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Determinants of Children U5 Mortality due to Malaria in Ghana

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Abstract
Sustainable development cannot be fulfilled without developing an effective health sector to address health-related issues among children, especially in underdeveloped countries like Ghana. Malaria, in particular, has been identified as a significant disease and cause of death among children under five years of age (U5) in Ghana, although it has drastically reduced in recent years. Against this background, this paper attempts to assess some factors that may have determined the development of U5 mortality due to malaria in Ghana using time series data from 2000-2019. The OLS regression results indicate that domestic government health expenditure, clean drinking water and insecticide-treated nets have a negative connection with children U5 mortality due to malaria in the country. The findings also show a weak positive relationship between malaria infection prevalence and U5 mortality from malaria. Contrary to prior expectations, the results reveal a negative relationship between low birth weight, overweight, stunted, and children U5 mortality from malaria infection. The study concludes that addressing malaria cases among children U5 would greatly depend on building and sustaining resource redistribution through strategic policy, reliable funding, and effective health institutions to tackle malaria incidence and deaths among U5 in the country.

Keywords: healthcare, health expenditure, ITNs, malaria, potable water, U5 mortality.

1. Introduction

Sustainable development cannot be fulfilled without addressing children's health issues worldwide. For the past two decades, the health of children under five years of age (U5) has gained significant attention globally. Considerable efforts have been made to promote child health and survival by identifying many causes of morbidity and mortality to inform health policies toward preventing and treating child health problems (Black et al., 2003; World Health Organization, 2015, 2022).
The United Nations introduced the Millennium Development Goals (MDGs) in 2000 to reduce U5 mortality by two-thirds by 2015. This initiative marked a rigorous global effort to promote child health and wellbeing. This led to the formulation and implementation of various interventions by the government and other stakeholders to achieve MDG 4 - reduce child mortality (United Nations, 2015; World Health Organization, 2021a). The end of the MDGs saw a significant global reduction of about 56% in U5 mortality from 93 to 41 deaths per 1,000 live births between 1991 and 2016, respectively, with a further decline to 37 deaths in 2020 (World Health Organization, 2022). However, evidence

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suggests that in 2015, which marked the deadline for the achievement of MDG 4, about 99% of the child mortality rate was prevalent in lower and middle-income countries, with about 50% occurring in Africa (World Health Organization, 2015). Within the same period, sub-Saharan Africa (SSA) recorded a high rate of U5 mortality of about 79 deaths per 1,000 live births compared to the global rate of 41 deaths per 1,000 live births (World Health Organization, 2022). Ghana could not achieve the MDG 4 as it recorded a U5 mortality rate of about 60 deaths per 1,000 live births against its national target of 40 deaths per l,000 live births by 2015 (Ghana Statistical Service, 2017).

One of the prevalent diseases that have affected U5 children and mothers globally, especially in SSA countries (O'Meara et al., 2010; Orok et al., 2021), such as Ghana, is malaria (Lamptey et al., 2018; O'Meara et al., 2010; Orok et al., 2021; Osarfo et al., 2022). Malaria is a deadly disease triggered by parasites transmitted to humans via the bites of infected female Anopheles mosquitoes (World Health Organization, 2021, 2022). Although the disease is preventable and curable, it continues to infect millions of people annually and has been a heavy burden on the health sector in African countries (World Health Organization, 2022).

With the ongoing UN Sustainable Development Goals (SDGs2030) under goal 3 to end preventable deaths of U5 and aggressively reduce the U5 mortality rate to 25 per 1,000 live births by 2030, it has become imperative for Ghana to revise its existing child health policies, formulate and implement new national health policies to achieve this goal. Thus, it is critical to understand the general weaknesses that made it challenging to meet MDG 4 and the necessary modifications and reforms to improve overall children's health (Bigdeli et al., 2020; Pyone et al., 2017).

The preceding evidence on the malaria cases and deaths among U5 proves that Ghana continues to contribute to the worldwide malaria burden and death rate among U5 (World Health Organization, 2022). Malaria in Ghana, particularly among children U5, appears to be a social problem that needs a sustainable solution.

This article assesses some determinants of U5 mortality from malaria in Ghana between 2000 and 2019. The research thesis is guided by the question to test and prove the hypotheses: Is there any relationship between health expenditure, portable water, low birth rate, malaria incidence, insecticide-treated bed nets, children overweight, stunting, pneumonia, and children U5 mortality, especially from malaria in Ghana?

