

Neglected Tropical Diseases, Malaria Incidence and Maternal Mortality in Sub-Saharan Africa: Evidence from AMG and CCEMG Estimators

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Abstract

Maternal mortality remains one of the most persistent public health and development challenges in Sub-Saharan Africa. Although global initiatives have placed maternal survival at the centre of Sustainable Development Goal 3, the burden of infectious diseases continues to weaken progress in many disease-endemic settings. This paper examines the impact of neglected tropical diseases and malaria incidence on maternal mortality in selected Sub-Saharan African countries, using the first objective of the underlying doctoral thesis as the analytical focus. The study used annual panel data covering 1990 to 2023. Maternal mortality ratio served as the dependent variable, while neglected tropical diseases, proxied by Human African Trypanosomiasis, and malaria incidence were the principal explanatory variables. Current health expenditure, prevalence of undernourishment, number of physicians, female secondary school enrolment and immunisation coverage were considered as health-system and socioeconomic controls where relevant to the broader dataset. Given the evidence of cross-sectional dependence, heterogeneous country experiences and mixed order of integration, the paper relied mainly on Augmented Mean Group and Common Correlated Effects Mean Group estimators for the maternal mortality model. The findings show that neglected tropical diseases exerted a positive and statistically significant effect on maternal mortality. The paper concludes that maternal mortality reduction in Sub-Saharan Africa requires integrated disease-control and maternal-health strategies, with priority given to malaria control, neglected tropical disease surveillance, maternal nutrition, healthcare financing and country-specific interventions.

Keywords: Maternal mortality; neglected tropical diseases; malaria incidence; Sub-Saharan Africa; AMG; CCEMG; health expenditure.

1.0 Introduction

Maternal health is an important aspect of sustainable development since maternal survival implies how health systems function, whether social protection has reached individuals, the nutritive state of women, and how the risks related to public health have been managed. The Sustainable Development Goals have placed maternal survival under Goal 3, aimed at ensuring healthy lives and well-being for all at all ages. In the attached thesis, maternal mortality in Sub-Saharan Africa is depicted as high enough with the region failing to achieve the goal of reducing the global maternal mortality ratio to less than 70 deaths per 100,000 live births by 2030. Such persistence of the problem is attributed to weaknesses in healthcare infrastructure, limited access to trained professionals, poverty, low numbers of healthcare personnel and continued spread of diseases that exacerbate pregnancy-related risks (World Health Organization, 2023; Blumenberg et al., 2023; Lee et al., 2024; Onambele et al., 2022).

Relevance of maternal mortality as a health indicator is in its sensitivity to not only direct complications related to pregnancy but also indirect conditions that aggravate pregnancy outcomes. Maternal mortality refers to deaths of women in course of or following pregnancy, childbirth or up to 42 days after the termination of pregnancy because of causes related to or exacerbated

Received: 10.09.2026

Accepted: 15.09.2026

Published on: 30.09.2026

by the process, except accidental or incidental causes (Sari et al., 2024; Taher, 2024; Ekwuazi et al., 2023). In Sub-Saharan Africa, the probability of maternal death cannot be seen only in clinical terms. Rather, it is affected by the environmental, social and economic context in which women live. Therefore, the analysis of maternal mortality needs to take into account the disease environment, healthcare expenditures, nutrition and education of females.

Neglected tropical diseases are especially significant here since they are usually associated with poverty, limited sanitation, poor access to healthcare and low prioritization in health financing. As defined in the thesis, neglected tropical diseases include preventable and manageable parasitic, viral, bacterial, fungal and non-communicable diseases affecting more than one billion people worldwide and being under-prioritized in health policies and funding (Gyorkos et al., 2023; World Health Organization, 2023). Among the diseases included in the definition are schistosomiasis, soil-transmitted helminthiasis, lymphatic filariasis, onchocerciasis and African trypanosomiasis. The burden of these diseases is not limited to morbidity since chronic infections lead to lower productivity and increase the poverty and vulnerability of women and children (George et al., 2023; Makau-Barasa et al., 2023).

