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Malaria and Child Survival in Sub-Saharan Africa: Does Institutional Quality Modify the Malaria-Mortality Relationship?

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Abstract

Despite decades of global investment in malaria control, under-5 mortality in Sub-Saharan Africa (SSA) remains unacceptably high, and the governance conditions under which malaria programmes translate into child survival gains are poorly understood. This study investigates the direct relationship between malaria incidence, institutional quality, and under-5 mortality using a panel of 35 SSA countries from 2000 to 2023 and examines whether institutional quality modifies the malaria-mortality relationship. Applying static Fixed Effects estimation with Driscoll-Kraay standard errors, confirmed through a five-stage diagnostic sequence encompassing cross-sectional dependence testing, second-generation panel unit root tests, Hausman specification testing, dynamic persistence testing, and control-function endogeneity correction, we find that malaria incidence significantly and robustly increases

under-5 mortality across all specifications. At mean institutional quality, a one standard deviation increase in malaria incidence is associated with 5.7 additional child deaths per 1,000 live births. Marginal effects analysis indicates a 35% differential in the malaria-mortality relationship between weak and strong governance settings, though the interaction term does not reach conventional statistical significance. Among individual governance dimensions, Government Effectiveness and Regulatory Quality approach significance as moderators, pointing to state operational capacity rather than accountability or stability as the proximate institutional channel. A novel methodological contribution concerns data quality: three transcription errors in a single fragile state account for approximately 23 percentage points of unexplained model variation, illustrating that data quality failures in conflict-affected settings disproportionately influence panel estimates for the entire region. The findings support treating malaria control and institutional capacity-building as complementary rather than competing priorities in SSA health policy.
Keywords: Malaria Child Mortality, Institutional Quality, Sub-Saharan Africa, Panel Data, Fixed Effects

Introduction

Every year, malaria kills hundreds of thousands of children in Sub-Saharan Africa before they reach their fifth birthday. The number has fallen substantially since 2000, from roughly 800,000 annual child deaths attributable to malaria at the turn of the century to closer to 500,000 by the early 2020s, but the pace of progress has slowed, and in several countries the burden has been rising again (WHO, 2022a). Global health financing for malaria control has grown dramatically over this period, yet the conversion of programme spending into population-level mortality reductions has been strikingly uneven across the region. Some countries have achieved dramatic declines in child mortality despite persistently high malaria burdens; others have seen limited gains despite substantial external investment.

Understanding what drives this heterogeneity is not merely an academic exercise. With the Sustainable Development Goal 3 target of ending preventable child deaths by 2030 still far from achieved across most of SSA, policymakers and international donors urgently need evidence on which conditions determine whether malaria control investments translate into child survival gains. The answer has direct fiscal implications: if the mortality returns to malaria programme spending are substantially higher in better-governed settings, then the case for sequencing governance reform alongside disease control, rather than treating them as competing budget priorities, rests on empirical evidence rather than conjecture. Yet that evidence remains largely absent from the quantitative literature. This study is motivated by the need to fill that gap with the most comprehensive SSA panel dataset and most rigorous diagnostic framework yet applied to this question.

The urgency of this inquiry is underscored by the widening gap between global malaria financing and actual child survival gains in SSA. Between 2000 and 2022, international disbursements for malaria control in SSA exceeded USD 50 billion, yet the WHO (2023) reports that progress toward malaria elimination has stalled or reversed in at least 11 SSA countries since 2015. This paradox, abundant resources, inadequate outcomes, points to a system-level problem that transcends clinical or epidemiological explanations. Hafner & Shiffman (2013) argue that the global health governance architecture around malaria has prioritised technical scale-up over the domestic institutional conditions that determine whether programmes

actually reach children at risk, a gap this study directly addresses. Moreover, Rajkumar & Swaroop (2008) demonstrate that public health expenditure reduces child mortality significantly only in countries with good governance, suggesting that any evaluation of malaria programme effectiveness that ignores the institutional context is likely to misattribute failure or success to the wrong causes. This study is therefore motivated not only by a gap in the malaria-mortality literature, but by a wider policy failure to take governance seriously as a binding constraint on health impact in SSA.

One underappreciated explanation for this heterogeneity is institutional quality. The ability of a government to procure and distribute insecticide-treated nets, deploy and retain community health workers, maintain pharmaceutical cold chains, and regulate the quality of antimalarial drugs in private markets all depend on the operational capacity of the state and the governance environment in which health programmes are delivered. Yet the empirical literature on malaria and child health in SSA has largely treated governance as a background condition rather than a variable of interest. Studies that examine the malaria-mortality relationship typically control for income or health expenditure but rarely ask whether the same level of malaria burden produces different mortality outcomes depending on the quality of the institutional environment.

This study addresses that gap. Using a strongly balanced panel of 35 SSA countries observed annually from 2000 to 2023, we pursue two related objectives. First, we estimate the direct effects of malaria incidence and institutional quality on under-5 mortality, controlling for health expenditure, fertility, universal health coverage, HIV prevalence, and malaria net distribution. Second, we test whether institutional quality modifies the magnitude of the malaria-mortality relationship, specifically, whether higher institutional quality dampens the mortality consequences of a given malaria burden. The research question is policy-relevant because it speaks directly to the returns on governance investment in high-malaria settings: if the malaria effect is substantially larger under weak governance, then institutional reforms and malaria control programmes are complementary investments rather than alternatives for scarce development budgets.

