IMMUNISATION AND INFANT MORTALITY IN SUB-SAHARAN AFRICAN COUNTRIES

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Abstract
A recent report claims that Sub-Saharan African (SSA) region is experiencing the highest infant mortality when paralleled to other regions. However, previous empirical studies mainly focus on health expenditure and infant mortality, while research on the influence of immunisation on newborn mortality is very scanty. Therefore, this study (unlike the existing one) considers the importance of health intervention particularly the potential of immunisations on reducing infant mortality in SSA countries. The study specifically focused on 28 selected countries from SSA. The observation period for the study spanned between 2005 and 2021. Grossman's theory was used as a theoretical framework. To control for endogeneity issues, the study employed Arellano-Bover/Blundell-Bond system GMM estimator technique. Findings show that immunisation (proxy by immunisation against Hepatitis B) and per capita income have negative effects on infant mortality; however, the population growth rate is positively related to infant mortality. Therefore, SSA governments may consider strategies to make immunisations easily accessible, and those policies that constrain population growth, and improve well-being should be prioritised.

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Introduction

The high number of newborn mortalities has long been an increasing concern in both developing and industrial sub-Saharan African (SSA) countries. Reports indicate that the region experienced high infant mortalities when paralleled to other regions over the last two decades. For instance, it is estimated that the infant mortalities annual's rate of decline in SSA's region is 3.1 per cent (World Health Organisation, 2022a). While this means that there will be an expected 54 mortalities per 1,000 live births in the region by 2030, this would be more than twice the global target of 25 per 1,000. Secondly, the issue is not only seen as a demographic or economic development measure but also as an indicator of human capital quality. The SSA region is often considered the region with the lowermost health-human capital indicators (WHO, 2022a)

The literature on health economics stressed that improving infant health is paramount to development because, it is the citizen's human right (Sen, 1999). Fiala and Arthur (2014) further observed health to be a key determinant of labour participation, socio-economic outcomes, and well-being. The infant's health is also key to their cognitive development and could predict their learning and thinking ability, as well as their social, emotional, and physical activeness (WHO, 2019; UNICEF, 2022). Indeed, the health outcomes of infants are central to the growth and development of any economy (Amiri & Gerdtham, 2013). Interestingly, the central focus of the United Nations' Sustainable Development Goal (SDGs) three (3) is also on achieving good health for all (including infants). The SSA region's infant death is about 43 per cent of the world's aggregate, with an average fertility rate of approximately 5 per woman in 2020 (WHO, 2022). This is massive when compared to the world's fertility average of 2.3 per woman, and shows clearly the possibility of increasing the future size of infant mortalities in the region. That is why perhaps Grossman (2017) observed that government health intervention is critical for improving infant health, particularly in developing countries.

Existing empirical studies, such as Onofrei & Cigu (2021), Beyene and Kotosz (2021), Houeninro (2022), and Sial, Arshed and Amjad (2022) revealed that newborn mortalities are largely associated with weak public health spending, on the nutritional issue, environmental and socio-economic factors. It is recognised in a few other kinds of literature that interventions such as improved access to immunisation against life-threatening diseases, such as Hepatitis B, measles, jaundice, and smallpox, among newborns, could also help in reducing the incidence of infant death (WHO, 2022b). Despite its potential to lower infant mortality, there are reported difficulties in making sure doses reach children and are completed in developing countries (UNICEF, 2022). Immunisation for infants is one of the highest protective measures to reduce infectious diseases and mortalities with the lowest opportunity cost. However, several countries in the SSA region are unable to reach the most affected infants, particularly in remote and rural areas (Bangura & Chen, 2020). Among factors associated with under-immunisation and non-immunisation as observed in literature are; parental attitudes and education, long waiting period, seasonal farm work, distance, staff shortage, cost of maintenance, storage and transportation issues (Dhrifi, 2018; Bangura & Chen, 2020; Houeninro, 2022). The puzzle here is what could be the impact of immunisation on infant mortality in the SSA region. Therefore, the focus of the study is to provide empirically-based evidence to underscore the imperative of effective immunisation as a tool for mitigating infant mortality in SSA.