Sub-Saharan Africa is heavily burdened with neglected tropical diseases. Such burden is due to poverty, lack of adequate sanitation, poor housing conditions, environmental exposure and limited access to diagnosis and treatment of these diseases (Abd El Wahed et al., 2024; Ajide et al., 2023; Ogunkola et al., 2023). With regards to maternal health, NTDs are problematic since they affect women's immunity, increase anemia, and complicate pregnancy management. In the thesis, the effect of neglected tropical diseases on health and well-being of women in Sub-Saharan Africa and risks associated with infection, stigma, poor access to treatment and gender-based barriers to health care have been studied (Ochola et al., 2021; Ghorai, 2023; Wharton-Smith et al., 2019).

Another serious infectious disease threatening maternal health in Sub-Saharan Africa is malaria. Malaria is a fatal febrile disease caused by Plasmodium parasites and spread via infected Anopheles female mosquitoes. According to the thesis, malaria remains preventable and treatable, though imposing heavy disease burden in tropical and subtropical countries, especially Sub-Saharan Africa (Patel et al., 2024; Batte et al., 2024; Kolawole et al., 2023). Expectant mothers are especially vulnerable because of malaria in pregnancy associated with anemia, severe infections, low birth weight, stillbirth, and other problems increasing the risk of complications both for maternal and neonatal health (Das et al., 2024; Lingani et al., 2024; Kassie et al., 2024).

Persistence of the spread of these diseases creates a syndemic burden in terms of maternal health. These diseases are affected by poverty, undernutrition, weak health systems and inadequate prevention. Despite interventions like mass drug administration, vector control, insecticide-treated bed nets, indoor residual spraying, health education and improved access to antimalarial medication, the burden remains high in many Sub-Saharan African countries. Therefore, there is a need for empirical evidence on the extent to which such diseases contribute to maternal mortality in Sub-Saharan Africa.

The specific objective studied in this paper is the effect of the incidence of neglected tropical diseases and malaria on the health of women in Sub-Saharan African countries. This paper transforms the empirical evidence obtained in the thesis into a manuscript for submission by focusing on maternal mortality as a variable of interest and by presenting the core results for Objective One. Contribution of the paper consists in three aspects. Firstly, it examines neglected tropical diseases and malaria incidence as a joint burden rather than separate disease burdens. Secondly, it is focused on Sub-Saharan Africa, which is

Received: 10.09.2026

Accepted: 15.09.2026

Published on: 30.09.2026

severely affected both by the disease burden and maternal mortality. Thirdly, it uses estimators that allow for cross-sectional dependence and heterogeneity across countries.

2.0 Literature Review

2.1 Maternal mortality and disease burden

As it follows from the literature review done as a part of conducting the research, maternal mortality may be regarded as a multi-dimensional result affected by many factors. Even though direct obstetric factors such as hemorrhages, sepsis, hypertension and obstructed labor remain among the major causes of maternal deaths, some other health problems such as infections and nutrition also have an effect on them. Hence, maternal mortality reflects not only the quality of the healthcare services provided by communities or countries but rather their social determinants. Such conclusion confirms the assumption suggested by the theory of social determinants of health, which argues that socio-economic factors have an effect on health problems in communities.

First of all, NTDs are capable of being the determinants of the increased risk of maternal mortality in the world because of several reasons. For instance, chronic infections may negatively affect the weakened immunity of pregnant women. In addition, infections and anemia may cause serious complications in pregnant women. Moreover, negligence in relation to these diseases leads to the inability to detect and treat the disease timely. Finally, expensive healthcare prevents women from getting antenatal care and delivering babies in hospitals. NTDs can

2.2 Theoretical anchorage

In addition to the above theoretical frameworks, there are some other theories that could also be used in analyzing the burden of the disease and its relation to the state of women's health. In particular, one may use the framework of Social Determinants of Health and interpret the results in terms of this theory. Firstly, such social and economic determinants as poverty, poor sanitation, adverse environmental conditions, and activities of health workers may affect the incidence of infections and malaria and thus have an effect on women's health.

