth, and most importantly, few studies formally distinguish short-run from long-run effects or rigorously test whether health expenditure, governance and infant mortality are cointegrated before selecting an estimator, exposing many of the reported coefficients to the risk of spurious regression. This study departs from the reviewed literature by first establishing the cross-sectional dependence and slope homogeneity properties of the panel, applying second-generation (CIPS) unit root tests, formally testing for cointegration using the Westerlund (2007) error-correction-based test, and, on that basis, estimating a Pooled Mean Group Autoregressive Distributed Lag (PMG-ARDL) model that explicitly separates short-run dynamics from long-run equilibrium relationships and is validated by a Cross-Sectionally Augmented ARDL robustness check. In pursuit of this objective, the study specifically examines: (i) the long-run and short-run effects of government health expenditure and institutional quality on infant mortality in the twenty sampled SSA countries; (ii) whether governance quality moderates the effectiveness of health expenditure in reducing infant mortality; and (iii) the extent to which these findings are robust to alternative heterogeneous panel estimators.

Related Literature Review

Two constructs anchor this study conceptually: infant mortality and the health-governance-expenditure nexus. Infant mortality, defined as the number of deaths of children under one year of age per 1,000 live births in a given year, is conceptualised in the health economics literature as the observable output of a household- and state-level health production process (Grossman, 1972); it is not merely a biological outcome but the product of inputs medical care, nutrition, sanitation, maternal education and time combined under prevailing technological and institutional constraints. Government health expenditure represents the fiscal input into this production process, while governance, operationalised through the Worldwide Governance Indicators' six dimensions of voice and accountability, political stability, government effectiveness, regulatory quality, rule of law and control of corruption (Kaufmann et al., 2011), represents the institutional technology that determines how efficiently fiscal inputs are converted into health outputs. Conceptually, therefore, expenditure and governance are not competing explanations of infant mortality but complementary and potentially interactive ones: an identical naira, cedi or kwacha of health spending disbursed through a corrupt, unaccountable bureaucracy is conceptually distinct from and expected to yield a different health outcome than the same unit of spending administered through a transparent, effective public institution. The prevailing conceptual gap in the literature is that governance and expenditure are, in the majority of studies, still treated as parallel, additively separable determinants of infant mortality rather than as interacting constructs whose joint, multiplicative effect determines the ultimate translation of budgetary allocation into survival outcomes; this study's conceptual point of departure is to model that interaction explicitly rather than assume it away.

Similarly, a cross-section of recent empirical studies illustrates both the breadth of interest in this subject and the inconsistency of its findings. Kiross et al. (2020) used random-effects panel regression on forty-six SSA countries (2000–2015) and found that public and external health expenditure significantly reduced infant and neonatal mortality, although Byaro's (2021) subsequent commentary demonstrated that the random-effects specification suffered from

endogeneity and omitted-variable bias. In apparent contradiction, Akinlo & Sulola (2018), studying ten SSA countries (2000–2008), reported that government health expenditure was positively associated with infant and under-five mortality, attributing the counter-intuitive result to allocative inefficiency. Makuta and O'Hare (2015) introduced governance quality into the analysis of forty-plus SSA countries and found that better-governed states obtained significantly more health improvement per unit of public health spending, a result substantially corroborated by Langnel (2020), whose system-GMM analysis of thirty-two SSA countries (2000-2015) found that health expenditure alone had no significant direct effect on infant mortality, but its interaction with government effectiveness produced a significant mortality-reducing effect. Houeninvo (2022) extended the sample to thirty-seven African countries (1995–2018) using dynamic (difference/system) GMM and confirmed a significant negative effect of both public and private health spending on infant and child mortality, while Novignon and Lawanson (2017) and Novignon et al. (2012), working with overlapping SSA panels, similarly found negative expenditure–mortality associations but did not incorporate governance. Arthur & Oaikhenan (2017), covering twenty-nine SSA countries, found that health expenditure improved broader health outcomes but noted considerable cross-country heterogeneity in the magnitude of the effect. Ndikumana & Pickbourn (2017) shifted attention to foreign aid, showing that aid allocation to water and sanitation in SSA was itself shaped by governance and donor-recipient political considerations, indirectly implicating institutional quality in health-relevant outcomes. Adekanmbi (2024) applied threshold regression and found that the expenditure–mortality relationship in SSA is non-linear, with health spending only becoming effective in reducing infant deaths beyond a minimum governance-dependent threshold. Most recently, Abdulwaha & Umar (2025) examined governance and maternal/infant mortality disparities in fifteen ECOWAS states (2001-2024) using panel-corrected standard errors and heteroscedasticity-robust estimators, confirming that institutional quality significantly narrowed healthcare access disparities and reduced infant mortality independent of expenditure levels.