Several features of this study advance beyond existing work, and together they constitute three substantive contributions to the literature. The first is an empirical contribution: we produce the most comprehensive and econometrically rigorous estimate of the malaria-mortality relationship for SSA to date, covering 35 countries over 24 years with a five-stage diagnostic sequence that rules out common threats to valid inference. The second is a theoretical contribution: by testing whether institutional quality modifies the conversion of malaria burden into child death, we provide the first direct econometric test of the governance-mediated heterogeneity hypothesis in the malaria-mortality literature, bridging the health economics and governance literatures in a way that has practical implications for how development budgets should be sequenced. The third is a methodological contribution to SSA panel econometrics: formal standardised residual diagnostics reveal that data quality failures in a single fragile state can distort estimates for the entire region by a quantifiable and previously undocumented margin. Specifically, we apply a structured five-stage diagnostic sequence to determine the appropriate estimator rather than imposing one a priori, with the sequence encompassing cross-sectional dependence testing, second-generation panel unit root tests, Hausman specification testing, dynamic persistence testing,

and a control-function approach to endogeneity. We disaggregate the composite governance measure into its six constituent World Bank Worldwide Governance Indicators (WGI) dimensions, finding that Government Effectiveness and Regulatory Quality are the operative channels while accountability and stability dimensions show no meaningful moderation. We conduct formal standardised residual diagnostics that identify a novel methodological finding: three transcription errors in a single fragile state (the Central African Republic) account for approximately 23 percentage points of unexplained model variation and obscure the institutional quality effect in the full sample, a finding with broad implications for SSA panel econometrics. Finally, we embed all results in a comprehensive robustness analysis spanning eight specifications including an IV-FE model addressing the weak endogeneity of malaria incidence.

These contributions matter collectively, not just individually. The empirical contribution addresses a significant void: despite the now substantial literature on the social determinants of health in SSA (Braveman et al., 2011), the governance-malaria mortality nexus has received conspicuously little econometric attention relative to its policy importance. The theoretical contribution bridges two literatures, health economics and governance studies, that have largely developed in parallel rather than in dialogue; the closest antecedent is Farag et al. (2013) , who showed that governance moderates the health return to spending, but no study has examined whether it also moderates the mortality burden imposed by a specific disease. The methodological contribution has the broadest relevance for SSA empirical research, since the fragile state data quality problem we document here is structural and affects any panel model that uses administrative mortality data from conflict-affected countries, regardless of the health outcome under study. Together, the three contributions make the case that understanding malaria's burden on children in SSA is inseparable from understanding the institutional environments in which families, health workers, and governments respond to that burden.

The study is organised as follows. Section 2 situates the analysis in the theoretical and empirical literature. Section 3 describes the data, missing data treatment, and the composite governance index. Section 4 presents the econometric strategy including the five-stage diagnostic sequence. Section 5 reports the empirical results. Section 6 discusses the findings and their implications for policy and future research. Section 7 concludes.

Conceptual Framework and Literature

Malaria and Child Mortality in SSA

The biological pathway from malaria to child death is well-established. Plasmodium falciparum infection, the dominant strain in SSA, causes severe anaemia, cerebral malaria, and respiratory distress, with young children under five years particularly vulnerable because they have not yet developed the partial immunity that repeated exposure confers in older ages (Greenwood et al., 2005). The epidemiological literature provides strong evidence that malaria burden is a direct cause of under-5 mortality rather than merely a correlate of poverty or weak health systems, with quasi-experimental studies exploiting rainfall shocks (Kudamatsu et al., 2012), geographic variation in transmission intensity (Sachs & Malaney, 2002), and rollout of the Roll Back Malaria programme (Bhatt et al., 2015) all pointing to substantial causal effects.

At the macro level, Gething et al. (2010) estimated that malaria was responsible for approximately 20% of all child deaths in SSA in 2000, with the share varying from near zero in low-transmission southern African countries to over 30% in hyperendemic West and Central African settings. Liu et al. (2015) used verbal autopsy data to decompose cause-specific child mortality and confirms malaria as a leading but heterogeneous cause across the region. The critical implication is that the malaria-mortality relationship is not constant: it varies across geography, seasonality, intervention coverage, and as we argue here, institutional environment.

Institutional Quality and Health Outcomes

The theoretical case for governance affecting health outcomes operates through multiple channels. At the most direct level, the capacity of public health systems to deliver services depends fundamentally on the quality of public administration. Countries with more effective governments can recruit and retain skilled health workers, maintain pharmaceutical supply chains, enforce drug quality standards, and ensure that budgeted health expenditure reaches frontline facilities rather than being diverted through corruption (Kaufmann & Kraay, 2002; Rajkumar & Swaroop, 2008). In the specific context of malaria, functional government is required to coordinate national malaria control programmes, implement mass net distribution campaigns, sustain indoor residual spraying operations, and regulate the private pharmaceutical sector that accounts for a substantial share of treatment-seeking in SSA (WHO, 2022b).