The study's problem leads to formulating the hypothesis: There is no relationship between health expenditure, portable water, low birth rate, malaria incidence, insecticide-treated bed nets, overweight children, stunting, pneumonia, and children U5 mortality, especially from malaria in Ghana.

1.1 Some Empirical Evidence on U5 Mortality

Some scholars (Abu et al., 2015; Afoakwah et al., 2015, 2018; Bigdeli et al., 2020; Chowdhury, 2013; DaVanzo et al., 1983; Florey et al., 2017; Kanmiki et al., 2014; Kerber et al., 2007; Nyaaba et al., 2020; Pyone et al., 2017; Worku et al., 2021) have attempted to assess some determinants of U5 mortality in countries in recent years. For instance, mothers' age at birth, place of delivery, sex of the baby, baby size or weight at birth, and breastfeeding were significant determinants of U5 mortality. Chowdhury (2013) examines

determinants of mortality in Bangladesh: father's education, region of residence, place of residence, number of children U5, previous death of siblings, mother's age, and breastfeeding have significant implications for mortality in the country.
Abu et al. (2015) examine the prevalence and the socio-economic and demographic determinants of mortality in Benue State, Nigeria. The analysis showed that educational status, wealth, mothers' age, and breastfeeding length affect child survival in the country. Worku et al. (2021) verify some determinants of U5MR in regions of Ethiopia. Their results show that parity, multiple births, antenatal clinic visits, and preceding birth intervals significantly predict U5 mortality in the regions.
Insecticide-treated nets (ITNs) are highly effective at lowering children's malaria morbidity and U5 mortality (Florey et al., 2017). Evidence from scholars (Chaudoir et al., 2013; Durlak & DuPre, 2008; Knoepfel et al., 2010; Potůček et al., 2016) confirm that policy implementation indeed impacts or influences the outcomes. It also seeks to understand the forces influencing why and how policies are initiated, developed or formulated, negotiated, communicated, implemented, and evaluated, including how researchers influence policymaking.
Kanmiki et al. (2014) show that mothers' age, educational level, and marital status affect U5 mortality in rural northern Ghana. Nyaaba et al. (2020) investigate the strength of the linkage between socio-economic, maternal, and environmental determinants and mortality in Ghana using data from the 2014 Ghana Demographic and Health Survey. The results show that children of women with secondary education and above and women with middle-wealth status are less likely to experience U5 deaths than women with no education and those with low-wealth status. Similarly, women who had their first birth at 20-29 were less likely to experience U5 deaths than those aged 15-19. Women who used boreholes/healthy water were more likely to experience U5 deaths than those who used piped water. They stress a need for increased maternal education, delayed childbearing, and improved drinking water and toilet facilities to reduce U5 mortality in Ghana. Acheampong and Avorgbedor (2017) find a positive relationship between the mother's age, maternal marital status, breastfeeding, mother's education, and source of drinking and U5 mortality in Ghana.
Insecticide-treated bed net usage among children improves their survival rates. Thus, children's U5 mortality under treated bed nets is about 18.8% lower than those without sleep under treated bed nets. Whereas health facility delivery has been shown to reduce U5 mortality, childbearing among older women is detrimental to the child's survival (Afoakwah et al., 2018). This present study attempts to contribute to the body of the previous research by investigating factors that seemingly affect malaria mortality among children U5 in Ghana in recent years.

1.2 Overview of Malaria in Ghana

The global malaria cases were estimated to have risen from 227 million in 2019 to 241 million in 2020 and then 247 million in 2021 (World Health Organization, 2022). Similarly, the estimated number of malaria deaths rose from 405,000 in 2018 to 627,000 in 2020. Also, the percentage of children U5 with malaria deaths increased from 67% in 2018 to 77% in 2020 (World Health Organization, 2021).

Africa recorded a 95% share of all malaria cases (228 million), 96% of global malaria deaths (602,000), and 80% of all malaria deaths in children U5 in 2021. However, funding for malaria increased from $3 billion in 2019 to $3.5 billion in 2021 (World Health Organization, 2022). In 2021, monetary contributions from governments of endemic countries amounted to US$ 1.1 billion in funding for malaria issues (World Health Organization, 2022). Despite these investments, malaria continues to ravage the health of many countries like Nigeria, the Democratic Republic of Congo, Uganda, Côte d'Ivoire, Mozambique, Niger, and Ghana, among others. With increasing financial investments in the fight against malaria (Orok et al., 2021; World Health Organization, 2021), one would have anticipated a drastic fall in reported cases. However, this much-awaited result is yet to be realised.