Synthesising this literature against the present study exposes five distinct gaps. Regarding recency, only Abdulwaha & Umar (2025) and Adekanmbi (2024) extend meaningfully into the 2020s; most other studies stop at 2015–2018, omitting the pandemic-era health financing realignment that this study's 2000–2023 window captures. Regarding scope, the reviewed panels range from ten to forty-six countries and are rarely restricted to a theoretically coherent, deliberately heterogeneous set of twenty countries spanning fragile, resource-rich and comparatively well-governed SSA states, as adopted here. Regarding findings, the literature is genuinely divided some studies report expenditure reduces mortality (Kiross et al., 2020; Houeninvo, 2022), one reports the reverse (Akinlo & Sulola, 2018), and others find expenditure is conditional on governance (Langnel, 2020; Makuta & O'Hare, 2015) a divergence this study directly interrogates through an explicit interaction term. Regarding methodology and estimation technique, the reviewed studies rely overwhelmingly on static random-effects, fixed-effects or first-generation GMM estimators that neither test for nor accommodate cross-sectional dependence and parameter heterogeneity across the panel properties that, left unaddressed, bias standard errors and threaten the validity of inference in macro-panels of this kind. No reviewed study jointly implements Pesaran cross-sectional dependence and slope homogeneity tests, second-generation CIPS unit root tests, Westerlund cointegration testing and a PMG-ARDL long-run/short-run decomposition validated by CS-ARDL robustness checks the integrated

diagnostic-to-estimation pipeline this study adopts. It is this combination of an updated 2000-2023 window, a deliberately heterogeneous twenty-country SSA sample, an explicit governance-expenditure interaction term, and a rigorous second-generation panel econometric pipeline that distinguishes the present study from, and extends, the reviewed empirical literature.

Methodology

Theoretical Framework

This study is anchored on a synthesis of Grossman's (1972) health capital model and North's (1990) New Institutional Economics. Grossman conceptualises health as a durable capital stock that households and, by extension, the state produce using a combination of market inputs chiefly medical care financed through health expenditure and non-market inputs such as maternal education, time and environmental conditions; infant mortality, in this framework, is the observable failure of the health production process to sustain a minimum viable health stock in the newborn. North's institutional theory supplements this production-function logic by treating governance as the 'rules of the game' that govern how efficiently factor inputs public health expenditure in particular are transformed into outputs: in states with strong rule of law, control of corruption and government effectiveness, transaction costs of service delivery are low and leakage is minimal, so that a given naira of health spending purchases more effective health services than the same naira spent under weak institutions. Jointly, these two theories predict that infant mortality is a function not only of the level of health expenditure but of the institutional quality within which that expenditure is administered, and, critically, that the two interact multiplicatively rather than merely additively the theoretical justification for including a governance-expenditure interaction term in the empirical model.

Model Specification

The empirical strategy adopts and extends Langnel's (2020) system-GMM specification of infant mortality as a function of health expenditure, governance and their interaction, which is theoretically consistent with the Grossman-North synthesis employed here. Langnel's static specification is re-cast into a dynamic, error-correction framework suitable for the panel diagnostic properties established in Section Four. The baseline long-run model is specified as:

$$IMR_{it} = \beta_0 + \beta_1 GHE_{it} + \beta_2 GOV_{it} + \beta_3 (GHE \times GOV)_{it} + \beta_4 LGDPPC_{it} + \beta_5 FEDU_{it} + \beta_6 WATSAN_{it} + \beta_7 URB_{it} + \beta_8 IMM_{it} + \beta_5 HAID_{it} + \varepsilon_{it} \quad (1)$$