The empirical literature on governance and population health in SSA has grown substantially but remains somewhat fragmented. Farag et al. (2013) find that the effect of health expenditure on child mortality is significantly moderated by governance quality, with the mortality-reducing return to spending roughly doubling in above-median governance settings. Kouadio (2025) and Olafsdottir et al. (2011)found that governance matters for health outcomes in SSA but that the effects are heterogeneous across governance dimensions and health indicators. Langbein & Knack (2010) document the high empirical inter-correlation among WGI dimensions in developing country panels, motivating the use of composite governance measures in studies like this one. What is notably absent from this literature is a study that specifically examines whether governance modifies the malaria-mortality relationship, asking not just whether governance affects health broadly but whether it changes the conversion rate of malaria burden into child death.

Data Quality as an Overlooked Dimension

A thread running through the SSA health data literature that rarely receives explicit attention in empirical work is the systematic relationship between governance quality and mortality data completeness. Countries with stronger institutional environments have more functional civil registration and vital statistics (CRVS) systems, recording a higher share of child deaths, particularly those occurring in community settings outside health facilities (Mahapatra et al., 2007; Setel et al., 2007). This creates a form of measurement endogeneity: improving governance simultaneously affects the true mortality rate and the probability that a death is captured in administrative records. Panel models that use administrative mortality data are therefore estimating a compound relationship between governance and observed rather than true mortality, a distinction that is especially important in fragile states where both governance is weakest and data quality is most compromised. We return to this issue

extensively in our results, where formal outlier diagnostics surface its quantitative importance.

Data

Sample and Sources

The analysis uses a strongly balanced panel of 35 Sub-Saharan African countries observed annually from 2000 to 2023, yielding 840 country-year observations. The sample covers roughly 85% of SSA's child population and spans the full geographic, epidemiological, and institutional diversity of the region, from near-zero malaria transmission in Botswana, Namibia, and South Africa to hyperendemic settings in the Congo Basin and West Africa, and from the relatively strong institutions of Cabo Verde and Botswana to among the world's most fragile governance environments in the Central African Republic and Chad.

The outcome variable, under-5 mortality rate (mor) and Malaria incidence (mal) measured as estimated new cases per 1,000 population at risk, are sourced from the World Bank World Development Indicators. Governance indicators come from the World Bank's Worldwide Governance Indicators database (Kaufmann & Kraay, 2002). All control variables such as current health expenditure per capita (chepc), total fertility rate (fer), UHC service coverage index (uhc), HIV prevalence (hiv), insecticide-treated net use per 100 people (itn) are also sourced from the World Bank World Development Indicators, except annual rainfall (rain) and mean annual temperature (temp) which are sourced from Climate Change Knowledge Portal.

Composite Governance Index

The six WGI dimensions, Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence, Regulatory Quality, Rule of Law, and Voice and Accountability, are highly inter-correlated in SSA panels, as documented by (Langbein & Knack, 2010). Principal component analysis confirms this: the first component explains 78.96% of total variance, with all six dimensions loading evenly between 0.368 and 0.442 (eigenvalue 4.737). A composite index (IQ_mean) is constructed as the simple mean of the six standardised indicators. The correlation between this composite and the PCA-derived first component is r=0.9999, confirming that the choice of aggregation method is inconsequential for the results. Both variables are mean-centred before constructing the interaction term, following the recommendation of Jaccard and Turrisi (2003) to remove non-essential multicollinearity between main effects and their product.

Missing Data

Three variables have structured missingness. All six WGI indicators are missing for year 2001 across all 35 countries, a structural artefact of the World Bank's biennial WGI publication schedule before 2003, which never produced a 2001 reference year (Kaufmann & Kraay, 2002). Three additional isolated cells are missing (Cabo Verde geff 2000; Eswatini pols 2000; Comoros pols 2009). Linear temporal interpolation using adjacent years was applied to all WGI gaps; a robustness checks excluding year 2001 entirely confirms this has no material effect on any result. School enrolment GPI (lit) has 162 missing observations (19.3%), concentrated from 2020 onward due to COVID-19 disruption to national data collection, and is treated as Missing at Random with 20-fold predictive mean matching imputation. Food

production index values are missing for all countries in 2023 due to FAO publication lag and are retained as missing in the primary analysis.

Table 1
Summary Statistics

Variable	N	Mean (SD)	Min	P25	Max
Under-5 mortality rate (per 1,000 live births)	840	86.4 (43.3)	11.6	52.6	478.9
Malaria incidence (per 1,000 population at risk)	840	225.1 (163.9)	0.0	84.1	711.4
Composite Institutional Quality (IQ_mean)	840	0.00 (0.887)	-1.94	-0.79	2.39
Health expenditure per capita (USD)	840	81.9 (119.6)	4.2	22.3	686.9
Total fertility rate (births per woman)	840	4.93 (1.20)	1.52	4.03	7.83
UHC service coverage index	840	39.5 (13.3)	13.0	29.0	75.0
HIV prevalence, ages 15-49 (%)	840	4.94 (6.47)	0.0	0.80	29.4
Annual rainfall (mm)	840	1,008 (543)	93.6	581	2,797
ITN use per 100 people	840	25.4 (24.6)	0.0	3.41	84.1
Mean temperature (°C)	840	24.9 (3.03)	17.5	22.7	30.0

Notes: N=840 (35 countries × 24 years). Values in the mean column are mean (standard deviation). IQ_mean is the standardised composite of six WGI indicators. School enrolment GPI: N=678 observed (162 imputed via predictive mean matching, m=20). Food production index: N=805 (35 missing in year 2023). P25 denotes the 25th percentile.