For appropriate immunisation policies, the research questions that guide this study are: what is the effect of immunisation against Hepatitis B on infant mortality in SSA countries? To provide empirical answers to this question, the central focus of this study is to investigate the impact of immunisation on infant mortality in SSA countries. This is considered critical as infant health outcomes depend on social, economic, and environmental factors (Grossman, 2017; WHO, 2022). It implies the need for health policy interventions particularly in developing countries. Thus, unlike existing literature, one of the major value addition to the literature is the fact that access to an infant's immunisation could serve as a key indicator to determine infant healthiness. The body of infants often produces antibodies against diseases upon the administration of a quality vaccine and immunisation (UNICEF, 2022). And so making sure that every infant can thrive largely depend on access to routine immunisation.

The structure of this study is as follows; the next section reviewed the literature, followed by section three which focused on research methodology. Section four presented the study's data, analysis, and discussion of findings. The last section concludes the study as well as providing policy implications of the study.

Literature Review

Infant mortality and immunisation: Stylised facts

Infant mortality is the number of children who die before reaching their first birthday in a particular year (WHO, 2020). It is often expressed per 1,000 live births. There are various sources of these statistics, these include; estimates from censuses, sample registration, and surveys. On the other hand, immunisation is the action of making an infant or person resistant to a particular infectious disease(s). It is also the process by which an infant becomes protected against a disease through vaccination. Meanwhile, immunisation is often used interchangeably with vaccination, but the latter is the act of protecting from a specific disease via the administration of a vaccine into the body. Thus, immunisation is a key component of primary healthcare for infants and it is an indisputable human right globally. As WHO (2020) noted, it is one of the best health investments money can buy, because vaccines are critical to the prevention and control of infectious diseases that are common among infants.

Despite the rise in the real GDP growth in the SSA region from US$423.03 billion in 2000 to US$1,719.01 billion in 2020, the statistics in Table 1 revealed that the infant mortality rates in the SSA region are quite more. For example, while immunisation currently prevents between 3.5 to 5 million infant mortalities annually, and with substantial global progress being made in reducing infant mortality since 2000, SSA remains the region with the highest infant mortalities in the world with more than 51 mortalities in every 1,000 live mortalities in 2020 (World Bank, 2023).

Table 1. Comparative Infant Mortalities (per 1,000)

Region	2000	2005	2010	2015	2020
World	53.1	44.6	37.1	31.8	28.9
Sub-Saharan Africa	91.4	77	65.5	57.7	51.1
Latin America & Caribbean	28.6	22.6	19.1	15.8	13.8
Middle East & North Africa	37.3	30.2	24.7	22.1	20.0
East Asia & Pacific	33.0	24.4	18.2	14.2	12.6
Latin America & the Caribbean	27.8	22.1	18.7	15.8	14.1
Europe & Central Asia	30.0	21.4	15.7	12.0	9.9
European Union	5.9	4.9	4.0	3.5	3.2
North America	7	6.6	6.1	5.7	5.4

Source: World Bank (2023)

Table 1 further shows that compared to global and European Union averages of 53.1 and 5.9 infant death per 1,000 in 2000 respectively, the SSA average was as high as 91.4 infant death per 1,000 (World Bank, 2023). While the SSA infant death per 1000 reduced to 51.1 in 2020, it remains high when compared with the 28.9 and 3.2 infant death per 1,000 for the world and European Union respectively in the year 2020.