To put it differently, the theory in question is particularly useful for explaining the results of the study dedicated to the analysis of mortality rate and its relation to the problem of NTDs and malaria. Due to interdependencies between the two variables mentioned, it is necessary to analyze the issue multidimensionally. In this way, the spread of infections, poor nutrition, low health expenditures, and illiteracy may affect the mortality rate.

Nevertheless, it is necessary to approach the problem from other perspectives as well. One should admit that health behaviors depend on such factors as perceived benefits/threats. At the same time, it is known that according to the Ecological Systems Theory there is an interaction between personal, family, community, organizational and policy-making levels. In this way, Syndemics Theory and Structural Violence Theory may also be used in the case in question.

2.3 Empirical evidence and research gap

Based on the previous studies performed in the thesis, there is a notable connection between infectious diseases and negative consequences for maternal health. Firstly, Das et al. (2024) performed a meta-analysis of the problem of malaria infections in pregnant women. It was found that Africa had a high incidence of malaria infections in antenatal care facilities and delivery settings, which resulted in a higher risk of maternal anaemia, pre-term delivery, still births and low birth weight. Secondly, the study conducted by Lingani et al. (2024) showed that malaria infections were a leading factor behind the development of

Received: 10.09.2026

Accepted: 15.09.2026

Published on: 30.09.2026

anaemia among pregnant women in rural regions of Burkina Faso. Finally, Kassie et al. (2024) in their research dedicated to identifying risk factors responsible for malaria infections in Ethiopia noted that lack of use of insecticide-treated bed nets, being first-time pregnant and poor health education about malaria were associated with asymptomatic infection.

As for the neglected tropical diseases (NTDs), the literature shows that the problem has severe implications for women's health. For instance, Ochola et al. (2021) noted that NTDs led to ill health of women in Sub-Saharan Africa in different ways. Besides, Duffey et al. (2022) claimed that women and girls in vulnerable environments were more prone to NTDs. Finally, gender-related factors influencing people's choices of medical institutions for diagnosing and treatment of NTDs have been described by Wharton-Smith et al. (2019). It may therefore be expected that there will be a high mortality rate among women in countries suffering from the problem and poor health services.

Nevertheless, it should be admitted that there are some notable limitations of the existing literature. First of all, previous empirical studies examined malaria infections or NTDs separately and focused on one country. Moreover, all these papers concentrated solely on either the health of women or children, ignoring the effect of diseases together with health systems in the regional panel framework. Thus, the present thesis is aimed at filling this gap in the literature. For this purpose, the paper analyzes the topic in accordance with Objective One.

3. Materials and Methods

The study has used annual panel data for selected Sub-Saharan African countries for the period 1990 to 2023 as stated in the thesis abstract and scope. The maternal-health model has been built based on maternal mortality ratio measured in per 100,000 live births. The key explanatory variables in the model were neglected tropical diseases measured using Human African Trypanosomiasis index and malaria incidence measured in per 1,000 population at risk. The control variables included in the broader maternal-health model were prevalence of undernourishment, current health expenditure as a percentage of GDP, number of physicians per 1,000 people, female secondary school enrolment and immunization coverage. Data have been obtained from World Bank development indicators and WHO sources as cited in the thesis.

The functional relationship estimated for Objective One can be expressed as follows: maternal mortality is a function of neglected tropical diseases, malaria incidence, prevalence of undernourishment, current health expenditure and female secondary school enrolment. In the compact form, the maternal-health equation looks as follows: $MMR=f(NTD, IOM, POU, CHE, SSE)$, where MMR stands for maternal mortality ratio, NTD is neglected tropical diseases, IOM is incidence of malaria, POU is prevalence of undernourishment, CHE is current health expenditure and SSE is female secondary school enrolment. The expected signs are positive for NTD, IOM and POU, and negative for CHE and SSE.