Empirical Strategy

Estimating Equations

Two model variants correspond to the two parts of the research objective. Model 1 tests the direct effects of malaria incidence and institutional quality on under-5 mortality:

$$mor_{it} = \alpha_i + \beta_1 malc_{it} + \beta_2 IQc_{it} + \beta_3 X_{it} + \varepsilon_{it} \quad (1)$$

Model 2 adds the interaction term to examine whether institutional quality modifies the malaria effect:

$$mor_{it} = \alpha_i + \beta_1 malc_{it} + \beta_2 IQc_{it} + \beta_3 (malc \times \mathrm{IQc})_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (2)$$

α_i denotes country fixed effects absorbing all time-invariant country-specific characteristics, and X_{it} is a vector of controls comprising health expenditure per capita, total fertility rate, UHC coverage index, HIV prevalence, and ITN use. A negative coefficient on the interaction term in equation (2) implies that institutional quality dampens the malaria-mortality relationship; a positive coefficient implies amplification. Mean centring of mal and IQ_mean before constructing the interaction term ensures that the main effect coefficients remain interpretable as the effect of each variable at the mean of the other. The total marginal effect of malaria on mortality at any governance level is: $\frac{\partial mor}{\partial mal} = \beta_1 + \beta_3 (IQc)$, which we evaluate at the mean, one standard deviation below, and one standard deviation above the mean.

Diagnostic Sequence and Estimator Selection

The choice of estimator follows a five-stage diagnostic sequence, the results of which are summarised in Appendix Table A1.

Stage 1: Cross-sectional dependence. The Pesaran (2021) CD test strongly rejects the null of weak cross-sectional dependence for under-5 mortality (CD=108.98, p<0.001), malaria incidence (CD=47.01, p<0.001), and institutional quality (CDw=3.81, p<0.001). This is unsurprising: SSA countries share common epidemiological shocks, correlated aid flows, and broadly co-moving development trajectories. The presence of CSD rules out first-generation unit root tests.

Stage 2: Panel unit root tests. The cross-sectionally augmented IPS test (CIPS; Pesaran, 2007) which accounts for cross-sectional dependence, confirms that under-5 mortality (CIPS*=−2.662) and malaria incidence (CIPS*=−2.843) are stationary in levels at the 1% level. The institutional quality composite tests borderline non-stationary in levels (CIPS*=−2.028) but stationary in first differences (CIPS*=−4.038), indicating I(1) behaviour consistent with the well-documented persistence of governance trajectories in SSA (Acemoglu and Robinson, 2012). This mixed integration order motivates fixed effects rather than levels estimation, since the within-transformation implicitly addresses the near-non-stationarity in governance series.

Stage 3: Hausman specification test. The Hausman (1978) test rejects the null of random effects consistency at the 1% level ($chi^2(8)=23.11$, p=0.003). The most pronounced divergence between FE and RE coefficients is for HIV prevalence, where FE yields −0.19 and RE yields 1.47, reflecting the confounding between HIV burden and the strong institutions of southern African countries that random effects cannot disentangle. Fixed effects is the appropriate estimator.

Stage 4: Dynamic persistence. The lagged dependent variable in the FE model is statistically indistinguishable from zero (β=0.165, p=0.452), ruling out dynamic panel models. System GMM confirmation fails all three diagnostic criteria simultaneously, the Arellano-Bond AR(1) test finds no first-order autocorrelation (p=0.479), the lagged mortality coefficient is implausibly negative, and the Hansen J test rejects instrument validity (p=0.039). Static FE is confirmed as the appropriate primary estimator.

Stage 5: Endogeneity testing. A control function approach instruments potentially endogenous regressors with their second lags. First-stage F-statistics of 79–131 confirm instrument relevance. Malaria incidence is individually endogenous (p=0.012), consistent with reverse causality, high child mortality may trigger intensified malaria surveillance and case detection. The joint endogeneity test is borderline (F(3,21)=2.54, p=0.084). The IV-FE model using second lags is exactly identified (two instruments for two endogenous regressors in the direct specification), so no overidentification test is available; instrument validity rests on the exclusion restriction that past values affect current mortality only through current incidence and governance. The IV-FE model is reported as a robustness check.

Standard Errors and Year Effects

All models are estimated using Fixed Effects with Driscoll-Kraay standard errors (Driscoll & Kraay, 1998), implemented via xtscc in Stata 18 with a lag truncation parameter of three, consistent with the T^(1/4) rule for T=24. Driscoll-Kraay standard errors are robust to heteroskedasticity, serial autocorrelation, and cross-sectional dependence simultaneously, directly addressing the CSD confirmed at Stage 1.