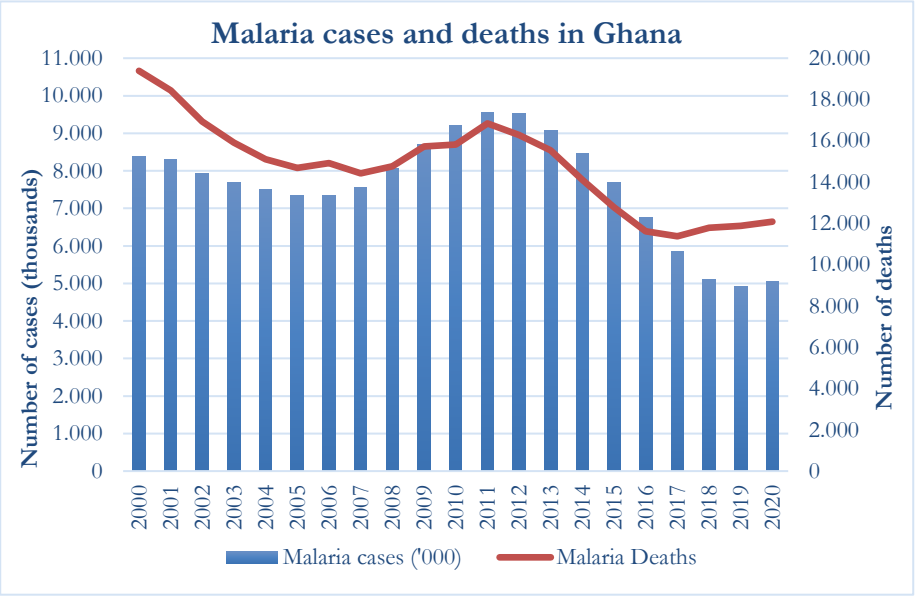

Figure 1. Malaria cases (thousands) and deaths in Ghana, 2000-2020
Source: World Health Organization, 2021

Malaria in Ghana is one of the causative diseases of illness and mortality among pregnant women and children U5. It also contributes significantly to the country's hospital attendance (Ghana Statistical Service, 2017). Malaria cases in Ghana between 2000 and 2020 slightly fluctuated and declined from 8.4 million to 5.06 million malaria cases. Notwithstanding that the country failed to meet the MDG 4 target, it was able to reduce its malaria burden. This development may be partially attributed to government policies tackling the country's menace. Similarly, malaria deaths in Ghana declined from 19,388 in 2000 to 12,084 in 2020 (Figure 1).

1.3 Africa Malaria Burden Among Children U5

Africa has recorded a large percentage of the global malaria burden. In 2018, it was reported that up to 79% of children U5 diagnosed with malaria in high-burden regions of Africa had anaemia (World Health Organization, 2018). In Africa, U5 malaria mortality is prevalent in the sub-Saharan region (Table 1).

Table 1. Children U5 malaria mortality (number) in Ghana, SSA and some selected African countries

Year	SSA	Ghana	Nigeria	Cote D'Ivoire	Botswana	South Africa
2000	549,725	13,937	141,820	18,316	23	2
2001	569,721	14,956	145,973	19,562	13	17
2002	574,559	15,664	147,729	20,562	7	9
2003	590,116	17,024	151,611	21,499	5	6
2004	592,486	17,127	150,881	22,405	4	5
2005	579,048	17,171	153,320	22,707	2	3
2006	577,654	16,823	162,657	23,867	4	4
2007	571,481	16,939	167,927	24,368	4	2
2008	565,534	17,067	175,925	24,303	6	2
2009	558,149	16,817	174,579	23,626	5	2
2010	542,086	16,334	168,415	22,151	5	3
2011	512,961	15,725	161,182	20,218	1	4
2012	487,446	14,978	153,368	18,729	1	2
2013	465,724	14,055	146,253	16,172	1	5
2014	434,573	13,508	138,670	14,718	3	5
2015	413,722	12,596	126,073	14,884	1	0
2016	384,191	11,591	106,104	15,414	2	1
2017	355,340	10,587	93,395	14,981	4	12
2018	344,915	10,618	96,005	13,546	5	13
2019	345,485	10,112	95,636	13,994	6	39