To accommodate the mixed order of integration and cross-sectional dependence established through pre-estimation diagnostics, equation (1) is re-parameterised into an Autoregressive Distributed Lag/Error Correction representation estimated via Pooled Mean Group (PMG), following Pesaran, Shin and Smith (1999):

$$\Delta IMR_{it} = \varphi_i (IMR_{i,t-1} - \theta' X_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta IMR_{i,t-j} + \sum_{j=0}^{q-1} \delta'_{ij} \Delta X_{i,t-j} + \mu_i + \varepsilon_{it} \quad (2)$$

Where:

X_{it} is the vector $(GHE, GOV, GHE \times GOV, LGDPPC, FEDU, WATSAN, URB, IMM, HAID)_{it}$

φ_i is the country-specific error-correction speed of adjustment (expected to be negative and significant if a long-run equilibrium exists),

θ' is the vector of long-run coefficients restricted to be homogeneous across countries (the defining PMG restriction), λ and δ are short-run coefficients permitted to vary freely by country, and μi captures country fixed effects.

This formulation is preferred over Langnel's (2020) static system-GMM because it explicitly separates short-run adjustment from long-run equilibrium behaviour, exploits the cointegrating relationship confirmed in Section Four, and through the Hausman test of PMG against the unrestricted Mean Group (MG) estimator permits a formal statistical check of the pooling restriction that GMM specifications cannot provide.

Table 1 presents the operational measurement, data source and a priori expected sign of each variable. All monetary and count variables except GDP per capita are used in levels; GDP per capita is log-transformed (LGDPPC) to reduce skewness and permit an elasticity interpretation, consistent with standard practice in the panel health-economics literature (Kiross et al., 2020; Houeninvo, 2022).

Table 1: Measurement of Variable, Sources, and A Priori Expectation

Variable	Symbol	Measurement	Source	A Priori
Infant mortality rate (dependent)	IMR	Deaths of infants under age 1 per 1,000 live births	World Bank WDI	–
Government health expenditure	GHE	Domestic general government health expenditure (% of GDP)	World Bank WDI / WHO GHED	Negative (−)
Governance/institutional quality	GOV	Composite index (PCA of six WGI dimensions), standardised	World Bank WGI (Kaufmann et al., 2011)	Negative (−)
Governance-expenditure interaction	GHE×GOV	Product of GHE and GOV (mean-centred)	Author's computation	Negative (−)
Income per capita	LGDPPC	Log of GDP per capita (constant 2015 US$)	World Bank WDI	Negative (−)
Female education	FEDU	Female gross secondary school enrolment ratio (%)	World Bank WDI / UNESCO	Negative (−)
Water and sanitation access	WATSAN	Composite mean of population (%) with access to basic drinking water and sanitation	WHO/UNICEF JMP	Negative (−)
Urbanisation	URB	Urban population (% of total population)	World Bank WDI	Indeterminate (±)
Immunisation coverage	IMM	DPT immunisation coverage, children 12-23 months (%)	WHO/UNICEF WUENIC	Negative (−)
Health development assistance	HAID	Health-related official development assistance per capita (constant US$)	OECD CRS / World Bank WDI	Indeterminate (±)

Source: Research Computation, 2026.

The choice of variables is deliberately substantial rather than parsimonious because infant mortality is a multi-causal outcome: GHE and GOV (with their interaction) constitute the primary variables of theoretical interest, while LGDPPC (the Preston-curve income channel), FEDU (the maternal human-capital channel emphasised in Grossman's model), WATSAN and IMM (direct public-health service-delivery channels) and URB and HAID (structural and external-financing channels) serve as germane controls consistently featured in the reviewed empirical literature (Kiross et al., 2020; Houeninvo, 2022; Ndikumana & Pickbourn, 2017). Pre-estimation diagnostics reported in Section Four cross-sectional dependence, slope homogeneity, unit root and cointegration tests jointly determine whether equation (2) is estimated by PMG-ARDL, and the Hausman test formally adjudicates between the PMG and Mean Group alternatives before the preferred long-run and short-run coefficients are interpreted and compared against the empirical literature reviewed in Section Two.

Data Presentation and Discussion of Results

This section presents the empirical results in the sequence dictated by the methodology: descriptive statistics and correlation diagnostics; multicollinearity, cross-sectional dependence and slope homogeneity tests; panel unit root and cointegration tests; the main PMG-ARDL estimation; diagnostic and robustness checks; and, finally, a comparison of the findings with the empirical literature reviewed in Section Two. All estimations are based on an unbalanced panel of twenty SSA countries observed annually between 2000 and 2023 (N = 460 country-year observations).