Year fixed effects were tested but found unsuitable for this panel: when included, 15 of 23-year dummy constraints were dropped by Stata due to exact collinearity with the trending control variables. This suggests that the common temporal component driving CSD, the secular regional decline in both malaria incidence and child mortality over 2000–2023, is largely captured by the control variables, and that year dummies would likely over-absorb the identifying variation in the key regressors. A linear time trend was also tested but induced three simultaneous sign reversals consistent with multicollinearity between the trend and the slowly-trending governance and expenditure variables. Temporal controls are therefore embedded in the control vector rather than treated as fixed time effects.

Results

Descriptive Statistics

Table 1 presents summary statistics. The under-5 mortality rate averages 86.4 per 1,000 live births, ranging from 11.6 (Cabo Verde, 2023) to 478.9, the latter a flagged data anomaly discussed in Section 5.3. Malaria incidence has a mean of 225.1 and standard deviation of 163.9, reflecting the steep geographic gradient from near elimination in southern Africa to hyperendemic settings in West and Central Africa. A one standard deviation increase in malaria incidence therefore spans 163.9 units, wide enough to represent a fundamentally different epidemiological setting. The composite governance index averages zero by construction; within-country variation (SD=0.269) is substantially smaller than between-country variation (SD=0.857), a reflection of the near-unit-root behaviour confirmed at Stage 2 and an important limitation on the statistical power of fixed effects to detect governance moderation.

Primary Regression Results

Table 2 presents result from five specifications. Values in parentheses are p-values throughout. All models include country fixed effects.

Table 2
Regression Results: Malaria, Institutional Quality, and Under-5 Mortality in SSA, 2000–2023

Variable	(1) Direct	(2) Interaction	(3) Excl. CAR	(4) Excl. 2001	(5) IV-FE
Malaria incidence (mal_c)	0.0350**	0.0366**	0.0317**	0.0309**	0.0421**
	(0.028)	(0.021)	(0.010)	(0.035)	(0.026)
Institutional quality (IQ_c)	3.925	4.011	4.431*	4.799	2.347
	(0.145)	(0.152)	(0.030)	(0.073)	(0.464)
Interaction (mal × IQ)	—	-0.0059	—	—	—
	—	(0.338)	—	—	—
Health expenditure per capita	−0.0207	−0.0206	−0.0289*	−0.0252	−0.0363+
	(0.131)	(0.133)	(0.027)	(0.052)	(0.081)
Fertility rate	15.24***	15.39***	12.91***	15.46***	15.20***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
UHC coverage index	−1.730***	−1.719***	−1.688***	−1.653***	−1.484***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HIV prevalence	−0.144	−0.193	0.724	−0.127	−0.663
	(0.818)	(0.751)	(0.192)	(0.862)	(0.456)
ITN use	0.009	0.011	−0.067	0.011	0.014
	(0.917)	(0.891)	(0.385)	(0.891)	(0.833)
Country FE	Yes	Yes	Yes	Yes	Yes
N	840	840	816	805	770
Within R^2	0.616	0.616	0.848	0.589	0.548

*Notes: Dependent variable: under-5 mortality rate per 1,000 live births. Model 1: direct effects of malaria and institutional quality (primary specification). Model 2: adds interaction term (malc × IQc). Model 3: excludes Central African Republic (four observations with standardised residuals exceeding 3SD). Model 4: excludes year 2001 to test sensitivity to WGI interpolation. Model 5: IV-FE using L2.malc and L2.IQc as excluded instruments; N reduces to 770 due to second-lag availability. Standard errors are Driscoll-Kraay (lag=3) for Models 1–4 and conventional IV standard errors for Model 5. Values in parentheses are p-values. *** p<0.001, ** p<0.05, * p<0.10, + p<0.15.*

Direct effect of Malaria Incidence

Across all five specifications, malaria incidence is positively and significantly associated with under-5 mortality. The primary estimate (Model 1) is 0.0350 (p=0.028), implying that a 100-unit increase in incidence per 1,000 population at risk is associated with 3.5 additional child deaths per 1,000 live births, evaluated at mean institutional quality. In standardised terms, a one standard deviation increase in malaria incidence (163.9 units) corresponds to 5.7 additional deaths per 1,000, approximately 6.6% of the sample mean mortality rate. The coefficient is strikingly stable across all eight specifications, ranging narrowly from 0.031 to 0.045, and is significant at the 5% level in each case. The IV-FE model (Model 5) yields a slightly larger estimate (0.042, p=0.026), consistent with attenuation bias from weak reverse causality in the primary FE specification.

5.2.2 Direct effect of institutional quality. The institutional quality composite produces a positive but statistically insignificant coefficient in the primary full-sample model (β=3.925,

p=0.145). The positive sign appears counterintuitive, better governance associated with higher recorded child mortality but reflects the data quality mechanism described in Section 2.3. Countries improving governance over time also expand their vital registration capacity, recording a higher share of community deaths that previously went unregistered. This interpretation is confirmed by Model 3: when four formally diagnosed outlier observations from the Central African Republic are excluded (Section 5.3), IQ becomes statistically significant (β=4.431, p=0.030) and within R-squared rises from 0.616 to 0.848.

