

Private Healthcare Interventions, Maternal and Infant Mortality Nexus: A Toda-Yamamoto Approach

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ABSTRACT: This study investigates the effect of private healthcare interventions on maternal and infant mortality in Nigeria for the period 1990 to 2024. Private healthcare expenditure as aggregated is the independent variable while maternal mortality ratio and infant mortality ratio are the two dependent variables. Data are analyzed using the Toda-Yamamoto causality approach. The analysis reveals that private healthcare interventions have no statistically significant causal relationship with maternal mortality but it has statistically significant causal relationship with infant mortality in Nigeria. The conclusion emanating from the study is that while domestic interventions, particularly those led by the private sector have contributed meaningfully to reducing infant mortality, they have not yet had significant effects on maternal mortality in Nigeria. It is recommended that the Nigerian government should improve in their partnership with the private sector to increase investment in maternal healthcare services, and that the prevailing interventions by the private sector stakeholders towards reducing infant mortality in Nigeria should be sustained through effective monitoring and evaluation system.

KEYWORDS: Healthcare, Infant Mortality, Maternal Mortality, Private Healthcare Intervention, Toda-Yamamoto

1. INTRODUCTION

Nigeria is not only the most populated country in Africa with a population of more than 200 million, but it is also one of the most prominent countries in health debate across the globe. However, the nation has suffered various health issues like the high rate of infectious disease and maternal and child mortality in addition to the inaccessibility to quality healthcare despite the high human and economic resources. In Nigeria, the infant mortality rate stood at 54 deaths per 1,000 live births in the year 2024, a significantly higher number than the global infant mortality rate of 27 per 1,000 live births but still high compared to this rate in 2000 (54 deaths per 1,000 live births) (UNICEF, 2024). In Nigeria, the maternal mortality rates are also uncontrollable with 512.000 maternal deaths per 100,000 live births in 2024 in comparison with the global average of 211 (WHO, 2024).

The private sector has played an increasing role in Nigeria's health sector. According to World Bank (2024), private healthcare intervention in Nigeria is estimated at ₦2.05 billion in 1990. This rose to above ₦206.7bn in 2007 before falling sharply to ₦113.9bn in 2008. Steady progression in private healthcare intervention expenditure can be seen from 2008 through 2020 and 2024 when it rose rapidly to about ₦7.475 trillion (Fig. 1).

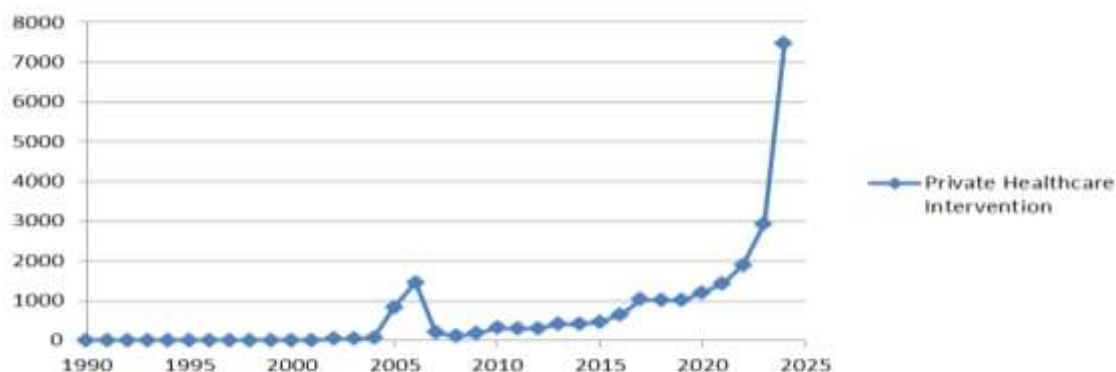


Figure 1: Trend of Private Healthcare Intervention in Nigeria (1990-2024)

(Source: World Bank, 2024)

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The private sector intervention areas includes hospitals, diagnostic centers, pharmaceutical companies, digital health and telemedicine, medical equipment supplies and NGOs providing specialized services in maternal health, infectious disease control, and telemedicine. Over the past decade, private investment has expanded through public-private partnerships (PPPs) and donor-supported programs aimed at improving access and quality of care (WHO, 2023; World Bank, 2024).