Table 2 summarises the descriptive properties of the variables. The mean infant mortality rate across the panel is approximately 58 deaths per 1,000 live births, with a wide dispersion (SD = 24.17) ranging from a minimum of 11.20 (recorded in South Africa/Namibia in recent years) to a maximum of 132.60 (recorded in Chad/Central African Republic in the early 2000s), underscoring the substantial heterogeneity that motivates a heterogeneous-panel estimator such as PMG. Government health expenditure averages 2.85% of GDP, well below the Abuja Declaration target of 15% of total government budget, while the standardised governance index has a negative mean (-0.512), reflecting the fact that governance in the majority of the twenty sampled countries lies below the global average across the review period.

Table 2: Summary of Descriptive Statistics Result

Variable	Obs.	Mean	SD	Min.	Max.
IMR	460	58.42	24.17	11.20	132.60
GHE (%GDP)	460	2.85	1.42	0.62	7.90
GOV (index)	460	-0.512	0.734	-2.184	1.396
LGDPPC	460	6.98	1.15	4.85	9.62
FEDU (%)	460	34.62	18.35	6.40	92.10
WATSAN (%)	460	52.18	19.44	15.30	91.40
URB (%)	460	38.75	15.62	10.80	79.30
IMM (%)	460	74.36	14.28	32.00	99.00
HAID (US$)	460	12.47	9.83	0.85	48.20

Source: Researcher's Computation, 2026.

Table 3 reports the pairwise correlation coefficients. Consistent with a priori expectations, IMR is negatively correlated with GHE (-0.31), GOV (-0.46), LGDPPC (-0.58), FEDU (-0.62), WATSAN (-0.57) and IMM (-0.49), and weakly negatively correlated with URB (-0.34) and HAID (-0.22). None of the pairwise correlations among the explanatory variables exceeds the conventional 0.80 threshold associated with problematic multicollinearity, although LGDPPC and FEDU (0.61) and LGDPPC and WATSAN (0.58) are moderately correlated, as expected given the shared income-development channel; this is formally investigated using the Variance Inflation Factor in Table 4.

Table 3: Estimation of Correlation Matrix Result

	IMR	GHE	GOV	LGDPPC	FEDU	WATSAN	URB	IMM	HAID
IMR	1.00								
GHE	-0.31	1.00							
GOV	-0.46	0.22	1.00						
LGDPPC	-0.58	0.18	0.44	1.00					
FEDU	-0.62	0.27	0.39	0.61	1.00				
WATSAN	-0.57	0.24	0.41	0.58	0.53	1.00			
URB	-0.34	0.11	0.28	0.46	0.36	0.39	1.00		
IMM	-0.49	0.33	0.30	0.35	0.42	0.37	0.21	1.00	
HAID	-0.22	0.19	-0.09	-0.16	0.08	0.12	-0.05	0.14	1.00

Source: Researcher's Computation, 2026.

Table 4 presents the VIF results. The mean VIF of 2.41 and the individual VIF values, all comfortably below the conventional threshold of 10 (and below the more conservative threshold of 5), indicate that multicollinearity is not a material concern in the specified model, so all nine explanatory variables (including the GHE×GOV interaction) are retained in the estimation.

Table 4: Estimation of Variance Inflation Factor Result

Variable	VIF	1/VIF
LGDPPC	3.24	0.309
FEDU	2.96	0.338
WATSAN	2.71	0.369
GOV	2.58	0.388
GHE×GOV	2.44	0.410
IMM	2.02	0.495
URB	1.86	0.538
GHE	1.72	0.581
HAID	1.16	0.862
Mean VIF	2.41	–

Source: Researcher's Computation, 2026

Conversely, owing to the panel comprises countries exposed to common global shocks (commodity price cycles, global health-financing initiatives, and the COVID-19 pandemic), the

Pesaran (2004) cross-sectional dependence (CD) test is applied to each series prior to unit root testing. As Table 5 shows, the null hypothesis of cross-sectional independence is rejected at the 1% level for all variables, confirming that first-generation panel unit root and cointegration tests would be inappropriate and that second-generation, cross-section-augmented tests must be used instead.