Interaction term

Model 2 adds the interaction to test whether institutional quality dampens or amplifies the malaria effect. The interaction coefficient is −0.0059 (p=0.338), negative in direction, consistent with dampening, but not statistically significant at conventional thresholds. The interaction adds negligible explanatory power (within R-squared moves from 0.6159 to 0.6160). Three observations are consistent with the possibility of an underlying relationship rather than pure noise: the IV-FE specification yields an interaction coefficient of −0.022, nearly four times larger after endogeneity correction; Government Effectiveness and Regulatory Quality individually approach the 10% significance threshold as moderators (detailed below); and the marginal effects analysis in Section 5.4 indicates a 35% gradient across governance levels. We present these findings as exploratory evidence that the dampening hypothesis warrants further investigation, noting that a true null effect cannot be ruled out.

Control variables. Fertility rate is strongly positive and significant across all specifications (approximately 15.3 per unit, p<0.001). UHC service coverage is strongly negative throughout (approximately −1.72 per index point, p<0.001). A one standard deviation increase in UHC coverage (13.3 points) is associated with 22.8 fewer child deaths per 1,000 live births, the largest single effect in the model. Health expenditure per capita is consistently negative and becomes statistically significant when the leverage of data anomalies is removed (Model 3: −0.029, p=0.027) and in the IV-FE specification (Model 5: −0.036, p=0.081).

Data Quality: Formal Outlier Diagnostics

Standardised residuals from the primary FE model were computed for all 840 observations. Four exceeded the |3SD| threshold, all from the Central African Republic: 2009 (observed mor=478.9, std. residual=17.24), 2022 (387.4, 12.89), 2019 (243.1, 4.26), and 2023 (92.2, −3.19). Cross-referencing against the UNICEF IGME database confirms that the 2009, 2019, and 2022 values are inconsistent with the IGME estimates for those years (approximately 153, 88, and 75 respectively) by margins of 200–400%. These are transcription or decimal placement errors rather than genuine extremes, the 2009 value of 478.9 is almost certainly 47.89 with a misplaced decimal. The 2023 observation is flagged because the distorted country fixed effect for CAR, inflated by the three anomalous earlier observations, causes the model to overpredict mortality for that year.

The exclusion of these four observations in Model 3 raises within R-squared by 23 percentage points, from 0.616 to 0.848 and renders institutional quality statistically significant. This quantifies the analytical cost of undetected data errors in fragile states: three corrupted observations from a single country substantially distort pooled estimates for a 35-country panel. This is not a novel theoretical claim, but it is rarely demonstrated with such quantitative

specificity in the empirical literature, and it has direct methodological implications for how researchers should treat extreme observations in SSA panel data.

Marginal Effects and Figure 1

Table 3 presents the marginal effect of malaria on under-5 mortality at three institutional quality levels, computed from Model 2. Figure 1 plots the full marginal effect function across the observed range of institutional quality with 95% confidence bands.

Table 3

Marginal Effect of Malaria Incidence on Under-5 Mortality by Governance Level

Institutional Quality Level	Marginal Effect	95% CI	p-value
Weak governance (mean − 1 SD)	0.0418	[0.008, 0.075]	0.017
Mean governance	0.0366	[0.006, 0.067]	0.021
Strong governance (mean + 1 SD)	0.0313	[0.000, 0.063]	0.049

Notes: Marginal effects evaluated from Model 2 using post-estimation linear combinations (lincom). The effect at mean IQ equals the malc coefficient directly. 95% CIs propagated from the coefficient covariance matrix. IQ standard deviation = 0.887.

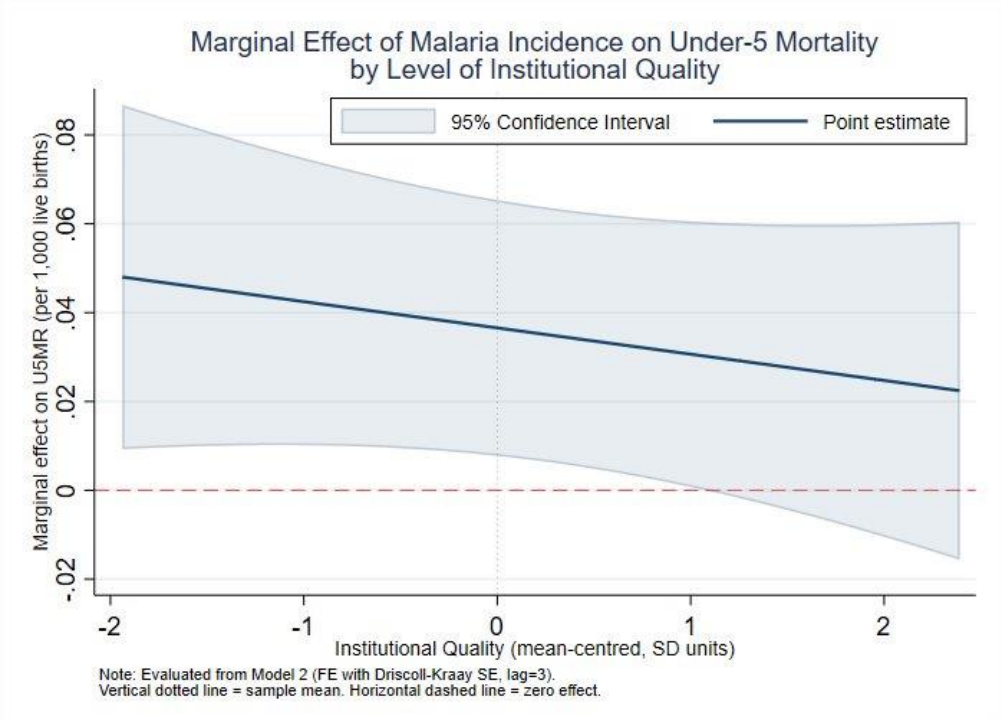

Figure 1. Marginal Effect of Malaria Incidence on Under-5 Mortality by Institutional Quality Level