Table 2. Newborn Mortalities in 2020 (among the top five countries with the highest number)

Position	Country	Number (‘000)
1	India	490
2	Nigeria	271
3	Pakistan	244
4	Ethiopia	97
5	Democratic Republic of Congo	96

Source: WHO, 2022

Although vaccination coverage globally has plateaued in recent years and dropped since 2020 when the world experienced the COVID-19 pandemic, however, a more worrisome fact about the SSA region is that three out of five countries with the highest newborn mortalities (Nigeria, Ethiopia, and Congo, D.C) are from the region (see Table 2). For instance, in the year 2020 alone, the three countries contributed about 464,000 infant mortalities to the world’s statistics. Hence, reducing the incidence of infant mortality in SSA has continued to be the main concern in public health policy and academic debates.

Theoretical underpinning

Theoretically, Grossman (2017) argued that infant health is a form of human capital that is influenced by many factors. He identified five main categories, known as the determinants of health genetics, behaviour, environmental, physical, medical care and social factors. It is worthy of note that these categories are greatly interconnected.

Infant mortality reflects the effect of these factors on infants and mothers (WHO, 2020). But infant mortalities can be reduced through cost-effective and appropriate health interventions (WHO, 2022a). It implies that the view of WHO (2020) is similar to Grossman's argument (see Grossman, 2017) that government policies and intervention programs that determine the availability of key health inputs, such as drugs and vaccines have critical effects on infants' health outcomes. These outcomes range from low birth weight to obesity and infant mortality. These outcomes are mostly of preventable causes (United Nations Children Fund, UNICEF, 2020), and could reduce through efficient management and treatment of infections, meningitis, and measles among infants (UNICEF, 2022). Hence, to better understand how the SDG targets on infant mortalities could be achieved in African countries, one way is to study the impact of immunisation on infant mortality in SSA.

Empirical literature

Several empirical studies such as Bareberg, Basu and Soylu (2017), Dhrifi (2018), Kinross (2020), Onofrei and Cigu (2021), Oladosu, Chanimbe and Anaduaka (2022), and Houeninro (2022) mainly observed the association between public health expenditure and infant mortality rate. For example, Houeninro (2022) examined the effect of private and public health expenditures on infant and child mortality rates using a panel of 37 African countries between 1995 and 2018. The result shows that the level of public health expenditures has positive effects on infant mortality reduction. Oladosu *et al.* (2022) investigated the impact of public health expenditure on health outcomes in Nigeria and Ghana. Their findings show that both countries experienced low health expenditure, and while the Ghanaian case reveal a negative relationship, Nigeria indicated a positive impact of health expenditure on infant mortality.

Similarly, Onofrei and Cigu (2021) estimated the relationship between health expenditure and health outcomes among European Union developing countries. Like Houeninro (2022) and Oladosu *et al.* (2022), Onofrei & Cigu (2021) also found a negative impact of health spending on infant mortality. But Anneka and Higashijima (2021) regressed the infant mortality rate on a cumulative score of democracy from 1800 and 2015 in 172 countries. Their finding indicated that political liberalisation has a positive effect on infant welfare in the long run. Other studies (Rasoulinezhad & Taghizableh-Hesary, 2020; Shobande, 2020; Sial, Arshed & Amjad, 2022) indicated that infant mortality rates are positively related to fossil fuel consumption and energy use. For instance, Sial *et al.* (2022) assessed the impact of fossil fuel energy consumption on infant mortality rate in 15 Asian economies between 1996 and 2019. The study found that a positive relationship exists between fossil fuel consumption and infant mortality.

The literature that has focused on the impact of sanitation, safe drinking water and health expenditure on infant mortality found that there is a long-run equilibrium among the variables of infant mortalities (see, for instance, Lu, Paramati & Bandara, 2020). However, Lin, Lin and Xu (2020) examined the effect of rainfall shocks on contemporaneous infant health and long-run socio-economic outcomes in China. The study results reveal that negative rainfall shocks are robustly correlated with higher infant mortality and lower birth weight. Ibrahim, Yusuf & Sahilu (2022) examined the link between energy poverty, under-five mortality and inequality in education using data from 33 African countries. The study found that energy poverty is negatively related to under-five mortality.