Source: Global Burden of Disease Collaborative Network, 2021

Between 2000 and 2019, Nigeria recorded the highest number of U5 malaria deaths, with a peak of 175,925 deaths in 2008. In 2019, the country recorded 95636 deaths, marking a decline of about 33% in U5 malaria deaths between 2000 and 2019. Similarly, Ghana and Cote d'Ivoire also recorded a reduction in U5 malaria deaths by 27% and 24%, respectively, between 2000 and 2019. Botswana and South Africa cases indicate that U5 malaria deaths are relatively low in Southern parts of Africa within the period understudied. This suggests that some African countries are making significant gains in fighting malaria among U5, while others are lagging (Table 1). Although there was a general decline in the U5 malaria death trend across Africa between 2000 and 2019, which may be attributed to various global and national interventions, the reduction in U5 malaria deaths is slower than expected. The number of U5 malaria deaths in some African countries is still alarming, which calls for urgent measures to reverse the trends drastically.

1.4 Ghana U5 Malaria Burden

Ghana is one of the 15 nations with the highest malaria burden. Since 2000, out-of-patient (OPD) and in-patient U5 malaria cases have increased. OPD U5 malaria cases increased from 516 thousand to 3.1 million between 2000 and 2012, while in-patient U5

malaria cases also rose from 27,478 to 177,836 within the same period. Malaria was responsible for 10.4 million OPD visits, with a case fatality rate of 0.32 among children U5 in 2016 (Dao et al., 2021). This is hugely significant. Malaria kills at least three children daily. Ghana's U5 malaria death rate fluctuated but declined from 458 to 255 deaths in 2019 (Table 2).

Table 2. Malaria death rate (per 100,000 individuals) by age: U5 and other ages in Ghana, 1990-2019

Year	U5	All Ages	70+ years	50-69 years	15-49 years	5-14 years
1990	365.45	91.72	243.09	125.52	22.57	11.32
1991	375.74	95.03	287.43	133.59	23.88	12.22
1992	381.19	96.49	298.62	139.19	24.83	12.74
1993	386.29	97.32	303.90	141.61	25.35	12.97
1994	388.52	97.99	312.45	145.82	26.04	13.12
1995	393.64	99.55	324.06	151.65	26.99	13.34
1996	404.79	102.66	341.26	160.40	28.36	13.69
1997	417.81	106.96	365.38	172.46	30.49	14.47
1998	432.34	111.13	388.22	182.70	32.24	15.05
1999	445.52	115.26	413.42	193.94	34.05	15.62
2000	458.16	119.09	365.08	212.10	36.94	16.39
2001	482.30	128.21	489.90	228.80	39.78	18.41
2002	495.28	132.10	430.16	247.42	42.83	19.70
2003	527.70	139.58	535.32	248.16	43.01	21.93
2004	520.35	138.81	543.28	251.22	43.38	22.52
2005	511.28	137.78	549.20	253.96	44.03	22.80
2006	490.94	133.52	455.99	260.60	45.21	22.68
2007	484.65	134.42	560.42	259.87	45.16	23.44
2008	479.24	136.00	489.64	284.43	49.29	24.12
2009	464.22	132.80	481.65	282.91	49.18	23.63
2010	444.20	128.46	472.79	280.57	48.79	22.61
2011	422.18	120.64	437.06	261.19	46.23	21.24
2012	397.70	113.27	410.88	247.89	43.85	19.70
2013	369.62	103.71	371.62	225.86	40.27	17.70
2014	352.29	95.72	405.14	195.37	35.11	15.96
2015	326.11	84.69	282.79	172.72	31.54	13.71
2016	298.00	75.33	297.42	143.96	26.9	11.69
2017	270.44	68.15	271.95	131.74	24.58	10.35
2018	269.54	71.06	304.49	145.39	26.86	11.29
2019	254.66	68.48	304.31	144.12	26.46	10.64

Source: Global Burden of Disease Collaborative Network, 2021

The diverse malaria health initiatives and interventions implemented by the government, international agencies, and donor organisations may have contributed to reducing malaria deaths among children U5 in Ghana. However, it cannot be denied that the number of U5 malaria deaths is still very significant. This raises questions about the impact of malaria policies and interventions and whether these policies and interventions are enough to achieve substantial gains in reducing U5 malaria deaths in the country or require some modifications.

2. Materials and methods

2.1 Data Sources

This study uses secondary data to assess the implications of malaria on U5 mortality in Ghana. In the same direction, time-series data for the descriptive and empirical analysis were obtained from the World Health Organisation, World Bank world development indicators, the Global Burden of Disease Collaborative Network, and other reputable agencies.