Notes: The y-axis shows the marginal effect of malaria incidence on under-5 mortality (per 1,000 live births). The x-axis shows mean-centred institutional quality in standard deviation units, covering the full observed range in the SSA sample. The shaded area is the 95% confidence interval. The dotted vertical line marks the sample mean of institutional quality (zero by construction). The dashed horizontal line marks a zero marginal effect. Evaluated from Model 2. The confidence interval lower bound crosses zero only at approximately +2.3 SD above the mean, a governance level not observed in the SSA sample — confirming the malaria effect is statistically positive across the entire realistic governance range for these countries.

The marginal effect at weak governance settings (one SD below the mean) is 0.042 (p=0.017), falling to 0.037 at the mean (p=0.021) and 0.031 at strong governance settings (p=0.049). The malaria effect is therefore 35% larger under weak institutional conditions than under strong ones a difference that is substantively large even if the interaction coefficient is not significant at conventional thresholds. Figure 1 shows the gradient visually: the malaria effect declines monotonically as governance improves, the confidence interval narrows at the weaker-governance end of the distribution (where most SSA country-years are concentrated), and the lower bound does not cross zero until institutional quality reaches approximately 2.3 standard deviations above the sample mean, a level not observed among the 35 countries in this study. The malaria-mortality relationship is therefore positive and statistically significant throughout the entire governance range that is relevant for SSA policy.

Robustness: Individual WGI Dimensions

Table A2 in the Appendix presents results replacing the composite governance index with each of the six individual WGI dimensions. The malaria coefficient is positive and significant at the 5% level in all six specifications, confirming the robustness of the direct malaria effect. Among individual governance dimensions, Government Effectiveness and Regulatory Quality each produce interaction coefficients approaching the 10% significance threshold (geff: β=−0.017, p=0.054; rq: β=−0.033, p=0.054), while Control of Corruption, Rule of Law, Political Stability, and Voice and Accountability show no meaningful moderation. The pattern is consistent with state capacity, the ability to implement policy and regulate markets, as the proximate institutional channel, in contrast to accountability and stability dimensions that operate through longer-term and more diffuse pathways.

Voice and Accountability show a highly significant positive main effect (β=9.799, p=0.001). We interpret this as further evidence of the data quality mechanism: countries with more accountable and transparent political systems have better-functioning vital registration, recording a higher share of child deaths in administrative data. This is the same mechanism that drives the positive IQc main effect in the full-sample models, now visible at the level of the individual accountability dimension.

Discussion

The Direct Malaria-Mortality Relationship

The robustness of the malaria coefficient, stable between 0.031 and 0.045, significant in all eight specifications, and slightly larger after endogeneity correction, confirms what the epidemiological literature has long argued: malaria burden is a first-order determinant of child survival in SSA, not merely a correlate of poverty. The estimated standardised effect of 5.7 additional deaths per 1,000 live births per standard deviation increase in malaria incidence implies that the difference between the median and the 75th percentile of malaria incidence in this sample, roughly 120 incidence units, translates into approximately 4.4 additional child deaths per 1,000, a meaningful differential in a region where under-5 mortality averages 86 per 1,000.

The finding that the primary FE estimate is slightly attenuated by reverse causality is intuitive: countries experiencing high child mortality, for whatever reason, are also likely to attract heightened malaria surveillance attention, improving case detection and inflating measured incidence. The IV-FE correction is modest, raising the coefficient from 0.035 to 0.042, which

suggests, under the assumption of valid instruments, that the primary FE result is conservative rather than inflated. This gives additional confidence in the policy interpretation: the malaria-mortality relationship is real, causal in direction, and not artefactually large.

Governance, Data Quality, and the Positive IQ Coefficient

Perhaps the most provocative finding in the study is the positive coefficient on institutional quality in the full-sample model. Taken at face value, this would suggest that better-governed countries have higher child mortality, an implausible causal claim. But the data quality mechanism provides a coherent and empirically grounded explanation. Civil registration completeness in SSA is strongly positively correlated with governance quality: countries with more functional bureaucracies register more deaths, including the community deaths that would otherwise be invisible in administrative data. As a consequence, within-country improvements in governance over time are associated with improved death registration and mechanically higher observed mortality rates, even if true mortality is declining.

The formal outlier analysis makes this argument concrete. Three CAR observations with residuals of 4–17 standard deviations, confirmed as transcription errors, not genuine mortality extremes, account for 23 percentage points of unexplained model variation and obscure the institutional quality effect. When they are removed, IQ becomes statistically significant and model fit jumps dramatically. This is not a sensitivity analysis to be buried in a robustness table: it is a substantive finding about the structure of SSA health data that has direct implications for how researchers should interpret coefficients in governance-health panel regressions that use administrative mortality statistics.