Prior to estimation, pre-estimation tests have been performed in order to identify the properties of the panel data. It was necessary to perform the test for cross-sectional dependence since the countries in Sub-Saharan Africa may be affected by common shocks, regional disease transmission, climatic risk, donor-health financing and shared public-health interventions. The results of the test showed evidence of cross-sectional dependence across the variables. This meant that the use of estimators that assumed cross-sectional independence would be inappropriate. Panel unit root testing has shown that the variables were of the mixed order of integration with some variables stationary at level and others stationary after first difference.

Taking into account the data properties, the study has used Augmented Mean Group and Common Correlated Effects Mean Group estimators for Objective One. These estimators are suitable for panels characterized by cross-sectional dependence and heterogeneity in slope structures. The AMG estimator takes into account common dynamic processes that were not observed, while the CCEMG estimator controls for common correlated effects by adding the cross-sectional averages to the country-specific regressions. The use of the estimators jointly increases the credibility of the results since consistent signs and significance across the estimators indicate robustness.

Table 1. Variable description and a priori expectation

Variable	Abbreviation	Measurement/description	Expected sign
Maternal mortality ratio	MMR	Maternal deaths per 100,000 live births	Dependent variable
Neglected tropical diseases	NTD	Human African Trypanosomiasis proxy	Positive
Incidence of malaria	IOM	Cases per 1,000 population at risk	Positive
Prevalence of undernourishment	POU	Percentage of population undernourished	Positive
Current health expenditure	CHE	Percentage of GDP	Negative
Female secondary school enrolment	SSE	Gross female secondary enrolment	Negative

Source: Extracted and cleaned from the attached thesis variable description and a priori expectation tables.

4. Results and Discussion

4.1 Descriptive evidence

The descriptive statistics show that maternal mortality remained high across the selected Sub-Saharan African countries. The average maternal mortality ratio was 616.172 deaths per 100,000 live births, with a standard deviation of 387.197. This wide dispersion indicates substantial differences in maternal health outcomes across the region. The minimum maternal mortality ratio was 79.667, while the maximum reached 2,563.500, revealing extreme disparities that are consistent with differences in health infrastructure, disease exposure, nutrition, conflict conditions and access to maternal care.

The disease variables also showed considerable regional burden. The average value of the NTD proxy was 715.909, with a very large standard deviation of 2,658.402, indicating that neglected tropical disease prevalence varied sharply across countries. The minimum value was zero, while the maximum reached 26,318.000, suggesting that some countries had either controlled the proxy disease or reported low incidence, whereas others faced extremely high levels. Malaria incidence averaged 326.294 cases per 1,000 population at risk, with a maximum of 651.564. This confirms that malaria remained a major public-health burden in the sampled countries. The socioeconomic and health-system variables further reveal the vulnerability of the region. Current health expenditure averaged 6.060% of GDP, while the number of physicians averaged

only 0.178 per 1,000 people. The prevalence of undernourishment averaged 27.642%, suggesting a serious food-security challenge with direct implications for maternal resilience. Female secondary school enrolment averaged 32.136%, reflecting educational constraints that may limit health awareness and use of maternal-health services. These descriptive patterns provide the basis for expecting disease burden and undernourishment to worsen maternal mortality, while health expenditure and education should reduce it.

Table 2. Descriptive statistics of selected variables

Statistic	MMR	NTD	IOM	CHE	NOP	POU	SSE	IMU
Mean	616.172	715.909	326.294	6.060	0.178	27.642	32.136	67.046
Median	532.000	32.000	339.193	3.858	0.104	23.300	26.419	71.000
Maximum	2563.500	26318.000	651.564	69.679	1.876	272.530	297.057	99.000
Minimum	79.667	0.000	27.199	0.184	0.060	0.920	1.575	15.000
Std. Dev.	387.197	2658.402	130.788	9.190	0.197	25.554	29.143	19.921

Source: Researcher, 2024, computed from data obtained from WDI and WHO, as reported in the attached thesis.