The other key drivers of infant health identified in Africa from empirical studies are education, environmental hazards, women empowerment, and health access quality (Beyene & Kotosz, 2021; Owusu, Sakodie & Pederson, 2021; Roberton, 2020; Bibi, Khan & Irshad, 2020; Chewe & Hangoma, 2020; Salami, Shaaban & Martins, 2019; and Nkalu & Edeme, 2019). Indeed, these studies largely ignored the potential impact of immunisation on infant mortality as theories predicted (Grossman, 2017; WHO, 2022). Therefore, unlike previous studies on infant mortalities, this study considers the importance of health interventions, such as immunisation and vaccinations in reducing infant mortality in SSA countries. In sum, achieving improvement in infant health on efficiency and equity rationale requires measures such as provision and ensuring access to quality immunisation. Hence the guiding conceptual framework for the study is presented in Figure 1 which forms the basis for the study's method.

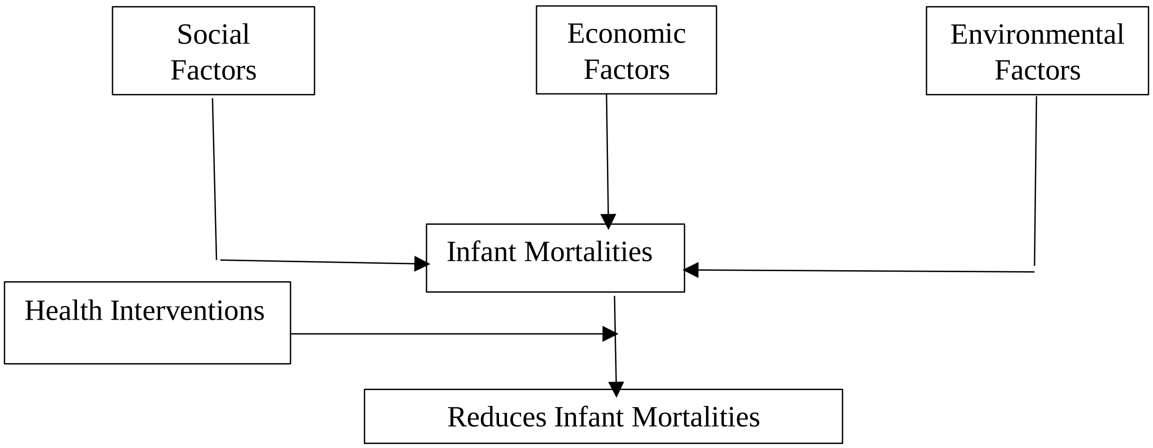

Figure 1. Immunisation-Infant Mortalities Links
Source: Author's drawing with insight from theory

Methodology

One of the important contributions of Grossman's health-human capital model is that it enables health intervention to be introduced fundamentally, as a determinant of infant's health outcomes. Figure 1 indicates that infant health outcomes depend on social, economic, and environmental factors. But unlike existing literature, access to an infant's immunisation could serve as a major indicator to determine infant health outcomes. This suggests that the body of infants often produces antibodies against diseases upon the administration of the quality vaccine and immunisation (UNICEF, 2022). This implies that making sure that every infant can thrive largely depends on access to routine immunisation. However, existing literature ignored this. Therefore, mortalities re-estimating whether this argument holds for the SSA region requires empirical investigation. Thus,

$$Infant\ deaths_{it} = f\ (Immunizations_{it}\ , Control\ Variables) \quad (1)$$

where $i = 1, 2, \ldots \ldots, 28$, the countries used for estimations; and $t = 2005, 2006, \ldots \ldots, 2021$, the year period considered in the study.