Although maternal mortality in Nigeria is decreasing between 1,200 and 512 deaths per 100,000 live births in 2000 and 2024, respectively, it is still very high in comparison to the global benchmark of 211 per 100,000 live births (World Health Organization, 2024). The infant mortality ratio has also been reduced to 54 out of 1000 live births in 2024 after being 126 in 2000. The increasing private sector intervention in Nigeria's healthcare sector and the statistics on maternal mortality and infant mortality ratio in Nigeria appear to be like a paradox. There is rising intervention intensity in the healthcare sector especially from the private sector but Nigeria has witnessed modest and uneven health outcome (maternal and infant mortality) hence raising critical questions about the direction, efficiency, and causal dynamics linking private health interventions and health outcomes. This unresolved nexus forms the motivation for this study.

Again, there appears to be limited empirical research on how the private sector interventions in the healthcare sector have enhanced health outcomes in developing country such as Nigeria. While several studies have tried to examine private sector interventions in the healthcare sector (Brandish *et al.*, 2024; Okeke *et al.*, 2021; Iloh *et al.*, 2020), none of these studies linked it to infant and maternal mortality ratio. Furthermore, most of these studies are not carried out in Nigeria thereby creating a problem of policy inconsistency resulting from limited research that would have guided government policy in this direction. This problem presented above culminates in setting specific objectives for this study which are to:

1. analyze the relationship between private healthcare intervention and maternal mortality in Nigeria;
2. investigate the extent to which private healthcare intervention affect infant mortality in Nigeria.

In order to empirically achieve these stated objectives, the research formulates the following hypotheses:

- H₀₁: There is no significant relationship between private healthcare intervention and maternal mortality in Nigeria.
H₀₂: Private healthcare intervention has no significant relationship with infant mortality in Nigeria.

2. REVIEW OF RELATED LITERATURE

Private healthcare interventions broadly refer to programs, policies, and service delivery initiatives driven by non-governmental actors ranging from for-profit clinics, hospitals, and pharmacies to non-profit organizations, donor-funded projects, and faith-based providers (Mackintosh *et al.*, 2016; WHO, 2016). In countries like Nigeria, where public health infrastructure is underfunded and overstretched, the private sector accounts for up to 70% of healthcare service delivery (WHO, 2024). These interventions play a critical role in maternal health, child survival, communicable disease control, and emerging digital health innovations.

There are various forms of private healthcare interventions according to the World Health Organization (2024), and these forms are discussed here as follows:

a) Direct Service Provision: Private hospitals, clinics, pharmacies, and diagnostic centers provide outpatient, inpatient, and emergency services. In Nigeria, private maternity homes and mission hospitals often serve as the first point of contact for maternal and child health care, especially in semi-urban and rural areas.

b) Health Financing and Insurance Models: Private HMOs (Health Maintenance Organizations), micro-insurance schemes, and community-based health financing initiatives are designed to reduce out-of-pocket payments and spread risk among users. Some programs integrate mobile payment platforms to enhance accessibility for low-income populations.

c) Public-Private Collaborations: Private actors often implement donor-funded programs (e.g., HIV/AIDS, TB, malaria interventions) in partnership with public agencies. These collaborations expand service coverage but may sometimes create parallel structures that complicate coordination.

d) Digital and Technological Innovations: Telemedicine platforms, e-pharmacies, mobile health apps, and diagnostic innovations led by startups are redefining access to care. In Nigeria, digital private healthcare is especially important in urban centers, though rural uptake remains limited by digital divides.

e) Faith-Based and Nonprofit Interventions: Religious organizations run hospitals, clinics, and outreach programs, often trusted by communities and more affordable than private for-profit facilities. Nonprofits also provide targeted interventions, particularly in immunization, nutrition, and maternal health.