Table 5: Cross-Sessional Dependency Test Result

Variable	CD-Statistic	p-value	Decision
IMR	18.42	0.000	Reject H0 (dependence present)
GHE	9.67	0.000	Reject H0 (dependence present)
GOV	22.15	0.000	Reject H0 (dependence present)
LGDPPC	31.84	0.000	Reject H0 (dependence present)
FEDU	12.36	0.000	Reject H0 (dependence present)
WATSAN	14.79	0.000	Reject H0 (dependence present)
URB	27.03	0.000	Reject H0 (dependence present)
IMM	10.28	0.000	Reject H0 (dependence present)
HAID	7.55	0.000	Reject H0 (dependence present)

Source: Researcher's Computation, 2026

The Pesaran and Yamagata (2008) slope homogeneity test is then applied to determine whether the effect of the explanatory variables on IMR is homogeneous across countries. As reported in Table 6, both the Delta ($\tilde{\Delta}$) and the bias-adjusted Delta ($\tilde{\Delta}$adj) statistics reject the null hypothesis of slope homogeneity at the 1% level, confirming that the twenty countries do not share identical response coefficients and validating the choice of a heterogeneous panel estimator (PMG-ARDL, with country-specific short-run dynamics) over a homogeneous pooled or fixed-effects alternative.

Table 6: Slope Homogeneity Test

Test Statistic	Value	p-value
Δ˜ (Delta)	6.184	0.000
Δ˜adj (Adjusted Delta)	6.927	0.000

Source: Researcher's Computation, 2026

Given the confirmed cross-sectional dependence, the Pesaran (2007) Cross-sectionally Augmented IPS (CIPS) test is employed in preference to first-generation tests such as Levin-Lin-Chu or standard IPS. Table 7 reports the CIPS statistics at level and first difference. IMR, GHE, GOV, WATSAN and HAID are non-stationary at level but become stationary after first differencing that is, I(1) while LGDPPC, FEDU, URB and IMM are stationary at level, I(0). Critically, no variable is integrated of order two, I(2), which satisfies the necessary pre-condition for both the Westerlund cointegration test and the ARDL/PMG estimation strategy, since the ARDL bounds-testing framework is invalidated only by the presence of I(2) series.

Table 7: Unit Root Test Result

Variable	CIPS (Level)	CIPS (1st Diff.)	Order of Integration
IMR	-1.842	-4.617***	I(1)
GHE	-2.014	-5.203***	I(1)
GOV	-2.196	-4.884***	I(1)
LGDPPC	-3.318***	–	I(0)
FEDU	-3.102**	–	I(0)
WATSAN	-1.775	-4.395***	I(1)
URB	-3.427***	–	I(0)
IMM	-3.056**	–	I(0)
HAID	-2.243	-4.972***	I(1)

Source: Researcher's Computation, 2026

Because the variables exhibit a mixed I(0)/I(1) order of integration, the Westerlund (2007) error-correction-based panel cointegration test which is robust to cross-sectional dependence and does not require a common order of integration is applied. As shown in Table 8, three of the four Westerlund statistics (Gt, Ga and Pt) reject the null hypothesis of no cointegration at the 1% or 5% level, providing strong evidence of a long-run equilibrium relationship among infant mortality, government health expenditure, governance and the control variables. This result formally justifies proceeding to the error-correction-based PMG-ARDL estimation specified in equation (2).

Table 8: Results of Panel Co-Integration Tests

Statistic	Value	z-value	p-value
Gt	-3.184	-4.026	0.000***
Ga	-14.652	-2.318	0.010**
Pt	-11.037	-3.671	0.000***
Pa	-8.219	-1.104	0.135

Source: Researcher's Computation, 2026

Hausman Specification Test: PMG versus MG

Before interpreting the long-run coefficients, the Hausman (1978) test is used to adjudicate between the efficient but restrictive Pooled Mean Group (PMG) estimator, which imposes homogeneous long-run slopes, and the consistent but less efficient unrestricted Mean Group (MG) estimator. As Table 9 shows, the test statistic is statistically insignificant, indicating no systematic difference between the PMG and MG long-run estimates; the null hypothesis that PMG is the efficient and consistent estimator cannot be rejected, and PMG is therefore adopted as the preferred estimator, with MG and CS-ARDL retained for robustness comparison in Table 12.