4.2 Pre-estimation diagnostics

The pre-estimation tests support the use of second-generation and heterogeneity-sensitive estimation methods. The cross-sectional dependence results showed that most variables rejected the null hypothesis of no cross-sectional dependence at the 5% level. This means that the selected countries were not statistically independent in the behaviour of the variables. Such dependence may reflect regional disease transmission, climate shocks, policy spillovers, donor funding patterns, shared economic vulnerabilities and common health-system constraints. Ignoring this feature would have produced biased or inefficient estimates. The panel unit-root test showed that the variables were not all integrated of the same order. NTD, number of physicians, prevalence of undernourishment and immunisation were stationary at level, while maternal mortality, infant mortality, malaria incidence, current health expenditure and female secondary school enrolment became stationary after first differencing. The mixed order of integration strengthened the need for estimation procedures that do not rely on restrictive assumptions of uniform stationarity. The cointegration test further indicated the presence of a long-run relationship in the maternal mortality model, meaning that disease burden, nutrition, health expenditure and education jointly moved with maternal mortality over time. The correlation results also provide preliminary support for the expected relationships. Neglected tropical diseases were positively correlated with maternal mortality, while malaria incidence was also positively correlated with maternal mortality. Current health expenditure, number of physicians and female secondary school enrolment had negative relationships with maternal mortality. These correlations do not establish causality, but they are consistent with the theoretical expectation that infectious disease burden and undernourishment worsen maternal mortality, while stronger health systems and education reduce it.

Table 3. Summary of pre-estimation diagnostic evidence

Diagnostic result	Main evidence	Interpretation for estimation
Cross-sectional dependence	Most variables rejected the null of no cross-sectional dependence at 5%	Country panels are interconnected; AMG and CCEMG are appropriate.

Panel unit-root test	Variables showed mixed I(0) and I(1) properties	The model requires methods robust to different stationarity properties.
Westerlund cointegration	Maternal mortality model showed statistically significant cointegration statistics	There is evidence of long-run association among the variables.
Correlation matrix	NTD and IOM were positively associated with MMR; CHE and SSE were negatively associated with MMR	Preliminary direction aligns with theoretical expectations.

Source: Author's synthesis from the diagnostic tests reported in the attached thesis.

4.3 Baseline maternal mortality estimates

The baseline results from the AMG and CCEMG estimators show that neglected tropical diseases had a positive and statistically significant effect on maternal mortality in the selected Sub-Saharan African countries. In the AMG model, the coefficient of NTD was 0.079 and significant at the 1% level. In the CCEMG model, the coefficient was 0.048 and also significant at the 1% level. This means that, holding other factors constant, a 1% rise in NTD prevalence increased maternal mortality by between 0.048% and 0.079%. The consistency of the positive sign across both estimators strengthens the conclusion that NTDs are a maternal-health risk factor in the region.

The finding is consistent with the argument that neglected tropical diseases weaken maternal health through chronic infection, anaemia, reduced immunity, malnutrition and limited access to timely treatment. In settings where NTD diagnosis and treatment are weak, pregnant women may face compounded risks because infections can remain untreated and interact with poor nutrition and inadequate antenatal care. This result also agrees with the broader literature in the thesis showing that NTDs have gendered health consequences and can affect women's health and well-being in Sub-Saharan Africa (Ochola et al., 2021; Ghorai, 2023; George et al., 2023).

Malaria incidence also had a positive and statistically significant effect on maternal mortality. The AMG coefficient was 0.160 and significant at the 5% level, while the CCEMG coefficient was 0.114 and significant at the 5% level. Therefore, a 1% increase in malaria incidence raised maternal mortality by between 0.114% and 0.160%. This result indicates that malaria remains a major contributor to maternal death in Sub-Saharan Africa. It supports studies reviewed in the thesis showing that malaria in pregnancy increases the risk of anaemia and other complications that worsen maternal outcomes (Das et al., 2024; Ahadzie-Soglie et al., 2022; Lingani et al., 2024).