The study used population growth rate and per capita income as control variables. The population growth rate was added because it concerns the increase in the number of individuals in a given country i and at a particular time t. While per capita income could reflect the socioeconomic well-being of households. From equation (1),

$$IM_{it} = \alpha_{it} + \beta_1 IAH_{it} + \beta_j \sum Control\ Variables_{it} + \mu_{it} \quad (2)$$

where; IM_{it} represent the infant mortalities, α_{it} is country-specific effect; IAH_{it} denotes general immunisation completed by infant proxy by the immunisation against Hepatitis B. For the control variable, the study employed the percentage of annual population growth rate(PG_{it}), and the per capita income(PCI_{it}), and μ_{it} the error term. The rationale for the choice of these control variables (population growth and per capita income) is because; the more infants a woman loses, the more children she is likely to have to replace the former dead ones (Bibi et al. 2020). Secondly, birth defects, pre-term birth, and low birth weight are all related to reasons for the increase in population growth in developing regions such as SSA where access to healthcare is largely inadequate and inefficient (WHO, 2022). Thirdly, an improvement in per capita income suggests that the welfare and health-wellbeing of citizens are enhanced, leading to lower infant mortalities (UNICEF, 2022).

Numerous estimation concerns may arise in regressing Equation (2). First, since the model is a panel, there is a need to check for the presence of fixed effects country-specific (α_i). In cases like this, we equally need to test for Hausman specification, that is, the selection of either fixed or random effect results. Secondly, there is the possibility that the impact of immunisations (IAH) on infant mortalities (IM), and population growth on infant mortalities could run in both directions. Thus, immunisation and population growth are potentially endogenous. Statistically, endogeneity is a situation when endogenous variables, such as immunisation and population growth in a model are correlated with the error term (Gujarati, 2004). Overall anytime there is an endogeneity issue in estimation, this could lead to biases of parameters (Gujarati, 2004). Thus, considering the possibility of potential endogeneity in the model, the study applies a dynamic panel estimator by Arellaro and Bover (1995), and Blundell and Bond (1998). The study employed this technique because, like an instrumental variable estimator, it allows controlling for the endogeneity of all the other regressors in the model and at the same time control for the estimation issues that arise from the inclusion of the explanatory variables. The technique also involves estimating the equations, in levels and differences. For the level equation, lagged values of all explanatory variables are used as instruments. Thus from equation (2):

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \beta_j \sum Control\, Variables_{it} + \mu_i + v_{it} \qquad (3)$$

The differenced equation with lagged values in levels of all explanatory variables as instruments are:

$$\Delta IM_{it} = \alpha \Delta IM_{it-1} + \beta_1 \Delta IAH_{it} + \beta_j \Delta \sum Control\, Variables_{it} + \Delta v_{it} \qquad (4)$$

Next, the two equations are combined to give the Generalised Method of Moments (GMM) system estimators. These instrumental variables are referred to as internal instruments because their consistency relied on the second-order serial correction test. Hence, the first GMM model for infant mortality from Equation (4) can be estimated as:

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \Delta u_{1it} \qquad (5)$$

Where IM_{it} is the infant mortality, IM_{it-1} is the lagged value of infant mortality, while IAH_{it} is immunisation against HepB (the proxy for general immunisation) Δu_{it} is the difference of observation-specific error term left after the removal of fixed effects error Here the control variable was held constant.

However, the second to sixth models from Equation (5) added some controller variables as instruments. For instance, per capita income (PCI_{it}) and it is a one-year lag (PCI_{it-1}) are added to form Equations (6) and (7), accordingly.

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \beta_2 PCI_{it} + \Delta u_{2it} \qquad (6)$$

And

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \beta_2 PCI_{it} + \beta_3 PCI_{it-1} + \Delta u_{3it} \qquad (7)$$

The final model considers the population growth rate (PG_{it}) and it is a one-year lag (PG_{it-1}) as the instrument to measure the impact of immunisation on infant mortality as:

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \beta_2 PG_{it} + \Delta u_{4it} \qquad (8)$$

And

$$IM_{it} = \alpha IM_{it-1} + \beta_1 IAH_{it} + \beta_2 PG_{it} + \beta_3 PG_{it-1} + \Delta u_{5it} \qquad (9)$$

Therefore, the *a-priori* expectation of this study is that independent variables, population growth would be positive, and immunisation and per capita income would be negative as summarised in Table 3.