2.2 Model Estimations

The model used in this study is based on similar studies (Abu et al., 2015; Kanmiki et al., 2014; Nyaaba et al., 2020; Worku et al., 2021) regarding children's U5 mortality in other countries and regions. In the same direction, health expenditure, low birth rate, potable water, stunting, pneumonia, malaria incidence, children overweight, insecticide-treated bed nets, and maternal death indicators were incorporated into the regression model to determine factors that may have contributed to malaria deaths among children U5 in Ghana over two decades. The ordinal least square (OLS) multivariate regression is mathematically presented as follows:

$$U5MM_t = \beta_0 + \beta_1 DGHE_t + \beta_2 WATER_t + \beta_3 LBW_t + \beta_4 MC_t + \beta_5 ITNS_t + \beta_6 OVERWEIGHT_t + \beta_7 STUNTED_t + \beta_8 PHEUMONIA_t + \varepsilon_t \quad (1)$$

Where:
U5MM denotes children's U5 mortality rate from malaria (measured as the number of deaths per 100,000 individuals). DGHE represents domestic general government health expenditure (% of current health expenditure). The World Bank defines DGHE as the share of present health expenditures funded from domestic public sources for health, including domestic revenue as malaria incidence, internal transfers and grants, transfers, non-profit institutions serving households or enterprise financing schemes, and social health insurance contributions and compulsory prepayment. WATER represents the percentage of the population using potable water (%). LBW denotes low-birthweight (% of births), newborns weighing <2,500 grams, with measurements taken within the first hour of life. MC represents the number of new malaria cases per 100,000 persons in Ghana. ITNs are insecticide-treated bed nets that form a protective barrier around people sleeping under them. ITNs have been a significant intervention to prevent malaria, notably

among pregnant women and children U5. ITNs also act as mosquito repellents and kill mosquitoes. OVERWEIGHT is the prevalence of overweight, weight for height (% of children U5) in Ghana. Being overweight in childhood significantly impacts their physical and psychological health. STUNTED represents the prevalence of stunting and height for age (% of children U5). It impairs the growth and development of children U5 when they experience poor nutrition, repeated infection, and inadequate psychosocial stimulation; WHO defines stunted children if their height for age is above two standard deviations below the Child Growth Standards median. A substantial number of children's deaths are attributed to stunting. PNEUMONIA is the number of children U5 dying from pneumonia. Pneumonia, the deadliest communicable disease of lower respiratory tract infection rates, is most remarkable in children U5. β0 is the Y-intercept, while β1 to β8 are the slopes associated with each of the independent variables; ε is the error term. This study covers from 2000 to 2019. The period was chosen to assess the situation based on SDG2030 and data availability.

3. Results and Discussion

3.1 OLS Regression Analysis

Before presenting the result of regression analysis, it is imperative to check and be satisfied that some classical assumptions are met. Thus, diagnostic checklist tests for the OLS regression were done, and all the traditional assumptions were fulfilled (Table 3).

Table 3. Diagnostic test for OLS regression

Test	P. value
Heteroskedasticity Test: White	0.273
Heteroskedasticity Test: Breusch-Pagan	0.661
LM test for autocorrelation up to order 1	0.392
Autocorrelation up to order 1- Ljung-Box Q'	0.230
Test for normality of residual	0.945
Test for ARCH of order 1	0.39
Non-linearity test (squares)	0.112

As presented in Table 3, the model does not suffer from autocorrelation, heteroskedasticity, stability and normality tests, and other assumptions tests, implying that the findings should be accepted for further analysis.

3.2 Determinants of Children's U5 Mortality Due to Malaria in Ghana

The OLS regression result indicates that all the explanatory variables in the model jointly influence children's U5 mortality rate from malaria (U5MM) in Ghana. One (pneumonia) out of the eight independent variables was statistically insignificant. Domestic government health expenditure, availability of potable water, malaria infection prevalence, insecticide-treated nets, overweight, and stunted were statistically significant at certain levels and directions.

Similar to the results in model one, the findings show an inverse connection between domestic general government health expenditure (DGHE) and the children's U5 mortality rate from malaria infection in Ghana, statistically significant at 0.05 level (Table 4). Financing health care by the government and private sector is a critical component of policy implementation and a functioning health system governance, and it may contribute to reducing U5MM in the country if evenly distributed and effectively utilised. As earlier indicated in the study, the performance of malaria health policies in Ghana has been constrained by insufficient monetary, personnel, and logistic support. Kerber et al. (2007) posit that financial constraints, further distances, low transport, and poor-quality care in health facilities impede access to health care for users who need it most. It is essential to indicate that investments in healthcare are a priority for maternal and child health.