By way of conceptualization, maternal mortality refers to deaths resulting from complications experienced during child birth or within 42 days of delivery with exception of accidental or incidental causes (WHO, 2020). It is measured using maternal mortality ratio which measures the number of women that dies due to pregnancy complications relative to 100,000 live births. Infant mortality is the number of deaths explained in infants that are less than one year old out of every 1,000 live births in a given year

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(UNICEF, 2023). Put together maternal mortality and infant mortality are expected to improve just as private healthcare interventions increase.

The main theory guiding this study is the Grossman Health Capital Theory (1972), which conceptualizes health as a form of capital that can be accumulated through various health interventions and depreciates over time. This theory provides the mathematical and conceptual basis for assessing how government, private, and foreign healthcare interventions, along with overall health intervention intensity, influence key health outcomes such as maternal mortality, infant mortality, and life expectancy. According to Grossman (1972), individuals and societies accumulate health capital (H) through investments in healthcare and so private sector healthcare intervention is one aspect of investment in healthcare which is expected to improve both maternal and infant mortality rates in Nigeria.

Several studies have been carried out linking private healthcare intervention to various aspects of health outcomes. Onwujekwe et al. (2010) examined the role of private healthcare providers in delivering malaria treatment in southeast Nigeria. Using cross-sectional household surveys analyzed through logistic regression, the study found that most patients first sought treatment from private chemists and pharmacies. While accessibility was higher, quality of care was inconsistent, leading to mixed health outcomes. Nwakeze and Kandala (2011) analyzed the role of private healthcare facilities in reducing child mortality in Nigeria. Using logistic regression models, they found that households using private facilities had higher immunization coverage and reduced under-five mortality.

Similarly, Obikeze et al. (2013) reviewed private sector contributions to reproductive health services in Nigeria. Findings from descriptive and inferential statistics showed that private healthcare providers played an essential role in expanding contraceptive services and reducing maternal mortality. However, high service costs excluded the poorest households. Uzochukwu et al. (2015) assessed the contribution of private providers in maternal healthcare delivery in Enugu State, Nigeria. Findings showed that women preferred private facilities for antenatal and delivery services due to perceived better quality and responsiveness. However, high costs limited equitable access. Adebayo et al. (2015) found that although private pharmacies enhanced drug accessibility, irrational prescribing practices and substandard medicines undermined health outcomes.

Patel et al. (2016) used data drawn from Nigeria to evaluate private sector engagement in delivering essential medicines. Cross-country regression analysis revealed that the private sector significantly improved medicine availability but at higher costs, limiting accessibility for low-income populations. Iloh et al. (2020) examined the effect of private sector maternal care interventions on maternal mortality and morbidity. They found that private clinics were associated with higher rates of antenatal attendance and skilled deliveries. However, inequities persisted due to affordability issues. Okeke et al. (2021) focused on malaria interventions in Nigeria, with private pharmacies as a central variable alongside treatment adherence and recovery outcomes. Using cross-sectional surveys and regression analysis, the study revealed that private pharmacies remained the first treatment option for many households. While this increased accessibility, it also posed risks of inappropriate self-medication and overuse of anti-malarials.

Brandish et al. (2024) found that private sector facilities had variable AMS adherence, often driven by profit motives. However, targeted interventions such as training and supervision improved rational drug use. Bullen, Wattal, & Meacock (2025) did a comparative analysis between private and public hospital outcomes and found that public hospitals delivered better long-term outcomes, while private hospitals often focused on short-term performance indicators. These studies further amplifies the position of this study that there are few of non-existent literature linking private healthcare intervention to maternal and infant mortality rates in Nigeria. The role of the private sector is becoming crucial especially in Nigeria today and so carrying out a study that specifically analyzes how their healthcare intervention affect health outcomes is one that will fill the gap in literature.