Table 3. Description of data

S/N	Type	Indicator	Description	*A-priori* Expectation
1.	Endogenous	IM_{it}	IM represent infant mortality. This is the number of infants who died before their first birthday expressed per 1,000	
2.	Exogenous	IAH_{it}	IAH denotes immunisation against Hepatitis B for infants. Is the percentage of children who received hepatitis B vaccinations before 1 year; and an infant is considered adequately immunised after three doses.	Negative
3.	Control Variable	PG_{it}	PG is the percentage of the annual population growth rate. This is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	Positive
4.	Control Variable	PCI_{it}	PCI is the per capita income. It is the gross domestic product divided by the mid-year population.	Negative

Source: Author's Computation (2023)

Estimating technique

To estimate the models, the study employed Arellano-Bover/Blundell-Bond system GMM estimator. This estimator was developed by Arellano and Bover (1995) and Blundell and Bond (1998) as an improved GMM estimator to estimate dynamic models of panel data. When dealing with the possibility of endogeneity bias of estimates, the technique argued that past values could be used as instruments together with other instrumental variables. It also allows the introduction of more instruments and can greatly improve the efficiency of the estimations. This study adopted the estimator because it is an estimator to measure the linear functional relationship between infant mortality and immunisation. Secondly, it is a dynamic model based on its past realisations. Thirdly, the immunisation variable could not be strictly exogenous, that is, it could correlate with error terms. Lastly, SSA consisted of various developing countries that differ in several observable factors, such as per capita income, and population growth rate, among others factors; and unobservable that is not only limited to cultural, religious, and socio-economic factors. These could likely raise the endogeneity issues in estimating the model.

Scope and sources of data

SSA is the region of the African continent that lies in the south of the Sahara. The region consisted of 48 countries out of the 54 African countries. This study considers the region because the majority of SSA countries are the least developed. All the variables were sourced from the World Bank Development Indicator (2023). The study covers 17 years for 28 SSA countries. This is between 2005 and 2021. The countries are Cote d'Ivoire, Burundi, Cameroon, Comoros, Cabo Verde, Benin, Gabon, Eritrea, Ghana, Botswana, Gambia, Kenya, Tanzania, Lesotho, Madagascar, Uganda, Mauritania, Mali, Nigeria, Zimbabwe, Rwanda, Sudan, Mozambique, Mauritius, Zambia, Malawi, Senegal, and South Africa. The choice of the sampled countries as well as the scope was guided by the availability of data.

Results and Discussions

The descriptive results from this research are summarised in Table 4. The mean number of infant mortalities in the SSA region is almost 48 infants in every 1,000 live births. This is very massive as the region's infant death is more than twice of Europe and Central Asia (6.5), and Latin America and the Caribbean (13.6) combined (World Bank, 2023). The results generally reveal that there is a high number of newborn mortalities in the region when compare to the overall average of 28 in every 1,000 live births in 2021 (see World Bank, 2023).

The descriptive findings also show that the highest infant mortality of 95 mortalities was recorded in Nigeria in the year 2005. The average percentage of annual population growth rate in the SSA region is 2.37 per cent, and the mean of children per woman in the region is almost 5.

Table 4: Descriptive Results

	Averages	Standard Deviation	Minimum Value	Maximum Value	Observations
IM	47.67	16.94	11.7	95.0	476
IAH	83.92	12.99	18.0	99.0	476
PG	2.37	0.83	-0.40	5.07	476
PCI	2,070.67	2,378.85	151.18	11,645.98	476

Source: Author's Computation (2023)

Table 5 indicates the correlation matrix for the study. The statistics support the *a-priori* expectation of the study that there is an inverse relationship between infant mortalities and immunisation against all diseases. However, the correlation between infant mortality and the percentage of population growth rate is positive. For example, the study found a high negative correlation between infant mortality and immunisation indicator (51% for immunisation against Hepatitis B). On the other hand, a relatively low correlation was found for the control variables (per capita income and population growth rate).