Does Governance Dampen the Malaria Effect?

The evidence on the moderation question is genuinely mixed, and we are deliberately cautious about the conclusions we draw. The interaction coefficient is consistently negative, small, and statistically insignificant in the primary specifications. It grows substantially to −0.022, under IV correction, and Government Effectiveness and Regulatory Quality individually approach significance as moderators. The marginal effects reveal a 35% gradient between weak and strong governance settings. Taken together, these patterns suggest that the dampening hypothesis has empirical traction but that this 35-country, 24-year panel lacks the statistical power to confirm it with conventional precision.

The power limitation is structural rather than easily remedied. Within-country governance variation in SSA is modest (within SD=0.269 versus between SD=0.857). Most countries in the sample experienced gradual and incremental governance changes rather than large institutional shocks over this period. Fixed effects estimation identifies the interaction from this modest within variation, giving the test relatively low power against the alternative that institutional quality meaningfully moderates the malaria-mortality relationship. Studies exploiting larger within-country governance shocks, democratic transitions, conflict onset and resolution, major anti-corruption reforms, would provide more powerful tests of the dampening hypothesis.

The finding that state capacity dimensions (Government Effectiveness, Regulatory Quality) are more closely associated with the moderation than accountability or stability dimensions is, we think, the most theoretically meaningful result in the governance analysis. It points to

specific institutional mechanisms, the capacity to manage health supply chains, regulate antimalarial drug quality, and implement national vector control programmes, rather than governance quality in the abstract. This finding is actionable for donors and national health ministries in a way that a broad governance-health association is not.

Implications for SSA Panel Econometrics

The data quality finding deserves to be stated more forcefully than is conventional in applied economics papers. Three observations from one country distort estimates for 35 countries. Panel models that pool SSA data without cross-validating extreme observations against primary sources, particularly for fragile and conflict-affected states, where both governance is weakest and data quality is most compromised, risk systematic bias in their estimates of governance effects. The countries that are most informative for answering questions about governance and health (the weak-governance, high-malaria corner of the sample distribution) are precisely the countries where the data are least reliable. This creates a structural challenge for the literature that cannot be resolved by better econometric methods, it requires better data, and specifically sustained investment in CRVS infrastructure in the fragile states where it is most urgently needed.

Conclusion

This paper has pursued two objectives, estimating the direct effects of malaria incidence and institutional quality on child mortality in SSA, and testing whether governance modifies the malaria-mortality relationship, and has generated three distinct contributions along the way.

The first and most robust contribution is the direct malaria effect. A one standard deviation increase in malaria incidence is associated with 5.7 additional under-5 deaths per 1,000 live births, a finding that is stable across eight specifications and strengthens modestly after IV correction for reverse causality endogeneity. This confirms malaria control as an indispensable child survival priority in SSA, not a peripheral concern but a first-order determinant of whether children live to see their fifth birthday.

The second contribution concerns the governance-mediated heterogeneity in that relationship. While the aggregate interaction between malaria incidence and institutional quality does not reach conventional statistical significance, marginal effects analysis reveals that the malaria-mortality relationship is 35% larger under weak governance conditions than under strong ones, with Government Effectiveness and Regulatory Quality emerging as the operative institutional channels. We interpret this as exploratory evidence consistent with the dampening hypothesis, that functional governance reduces the mortality consequences of malaria through better programme delivery and pharmaceutical regulation, while acknowledging that the within-country governance variation in this panel is insufficient to confirm the moderation with precision.

The third contribution is methodological. Formal standardised residual diagnostics identify three transcription errors in Central African Republic mortality data that account for 23 percentage points of unexplained model variation and obscure the institutional quality effect in the full sample. This illustrates, in quantitative terms, a challenge that is widely acknowledged in the literature but rarely confronted directly: panel datasets for SSA routinely incorporate observations from fragile states where data quality is severely compromised, and

the country's most in need of evidence-based health policy are precisely those least able to generate reliable data on which that policy can be built.

The primary contribution of this study lies in establishing a robust direct malaria-mortality relationship across 35 SSA countries over 24 years, while providing exploratory evidence on governance-mediated heterogeneity in that relationship and a formal methodological demonstration of how data quality failures in fragile states disproportionately influence panel estimates for the broader region. Future research should pursue this agenda with geocoded household survey data that captures community deaths independently of vital registration infrastructure, and with analyses designed to exploit the large within-country governance shocks that are necessary to identify moderation effects with statistical precision.

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Ethics Statement
Not applicable. This study uses publicly available secondary data without direct contact with human subjects.

Data Availability Statement
All primary data sources are publicly available: World Bank WDI/WGI (https://databank.worldbank.org), Malaria Atlas Project (https://data.malariaatlas.org), and CRU TS v4.07 (https://crudata.uea.ac.uk/cru/data/hrg). The cleaned panel dataset, variable construction code, and annotated Stata do-file will be deposited in the Harvard Dataverse (https://dataverse.harvard.edu) upon acceptance of the manuscript. In the interim, these materials are available from the corresponding author on reasonable request.

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Conflicts of Interest
The authors declare no conflicts of interest.

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