3. METHODOLOGY

This study adopts the ex-post-facto research design. This is based on the fact that the study uses secondary data to establish with relationship between private healthcare intervention, maternal and infant mortality rates in Nigeria. This research examined the data by employing unit root test, cointegration and Toda-Yamamoto Vector Auto Regressive model. The Toda-Yamamoto (TY) - Vector Autoregressive (VAR) is appropriate in the context of the analysis of the study because it is powerful regarding the integration of variables of varying degrees of contribution and the possibility of non stationarity. In addition, the TY-VAR model can accommodate the more than one interrelated variable therefore making room for an evaluation of the short and long-run dynamics of the dependent variables in relation to the independent variables.

The data are sourced from annual publications of World Development Indicator (WDI) and the World Health Organization (WHO) for various years. The data was collected for the period 1990 to 2024.

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Model Specification

Maternal mortality and infant mortality are the most sensitive indicators of healthcare outcome, reflecting both the adequacy and quality of maternal and child health interventions. To assess the causal direction between private sector health interventions, maternal and infant mortality, this study adopts the Toda–Yamamoto (1995) causality framework, which augments a standard VAR model by incorporating the maximal order of integration (d_{max}) of the variables. This approach allows valid Granger causality testing regardless of whether the series are $I(0)$, $I(1)$ or cointegrated.

Stemming from the specification of Iloh et al. (2020), we aggregate private sector healthcare intervention while taking two dependent variables in order to test the effect on both maternal and infant mortality ratio. This is stated in its functional form as:

$$MMR_t = f(PHI_t) \quad [1]$$

$$IMR_t = f(PHI_t) \quad [2]$$

Where:

MMR_t = Maternal mortality ratio,

IMR = Infant mortality ratio

PHI_t = Private sector healthcare intervention expenditure

The general augmented VAR model is expressed as:

$$Y_t = \alpha_0 + \sum_{i=1}^k \alpha_i Y_{t-i} + \sum_{j=1}^{d_{max}} \beta_j Y_{t-j} + \varepsilon_t \quad [2]$$

The system of equations can be represented as:

$$MMR_t = \alpha_0 + \sum_{i=1}^k \alpha_{1i} MMR_{t-i} + \sum_{i=1}^k \beta_{1i} PHI_{t-i} + \varepsilon_{1t} \quad [3]$$

$$IMR_t = \mu_0 + \sum_{i=1}^k \mu_{1i} IMR_{t-i} + \sum_{i=1}^k \partial_{1i} PHI_{t-i} + \varepsilon_{2t} \quad [4]$$

Toda–Yamamoto Causality Test

The system of equations for the Toda–Yamamoto approach is written as an augmented VAR($k + d_{max}$) model:

$$Y_t = \alpha + \sum_{i=1}^k \beta_i Y_{t-i} + \sum_{j=k+1}^{k+d_{max}} \gamma_j Y_{t-j} + \varepsilon_t \quad [5]$$

Where:

$Y_t = (MMR_t, IMR_t)^T$ is the vector of all variables.

k = optimal lag length determined by AIC criterion.

d_{max} = maximum order of integration among the variables (usually 1 for $I(1)$ series).

ε_t = vector of white-noise error terms.

The steps involved in carrying out the Toda–Yamamoto causality analysis is that the data must be tested for stationarity (ADF, PP) to determine the maximum number of integration (d_{max}). The next is to select the optimal lag length k using the Akaike Information Criterion (AIC). Then, estimate augmented VAR($k+d_{max}$) in levels, and test for Granger non-causality using the VAR Granger Causality/Block Exogeneity test only on the first k lags.