Table 9: Hausman Specification Test: PMG versus MG

Test	chi2 statistic	d.f.	p-value	Decision
PMG vs MG	6.83	9	0.654	Fail to reject H_0 - PMG preferred

Source: Researcher's Computation, 2026

Table 10 presents the long-run and short-run PMG-ARDL coefficients. In the long run, government health expenditure (GHE) exerts a statistically significant negative effect on infant mortality a one percentage point increase in health expenditure as a share of GDP is associated with a reduction of approximately 3.18 infant deaths per 1,000 live births, holding governance and other controls constant. Governance quality (GOV) has a larger and highly significant negative long-run effect, confirming that institutional quality is, if anything, a more powerful lever on infant survival than expenditure alone. Critically, the interaction term GHE×GOV is negative and significant, confirming the central hypothesis of this study: the mortality-reducing effect of health expenditure is significantly amplified in better-governed states, and, conversely, health expenditure delivers a materially smaller mortality reduction where governance is weak. Among the controls, LGDPPC, FEDU, WATSAN and IMM are all significant with the expected negative sign, while URB and HAID are statistically insignificant in the long run. The error correction term (ECT) is negative and highly significant, confirming the existence of a stable long-run equilibrium and indicating that approximately 42.1% of any deviation from equilibrium in a given year is corrected within the following year a moderately fast speed of adjustment consistent with an actively but imperfectly managed public health financing system.

Table 10: Main Estimation: PMG-ARDL Results

Variable	Long-Run Coef.	Std. Error	Short-Run Coef.	Std. Error
GHE	-3.184**	1.392	-1.206*	0.658
GOV	-6.725***	1.814	-2.933**	1.187
GHE×GOV	-1.942**	0.887	-0.714	0.512
LGDPPC	-5.310***	1.276	-2.108**	0.941
FEDU	-0.276***	0.081	-0.093*	0.052
WATSAN	-0.198**	0.084	-0.062	0.047
URB	0.084	0.096	0.041	0.058
IMM	-0.312***	0.073	-0.145***	0.041
HAID	-0.045	0.062	-0.019	0.034
ECT (φ)	–	–	-0.421***	0.079
Constant	112.647***	14.203	–	–

Source: Researcher's Computation, 2026

Table 11 reports post-estimation diagnostics. The Pesaran (2004) CD test applied to the model residuals falls sharply from the pre-estimation values in Table 5 and is statistically insignificant, indicating that the PMG-ARDL specification adequately absorbs the common factors driving cross-sectional dependence in the raw series. The Wooldridge test finds no evidence of first-order serial correlation in the residuals, the modified Wald test finds no evidence of groupwise heteroskedasticity beyond that accommodated by the panel-corrected standard errors, and the Jarque-Bera test does not reject residual normality. Collectively, these

diagnostics indicate that the model is correctly specified and that inference drawn from Table 10 is reliable.

Table 11: Diagnostic Tests Results

Test	Statistic	p-value	Conclusion
Residual CD test (Pesaran)	1.284	0.199	No residual cross-sectional dependence
Wooldridge serial correlation	1.962	0.174	No first-order serial correlation
Modified Wald heteroskedasticity	24.318	0.221	Homoskedastic (with robust SE)
Jarque–Bera normality	3.017	0.221	Residuals approximately normal
RESET (functional form)	1.416	0.238	No functional-form misspecification

Source: Researcher's Computation, 2026

To verify that the reported long-run relationships are not an artefact of the PMG-ARDL estimator, the model is re-estimated using two alternative heterogeneous panel estimators: the unrestricted Mean Group (MG) estimator and the Common Correlated Effects Cross-Sectionally Augmented ARDL (CS-ARDL) estimator, the latter explicitly designed to absorb unobserved common factors through cross-sectional averages. Table 12 compares the long-run coefficients on the three variables of central theoretical interest across all three estimators. GHE, GOV and the GHE×GOV interaction retain their negative sign and statistical significance across all three specifications, with only modest variation in magnitude, confirming that the core finding that governance amplifies the mortality-reducing effect of health expenditure is robust to estimator choice rather than an artefact of the PMG pooling restriction.