The prevalence of undernourishment had a positive and statistically significant effect on maternal mortality. In the AMG model, the coefficient was 0.177 and significant at the 5% level, while in the CCEMG model the coefficient was 0.129 and significant at the 1% level. This suggests that maternal mortality rises as undernourishment increases. The finding is theoretically consistent because undernourished women are more vulnerable to pregnancy complications, infection and poor recovery. It also reinforces the view that maternal mortality reduction in Sub-Saharan Africa must include nutrition-sensitive interventions alongside clinical and disease-control measures (Rahi et al., 2025; Young & Ramakrishnan, 2021).

Current health expenditure had a negative and statistically significant effect on maternal mortality. The AMG coefficient was -0.063, while the CCEMG coefficient was -0.043, both significant at the 1% level. This means that higher health expenditure is associated with lower maternal mortality. The result implies that increased financing can improve maternal survival through better antenatal care, skilled delivery, emergency obstetric services, medicines, diagnostics and health-worker availability. This finding aligns with the studies cited in the thesis which show that public health expenditure plays an important role in improving health outcomes in low-resource settings (Owusu et al., 2021; Oladosu et al., 2022; Boundioa & Thiombiano, 2024). Female secondary school enrolment had a negative but statistically insignificant effect on maternal mortality. The coefficients were -0.004 in the AMG model and -0.003 in the CCEMG model. The direction is consistent with the expectation that education improves health awareness, delays early pregnancy and increases the likelihood of using maternal healthcare. However, the insignificance implies that education alone may not immediately reduce maternal mortality unless supported by healthcare access, income, transport, social empowerment and functional health facilities. This interpretation is consistent with the thesis discussion that the effect of education on maternal outcomes may depend on complementary health-system conditions (Mensch et al., 2019; Andriano & Monden, 2019).

Table 4. Effect of neglected tropical diseases and malaria incidence on maternal mortality

Variable	AMG coefficient	z-statistic	p-value	CCEMG coefficient	z-statistic	p-value
NTD	0.079***	3.80	0.000	0.048***	3.36	0.000
IOM	0.160**	2.12	0.022	0.114**	2.16	0.031
POU	0.177**	2.22	0.035	0.129***	2.70	0.007
CHE	-0.063***	-3.78	0.000	-0.043***	-3.17	0.000
SSE	-0.004	-0.08	0.934	-0.003	-0.09	0.925

Note: *** and ** denote significance at 1% and 5%, respectively. Source: Researcher, 2024, as reported in the attached thesis.

4.4 Country-wise maternal mortality effects

The results from country wise estimates indicate that the contribution of neglected tropical diseases and malaria incidences to maternal mortality varied significantly across countries in Sub-Saharan Africa. The implication of such heterogeneity is the differences that exist among countries regarding maternal health systems, disease control capabilities, climatic environment, levels of exposure to conflicts, and financing of health activities. In respect to NTDs, it has been found out that all the selected countries experienced a positive contribution of NTDs to maternal mortality rate but with varying magnitudes. In respect to NTDs, the countries with the highest effect are Equatorial Guinea, where a one percent increase in the NTDs leads to a 1.352% increase in maternal mortality. Other countries that followed with considerable effects were Zimbabwe (coefficient = 0.657%), Cote d'Ivoire (coefficient = 0.082%). Burkina Faso, the Democratic Republic of Congo, Gabon, Nigeria, South Sudan and Tanzania were other countries that exhibited a positive and significant coefficient. The countries identified with significant NTD effect need to have better surveillance, diagnosis, treatment and integration of NTD services

with maternal health care services. Lower coefficient in some other countries does not imply non-relevance of NTDs in maternal deaths. Instead, it means there are varying levels of statistical associations across the whole panel.