Table 5. Correlation Matrix Table

	IM	IAH	PG	PCI
IM	1.0000			
IAH	-0.5174	1.0000		
PG	0.399	-0.1982	1.0000	
PCI	-0.4454	0.0052	-0.4585	1.0000

Source: Author's Computation (2023)

The results for the system GMM are presented in Table 6. From the estimations, the one-year lag of the dependent variable IM_{it-1} shown a positive and significant impact on infant mortalities in all the models. Generally, the estimated elasticity of IM_{it-1} is 0.9 in all the models. Thus, a 1 per cent increase in previous infant mortalities on average leads to a 0.9 per cent increase in the current infant mortality. This is common to all five models. The result then suggests that the communicable or infectious disease outbreaks that resulted in mortalities and illness of infants in the previous year could increase infant mortality in recent years if not prevented.

Results of model 1 to 5 in Table 6 further shows that immunisation against Hepatitis B is inversely associated with infant mortalities. All the coefficients from the five models are statistically significant. On average estimates indicate that an increase of 10 per cent in access to immunisation against Hepatitis B reduces infant mortalities between 0.004 and 0.01 per cent points. The results suggest that as the infant gains more access to immunisations (as a proxy by immunisation against Hepatitis B), infant mortality would reduce in the SSA region.

The overall probability for all models was 0.0000, which suggests that all the models are significant at a 1 per cent level. These findings are in conformity with previous literature such as those by Kiross *et al.* (2020) that an increase in public health expenditure to provide quality immunisation reduces infant mortality in SSA countries.

Table 6. Infant Mortalities and Immunisation: Panel Dynamic Regression

Dependent Variable: Log of Infant Mortality (IM)					
	Model 1	Model 2	Model 3	Model 4	Model 5
Log{IM(-1)}	0.9716*	0.9819*	0.9827*	0.9886*	0.9879*
	(0.0028)	(0.0025)	(0.0026)	(0.0026)	(0.0026)
Immunisation against Hepatitis B	-0.0013*	-0.0010*	-0.0010*	-0.0005*	-0.0004*
	(0.0001)	(0.0001)	(0.00009)	(0.0001)	(0.0001)
Per capita income		-0.00011*	-0.00018		
		(0.000366)	(0.00011)		
Per capita income (-1)			-0.0003*		
			(0.0001)		
Population growth rate				0.0207*	0.0107*
				(0.0014)	(0.0027)
Population growth rate (-1)					0.0117*
					(0.0027)
Constant	0.1929*	0.1225*	0.1209*	0.1088*	0.1101*
	(0.0164)	(0.0151)	(0.0153)	(0.0144)	(0.0143)
The number of obs.	448	448	448	448	448
Number of groups	28	28	28	28	28
Wald chi2(5)	137,739	240,385	232,849	166,384	168,379
Probability	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan test for over-identifying restrictions:					
p-value	0.6324	0.5383	0.4167	0.7256	0.2941
Arellano-Bond test for autocorrelation:					
p-value of AR(2)	0.9011	0.7227	0.8162	0.8648	0.7310

Standard errors are put in brackets, *and** are significant levels of 1% and 5%, respectively
Source: Author's Computation (2023)

However, adding per capita income as an instrumental variable in Models 2 and 3 does not change the statistical relationship between immunisations and infant mortality, as the sign remains the same as before. The coefficient of the relationship between per capita income and infant mortalities was negatively and significantly related, also the coefficients of the one-year lag of per capita income indicate a negative and significant impact on infant mortalities in both models. With the elasticity of -0.0001, a 1 per cent increase in current per capita income, infant mortalities decline by 0.0011 per cent. Hence the biases of endogeneity have been corrected, per capita income estimates imply that with an improvement in the living standard of households, infant mortalities will also decrease significantly. That is, high per capita income plays a significant role in reducing infant mortalities.