Table 4. Determinants of U5 mortality due to malaria (U5MM) in Ghana, 2000-2019

Variable	***Coefficient***	***Std. Error***	***t-ratio***	***p-value***
Const	4229.43	725.213	5.832	0.000***
DGHE	−1.31152	0.447	−2.936	0.013**
WATER	−27.8810	7.898	−3.530	0.005***
LBW	−67.6221	14.758	−4.582	0.,000***
MC	0.2756	0.143	1.92	0.081*
ITNS	−1.5017	0.412	−3.646	0.004***
OVERWEIGHT	−77.4070	16.795	−4.609	0.001***
STUNTED	−27.1534	8.884	−3.056	0.012**
PNEUMONIA	0.003	0.008	0.368	0.720
R^2	0.9933	Adjusted R^2		0.9885
F(8, 11)	204.4543	P-value(F)		0.0000***

*Note: *, ** and *** denote statistically significant at 10%, 5% and 1% levels, respectively*

The findings indicate an inverse connection between the population using potable water (WATER) and the children mortality in Ghana, statistically significant at 0.01 level. This signifies that U5 mortality from malaria may be reduced if the number of inhabitants, including mothers and pregnant women, have access to clean and safe drinking water in the country (Table 4). Potable water is among the critical components of social amenities that need to be provided by the government for everyone, especially mothers and children U5. Nonetheless, it remains one of the significant issues in the country as some people do not have adequate access to clean water services. This finding contradicts the works by Acheampong and Avorgbedor (2017)), who found a positive relationship between the water source and U5M in Ghana. Notwithstanding, the finding is consistent with studies by Nyaaba et al. (2020) and DaVanzo et al. (1983). Arguably, pregnant women and children without access to clean potable water services may catapult to diseases that may affect their health and, to an extent, lead to a high U5 mortality rate in the country if drastic measures are not taken to mitigate it.

Contrary to a prior expectation, the findings indicate an inverse relationship between low birthweight (LBW) and children U5 mortality due to malaria in Ghana. This may be

because malaria mortality is too broad/narrow in clearly explaining the relationship with LBW as expected. This result contrasts with the studies by (Jana et al., 2023), who find a positive relationship between LBW and U5 mortality in India.

The findings show a positive relationship between the number of malaria cases and children U5 mortality from malaria in Ghana, albeit with a weak statistically significant level of 0.1.

The results show an inverse relationship between the insecticide-treated nets (ITNs) and the U5 mortality rate from malaria in Ghana, statistically significant at 0.01 level. This signifies that U5 mortality from malaria may be reduced if the number of ITNs is well distributed and used to prevent mosquito bites on children U5 in the country (Table 4). This result aligns with the finding of Afoakwah et al. (2018), who also stress that ITNs usage among children improves their survival rates.

Contrary to the expectation, the findings show an inverse relationship between overweight and the U5 mortality rate from malaria in Ghana, statistically significant at 0.01 level (Table 4). Similarly, the result shows an inverse connection between stunted children and the U5 mortality rate from malaria in Ghana, statistically significant at a 0.05 level. This result is at variance with the studies by Wright et al. (2021) who find that wasting and stunting are associated with a much higher risk of death than the nonwasted and nonstunted in Malawi, South Africa, and Pakistan.

Although the authors wanted to include data during the COVID-19 period (up to 2021), but could not get data on some variables within the period. Future researchers should include data during the COVID-19 period in their analysis to determine any effects of the pandemic on the U5 malaria mortality in the country.

4. Conclusion

The study aims to determine some factors contributing to children's U5 mortality due to malaria in Ghana. Specifically, secondary data for analyses span the period 2000-2019. The OLS regression results from the secondary data indicate that domestic government health expenditure, clean drinking water, and insecticide-treated nets have a negative connection with U5 malaria mortality in the country, statistically significant at appropriate levels. The findings also show a weak positive relationship between malaria infection prevalence and U5 mortality from malaria. Contrary to a prior expectation, the results reveal a negative relationship between low birth weight and U5 malaria deaths, overweight, stunted, and U5 mortality from malaria. This study concludes that addressing malaria cases among children U5 would greatly depend on building and sustaining resource redistribution through strategic policy, reliable funding, and effective health institutions to tackle malaria incidence and deaths among U5 in the country.

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