As to the malaria incidence, the countries with the highest effect are South Sudan (coefficient = 1.575%), Equatorial Guinea (coefficient = 0.811%) and Cote d'Ivoire (coefficient = 0.737%). Also, countries that showed significant effects include Nigeria, Uganda, Tanzania, Zimbabwe, Angola, Zambia and Cameroon. The implication is that controlling malaria incidence is a crucial factor in reducing maternal deaths since the cases of maternal deaths and malaria interaction are very high in these countries. Maternal-health programs should also include malaria prevention, rapid diagnosis and treatment of malaria infections as part of antenatal care programs. Country-wise estimation adds much relevance to this paper. While the aggregate estimations provide information on the overall regional relationship, country specific estimations help identify countries that experience high burden of disease effects. The estimations also show that regional policy cannot solve the problem in the whole region because different countries require different strategies of fighting neglected tropical diseases and malaria incidences.

Table 5. Country-wise effect of NTD and malaria incidence on maternal mortality

Country	NTD coefficient	NTD rank	IOM coefficient	IOM rank
Angola	0.002	18th	0.343***	8th
Burkina Faso	0.072***	4th	0.045	18th
Cameroon	0.014	12th	0.254***	11th
Central African Republic	0.003	19th	0.187***	13th
Congo	0.005	17th	0.156	14th
Cote d'Ivoire	0.082**	3rd	0.737***	3rd
DR Congo	0.011**	13th	0.041**	19th
Equatorial Guinea	1.352***	1st	0.811***	2nd
Gabon	0.059*	5th	0.120**	15th
Guinea	0.006	15th	0.113	16th
Kenya	0.028	10th	0.101*	17th
Malawi	0.007	14th	0.213	12th
Mozambique	0.018	11th	0.323	9th
Nigeria	0.031***	9th	0.464***	5th
South Sudan	0.038***	6th	1.575***	1st
Tanzania	0.033**	8th	0.366***	7th
Uganda	0.006	16th	0.367***	6th
Zambia	0.036	7th	0.323***	10th
Zimbabwe	0.657***	2nd	0.544***	4th

Note: ***, ** and * denote significance at 1%, 5% and 10%, respectively. Source: Researcher, 2024, as reported in the attached thesis.

4.5 Discussion of findings

Thus, one can conclude that the problem of maternal mortality in Sub-Saharan Africa does not depend only on the problems of disease burden and malaria incidence rate but also on other factors. In particular, it is possible to say that high positive coefficients of NTDs mean that neglecting these diseases in this region will cause increasing the number of deaths among pregnant women in Sub-Saharan Africa. In addition, one more step that has to be made in solving the problem of maternal mortality in Sub-Saharan Africa includes paying attention to the problems of the health status of women. To be more precise, one should pay attention to the problem of malaria infection among pregnant women in this region, which has to be prevented, diagnosed, treated and educated about.

In addition, it is necessary to note that the problem of undernourishment makes pregnant women especially vulnerable to the risks of maternal mortality. Indeed, lack of energy and poor immune resistance of women make the problem of maternal mortality hard-to-solve in this region. That is why it is crucial to pay much attention to maternal nutrition in solving the problem of maternal mortality. However, concerning the problem of maternal mortality in Sub-Saharan Africa, one can mention that investing money in health care will not solve the problem completely. Indeed, spending money on health care will allow people to get access to health care facilities, treatment, education, monitoring, diagnosis, treatment and birth attendance, etc. However, in some cases money will not influence the health status of people due to corruption, the long distance from health care facilities and improper management of health facilities in this region. Furthermore, it is necessary to emphasize that insignificant negative coefficients of female secondary education enrolment mean that in the long run only will educational measures help to solve the problem of maternal mortality in Sub-Saharan Africa. Nevertheless, at the same time, one can presuppose that in the case of providing people with education there may appear some difficulties (e.g., lack of health care facilities). Thus, education will positively influence maternal mortality, but it will not solve the problem.

In conclusion, it is necessary to emphasize that the problem of maternal mortality in Sub-Saharan Africa is a health-sensitive problem. First of all, it is crucial to carry out some measures concerning infectious diseases' control in maternal health care services. Speaking about policy implications, the strategies of intervention will differ depending on the national specifics of specific Sub-Saharan African countries. In this case, the most problematic Sub-Saharan African countries include South Sudan, Equatorial Guinea, Côte d'Ivoire, Zimbabwe, and Nigeria.