4. DATA ANALYSIS AND DISCUSSION

Table 1: Summary of Unit Root Test

Variable(s)	ADF Test Statistics		Decision	Order Of Integration
	At Level	At 1 st Diff.		
MMR	-0.6432 [0.8469]	-6.7645* [0.0000]	Stationary at 1 st difference	$I(1)$
IMR	1.3257 [0.9982]	-9.6587* [0.0000]	Stationary at 1 st difference	$I(1)$
PHI	-4.5832* [0.0009]	-7.1855* [0.0000]	Stationary at Level	$I(0)$

Source: Extracted from E-views 9 Output (See Appendix)

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Table 1 reveals that the two variables (MMR and IMR) became stationary after first differencing except for private health intervention (PHI) which was stationary at level. Therefore, the maximum order of integration is one, i.e. $d_{\max}$ for the TY-VAR model is 1.

Table 2: Bounds Test for Cointegration

Test Statistic	Value	k
F-statistic for Model One (MMR)	13.2346	4
F-statistic for Model Two (IMR)	6.4387	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
5%	2.86	4.01

Source: Extracted from E-views 9 Output (See Appendix)

From the result in Table 2 above, the F-statistic values for the two models are greater than the 5% critical value at $I\sim(0)$ and $I\sim(1)$ bounds. Thus, the null hypothesis is rejected meaning that there is a long run relationship between private health intervention and maternal mortality rate as well as with infant mortality rate in Nigeria.

Table 3: Lag Length Criteria Table

Model 1						
Lag	LogL	LR	FPE	AIC	SC	HQ
0	144.2944	NA	1.48e-10	-8.442083	-8.215340	-8.365791
1	289.3264	237.3251	1.05e-13	-15.71675	-14.35629*	-15.25900
2*	328.6849	52.47798*	4.91e-14*	-16.58696*	-14.09278	-15.74775*
Model 2						
0	141.4211	NA	1.77e-10	-8.267947	-8.041204	-8.191655
1	271.7102	213.2003*	3.05e-13	-14.64910	-13.28864*	-14.19135*
2*	298.6181	35.87718	3.04e-13*	-14.76473*	-12.27055	-13.92552

Source: Extracted from E-views 9 Output (See Appendix)

Table 3 shows that the two models have maximum of 2 lag lengths based on the Akaike Information Criterion (AIC). Thus, the models have lag orders of 2 implying that $k = 2$.

Estimation of the Toda-Yamamoto Causality Test

Earlier, from the unit root test, the maximum order of integration is one meaning that $d_{\max} = 1$. Also, the lag length is 2 meaning that $k = 2$. Thus, the Toda-Yamamoto causality test is estimated by adding the maximum integration order to the maximum lag length thus:

$$k + d_{\max} = 2 + 1 = 3$$

Given that the T-Y test uses $k + d_{\max}$ as its optimal length; the optimal lag length for the T-Y VAR models is 3. The Toda-Yamamoto causality result is summarized in Table 5 below:

Table 4: Toda-Yamamoto Chi-Sq. (*p-values*) For Model One and Two

Model 1			Model 2		
Variables	MMR	PHI	Variables	IMR	PHI
MMR	--	1.7503 (0.4168)	IMR	--	0.0119 (0.9941)
PHI	0.8531 (0.6528)	--	PHI	6.1413 (0.0464)	--
Total	0.8531 (0.4045)	1.7503 (0.2051)	Total	6.1413 (0.2262)	0.0119 (0.3532)

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Table 4 shows that the effect of private health intervention on MMR is not statistically significant ($p\text{-value} = 0.6528$). This indicates that while the private sector contributes to healthcare delivery, its role has not been strong enough to produce measurable changes in maternal mortality over time.

Conversely, the causality from private health intervention to infant mortality is statistically significant ($\chi^2 = 6.141$, $p\text{-value} = 0.0464$). This implies that the growth of private healthcare facilities, such as private hospitals, clinics, and nonprofit organizations, has had a positive and meaningful effect in reducing infant mortality. The private sector's responsiveness and accessibility, especially in urban areas, likely contributed to this impact.

Test of Hypotheses

Hypothesis One:

H₀₁: There is no significant relationship between private healthcare intervention and maternal mortality in Nigeria.