Conversely, the population growth rate estimates in Model 4 reveal a positive and significant impact on infant mortality. This implies that if the population growth rate increases, infant mortalities will also increase. The coefficients of population growth rate with positive signs confirm the economic theories that high population growth could increase dependency rate, particularly in developing regions such as SSA, thereby causing more infant mortality. The one-year lag of population growth also showed a positive and significant impact on infant mortality in Model 5. This reveals the fact that higher population growth in the previous year increases infant mortalities in the current year, perhaps because the increase in population can reduce the quality and limit access to immunisation, thereby increasing infant mortality. In sum, the coefficients of all control variables are according to the mainstream economic theory.

Going by these findings, the study tested the adequacy of the estimation models considering the Sargan test of over-identifying. The p-value of the Sargan test is high in all models and greater than the 10 per cent level. Since the null hypotheses (H_o) is that instrumental variables are not correlated to a set of results, therefore, the H_o that the instruments as a group are exogenous cannot be rejected. The study conducted Arellano-Bond tests to check whether the error term is serially correlated. The p-values of the AR (2) for Models 1 to 5 indicated that the study cannot reject the null hypothesis. The results show that p-values are quite high.

Overall, the results support the argument by Grossman (2017) that government health policies and medical intervention programs that focus on key health inputs, such as drugs and vaccines would have critical effects on reducing infant mortalities. This is also in agreement with the findings of Onofrei and Cigu (2021), Oladosu, Chanimbe and Anaduaka (2022), and Houeninro (2022). These studies showed that public health expenditure is key to constraining infant mortality rate. According to UNICEF (2020), access to immunisation will reduce the risks of an infant getting infectious diseases, because immunisation has the potential of improving the body's natural defences, and make them healthier. In addition, immunising newborns early will also prevent the spread of serious diseases, including Hepatitis B, measles, and smallpox, as it creates antibodies in their bodies (WHO, 2022a).

Conclusion and Policy Recommendations

This study examined the effects of immunisation on infant mortality in 28 SSA countries. The motivation for the study is as a result of the fact that the region is experiencing low infant health outcomes when paralleled with other regions. However, researches on the influence of immunisation on newborn mortalities is very scanty, as existing literature is dominated by health spending and health outcomes. The central objective was to empirically investigate the effects of immunisation on infant mortality in the SSA region. The observation period for the study spanned from 2005 and 2021.

Grossman's theory was used as a theoretical framework. Using dynamic panel and system GMM technique, the study found negative effects of immunisation, and per capita income on infant mortality. For instance, it was found that an increase of 10 per cent in access to immunisation against Hepatitis B reduces infant mortalities between 0.004 per cent and 0.01 per cent points. While per capita income was negatively associated with infant mortalities, contrarily, the impact of population growth rate on infant mortalities was positive. These results were significant statistically. These findings suggest that enhancing access to quality immunisation for infants, among others is paramount to their health. This is because, infected babies have a 90 per cent likelihood of experiencing other deadly infections (UNICEF, 2020). This can also lead to yellowing skin and eyes (jaundice). Thus, reducing these tendencies through quality vaccines against Hepatitis B could lead to less infant mortality. The second is the population growth rate. It was found that as the population growth rate is increasing, infant mortality also rises. However, improvement in household well-being (the per capita income) was found to be negatively associated with infant mortalities.

These findings suggest that SSA countries should seek to improve access to immunisation and reduce population growth rates to reduce infant mortality in the region. Perhaps in the absence of these considerations, the region will continue to face enormous infant mortalities and thereby dampening its prospects for achieving United Nations Sustainable Development Goals (SDG) health targets.

Further studies could explore the role of sociocultural factors and corruption as a mediation between immunisation and infant mortalities. The empirical enquiry may be on individual countries or the SSA region. It may also be extended to employing survey analysis to investigate immunisation and under-five mortality.

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