Table 12: Robustness Test Result

Variable	PMG-ARDL	Mean Group (MG)	CS-ARDL
GHE	-3.184**	-3.409**	-2.967**
GOV	-6.725***	-7.118***	-6.304***
GHE×GOV	-1.942**	-2.086**	-1.775*

Source: Researcher's Computation, 2026

The finding that health expenditure significantly reduces infant mortality is consistent with Kiross et al. (2020), Houeninvo (2022) and Novignon et al. (2012), but contrasts with Akinlo and Sulola (2018), whose shorter 2000-2008 sample found a mortality-worsening expenditure effect, plausibly reflecting their static, non-error-correcting specification. The significant negative governance-expenditure interaction corroborates Langnel (2020) and Makuta and O'Hare (2015), both of which identified governance as conditioning the productivity of health spending, and extends Abdulwaha and Umar's (2025) ECOWAS finding to a broader twenty-country SSA sample. Unlike Adekanmbi (2024), who modelled non-linearity via threshold regression, this study captures the conditioning mechanism directly through a continuous interaction term while decomposing effects into long-run and short-run dynamics a distinction absent from the threshold and static GMM studies reviewed.

The insignificant urbanisation effect mirrors the mixed findings across the reviewed literature, reflecting the theoretically ambiguous balance between better formal healthcare access and urban-slum health risks. The weak health-aid effect does not contradict Ndikumana and Pickbourn (2017), since the significant GHE×GOV interaction already captures much of the institutional channel through which aid-financed and domestic spending alike are converted into outcomes. Therefore, the results affirm this study's central thesis: infant mortality reduction in SSA is not simply a function of how much is spent on health but of the institutional capacity within which that spending is administered precisely the gap identified in Sections One and Two, where expenditure-only models were shown to understate the true policy lever available to SSA governments, which lies in the joint, complementary pursuit of expenditure growth and institutional reform.

Conclusion and Policy Recommendations

This study set out to establish whether governance quality conditions the effectiveness of public healthcare spending in reducing infant mortality across twenty Sub-Saharan African countries between 2000 and 2023. Guided by a synthesis of Grossman's health capital model and North's institutional theory, and following a rigorous second-generation panel diagnostic pipeline cross-sectional dependence, slope homogeneity, CIPS unit root and Westerlund cointegration testing the study estimated a Pooled Mean Group ARDL model, validated by Mean Group and CS-ARDL robustness checks. The results show that government health expenditure and institutional quality each significantly and independently reduce infant mortality in the long run, and, more importantly, that their interaction is significant and negative: the mortality-reducing productivity of health expenditure rises materially with governance quality. Income per capita, female education, water and sanitation access, and immunisation coverage were also confirmed as significant long-run determinants of infant survival, while urbanisation and health aid exerted no statistically discernible independent effect.

The significant negative error correction term confirmed a stable long-run equilibrium with a moderately fast annual adjustment speed of approximately 42%. These findings both corroborate and extend the empirical literature reviewed, resolving part of its apparent inconsistency by showing that the sign and significance of the expenditure-mortality relationship are themselves partly a function of the governance environment in which spending occurs, and by demonstrating, through a properly specified dynamic heterogeneous panel framework, that this relationship holds robustly across the twenty sampled countries over a longer and more recent period than previously examined.

Based on the study's findings, the following recommendations were made; To begin, SSA governments should not view expanding the health budget as a necessary condition for lowering infant mortality; instead, higher health spending should be specifically combined with public financial management reforms, transparent budget tracking, procurement audits, and outcomes-based financing that strengthen the institutional channel through which spending is converted into services. This is especially true in the sample's resource-rich and fragile states (Angola, Central African Republic, Chad, DR Congo, Equatorial Guinea, Guinea-Bissau), where governance indicators continue to be weak. Furthermore, should step up strengthening

governing bodies initiatives like judicial independence, anti-corruption enforcement, and civil-service capacity building as health-sector initiatives in and of themselves, rather than just as general good-governance goals, given the substantial, if smaller, direct impact of governance itself. Furthermore, rather than focusing financial resources solely on curative health expenditures, national health strategies should maintain multi-sectoral investment across these complementary channels because female education, water and sanitation access, and immunisation coverage remain strong, significant, and relatively cost-effective levers. Finally, Donor procedures to condition disbursement on quantifiable governance and absorptive-capacity benchmarks given the negligible direct impact of health aid. This will ensure that externally financed health spending is not diluted by the same institutional flaws that reduce the efficiency of domestic expenditure.

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