From Table 4, the chi-square statistic for the causality from Private Health Intervention (PHI) to Maternal Mortality Rate (MMR) is 0.8531 with a $p\text{-value}$ of 0.6528, which is greater than the 0.05 significance level. Therefore, the null hypothesis for this relationship is accepted. This implies that private healthcare interventions have no statistically significant causal relationship with maternal mortality in Nigeria.

Hypothesis Two:

H₀₂: Private healthcare intervention has no significant relationship with infant mortality in Nigeria.

In Table 4, the causality test result for Private Health Intervention to Infant Mortality Rate (IMR) reports a chi-square value of 6.1413 with a $p\text{-value}$ of 0.0464, which is below 0.05 critical value. Thus, the null hypothesis is rejected. This indicates that private health intervention has statistically significant relationship with infant mortality in Nigeria.

DISCUSSION OF FINDINGS

The results indicate that private health intervention does not significantly Granger-cause maternal mortality, but it shows a significant causal relationship with infant mortality. This mixed outcome reflects the differentiated focus and operational structure of private health services in Nigeria. For maternal mortality, the result ($p\text{-value} = 0.6528$) implies that private healthcare interventions have not yet translated into measurable reductions in maternal deaths. This can be attributed to the limited affordability and accessibility of private maternal care services, which predominantly serve middle- and upper-income groups in urban centers. The cost barrier remains a major challenge; Nwakeze and Kandala (2011) found that a significant proportion of women in rural Nigeria deliver outside formal health facilities due to high costs and limited access to private clinics. Iloh et al. (2020) further observed that although private hospitals offer higher quality obstetric services, their high user fees discourage utilization by low-income groups, who are at the highest risk of maternal mortality.

In contrast, private healthcare interventions significantly affected infant mortality ($p\text{-value} = 0.0464$). This finding suggests that the expansion of private pediatric and neonatal care facilities, especially in urban areas, has contributed to reducing infant deaths. Private hospitals and NGOs have been at the forefront of providing child immunization, nutrition counseling, and basic neonatal services, often filling the gaps left by the public sector. Adebayo et al. (2015) noted that the private sector's flexibility and responsiveness enable faster service delivery, while Patel et al. (2016) argued that private initiatives improve maternal and child healthcare outcomes when adequately regulated. The finding also aligns with Uzochukwu et al. (2015), who reported that private healthcare providers enhance healthcare access and responsiveness, especially in communities underserved by public facilities.

Intuitively, the private sector in Nigeria tends to focus more on decreasing the rate of infant mortality as against maternal health and other public health services, thereby limiting its broader impact on long-term population health. As Brandish et al. (2024) and Aremu (2024) contend, the private sector's potential contribution to health outcomes can only be fully realized when integrated with public health policy, regulation, and subsidized access for vulnerable populations especially mothers. Thus, private health interventions in Nigeria have a measurable and beneficial impact on reducing infant mortality due to their efficiency, innovation, and service availability. However, their limited accessibility, high cost structure, and urban bias have constrained their broader effects on maternal mortality in Nigeria.

5. CONCLUSION AND RECOMMENDATIONS

The conclusion emanating from the study is that while domestic interventions, particularly those led by the private sector have contributed meaningfully to reducing infant mortality, they have not yet had significant effects on maternal mortality in Nigeria. Thus, existing domestic healthcare interventions by the private sector in Nigeria has been more effective in addressing child health challenges than maternal health issues. The following are the recommendation's made:

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1. The Nigerian government should improve in their partnership with the private sector to increase investment in maternal healthcare services. This will ensure that there is quality access to prenatal, delivery and post-natal care services as well as ensure availability of trained birth attendants with modern facilities needed to reduce maternal mortality in Nigeria.
2. With significant change in infant mortality occasioned by increased private sector attention, efforts should be made by the private sector stakeholders in Nigeria's health sector to monitor existing interventions especially as it concerns infants and children welfare. The prevailing interventions in this direction should be sustained through effective monitoring and evaluation system.

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