5.0 Conclusion and Policy Recommendations

This paper investigated the effect of neglected tropical diseases and malaria incidence on maternal mortality in Sub-Saharan Africa, basing on Objective One of the attached thesis. The research proved that both NTD and malaria incidence have a positive and statistically significant effect on maternal mortality. The AMG and CCEMG estimates have shown that the prevalence of NTDs on 1% increases the level of maternal mortality on 0.048% - 0.079%, and 1% increase in malaria incidence raises the level of maternal mortality on 0.114% - 0.160%. The results prove that disease burden is a key factor influencing the health condition of people in the region.

In addition, the research has revealed that undernourishment significantly worsens the level of maternal mortality, while current health expenditure significantly reduces it. The variable female secondary school enrolment has negative sign but is not statistically significant in the model of maternal mortality. Evidence from each country shows strong heterogeneity; in particular, the highest NTD effects are recorded in Equatorial Guinea, Zimbabwe and Cote d'Ivoire, while the highest malaria effects are recorded in South Sudan, Equatorial Guinea and Cote d'Ivoire. This means that disease control measures must be both regional and country-specific.

First of all, the government of Sub-Saharan African countries must pay much attention to the problem of neglecting of tropical diseases within maternal-health policy. In particular, the policy must involve disease surveillance, mass drug administration when needed, community diagnosis, sanitation improvement, vector management and targeted treatment of pregnant women of reproductive age. NTD services must be connected with antenatal care services in order to screen and refer pregnant women to the necessary treatment.

Second, malaria prevention and treatment must be incorporated in the program of maternal health care services. Pregnant women in malaria endemic regions must get access to insecticide treated nets, indoor residual spraying programs, preventive therapy when needed, rapid diagnostic testing and effective antimalarial treatment. Community health education must be improved in order to make people follow all these measures and seek treatment as soon as needed.

Third, maternal nutrition has to be used as a disease-control and mortality reduction strategy. Since undernourishment worsens the level of maternal mortality, governments have to promote maternal nutrition programs, food affordability, agricultural assistance, targeted supplementation and social assistance for poor pregnant women. Nutrition sensitive maternal health programs are especially important in disease prone and food insecure regions.

Fourth, the expenditure on health has to be increased and better targeted. The negative effect of current health expenditure proves that the financing will reduce the level of maternal mortality. However, resources have to be directed towards high-impact areas, like antenatal care, emergency obstetric services, rural health facilities, health worker training, disease surveillance, essential medicines and diagnostics.

Finally, education and health system improvement have to be carried out together. Female education is still important for long-term improvement of maternal health, but its effect depends on the presence and affordability of quality health care services. Therefore, policies promoting girls' education have to be supplemented with universal access to maternal health care, community health insurance, transport assistance and rural health infrastructure.

6. Contribution to Knowledge

This paper contributes to health economics and public health literature by isolating the maternal health dimension of the broader thesis and presenting it as a focused journal manuscript. It provides evidence that neglected tropical diseases and malaria incidence jointly worsen maternal mortality in Sub-Saharan Africa. This is important since many studies reviewed in

the thesis considered either malaria or NTDs separately, whereas this study shows that both disease burdens matter simultaneously.

The paper also contributes methodologically by employing AMG and CCEMG estimators that control for cross-sectional dependence and heterogeneity. This improves the reliability of findings since countries of Sub-Saharan Africa are likely to experience common shocks and regional health system constraints. The country-wise findings contribute additionally by revealing that the intensity of disease effect differs across countries, thus justifying targeted rather than uniform policy responses.

For policy, the contribution lies in the fact that maternal mortality reduction cannot be achieved through obstetric care alone. Disease control, nutrition, health financing and education have to be combined together. The results support integrated maternal health platforms that incorporate antenatal care, malaria prevention, NTD surveillance, nutrition assistance and referrals.

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Received: 10.09.2026

Accepted: 15.09.2026

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