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Socio-economic inequalities in malaria prevalence among under-five children in Ghana between 2016 and 2019

Student name: Marian Yaa Abrafi Edusei

Student Number: Edsmar003

Supervisor: Dr. Olufunke Alaba

Co-supervisor: Dr. Amarech Obse

Health Economics Unit, University of Cape Town, Cape Town South Africa

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Dedication

I dedicate this study to my parents, Prof. Anthony K. Edusei and Mrs. Benedicta K. Edusei. To my siblings, Anthony Edusei and Emmanuela Edusei. I would not have realized this dream of completing my studies without your prayers and immense support. Thank you.

Thesis Abstract

Background

Globally, malaria is a preventable and treatable disease that still accounts for thousands of deaths annually, putting approximately 3.3 billion people at risk. Children under five are the most affected, with Sub-Saharan Africa bearing the highest burden. In Ghana, malaria causes nearly 20,000 child deaths each year, a quarter of which are in children under five. Although the association and socioeconomic inequalities related to malaria prevalence have been studied, there is limited evidence on socioeconomic status (SES)-related inequality in malaria prevalence among Ghanaian children under five. Understanding these inequalities is crucial for Ghana to advance towards its sustainable developmental goals (SDG) 10, which focuses on reducing inequalities, and SDG 3, which promotes health and well-being.

Methods

The study adopts a literature review structured into theoretical, methodological, and empirical sections. It discusses the economic burden of malaria and defines theoretical frameworks for SES-related inequalities, using the commission of social determinants of health (CSDH) framework as the conceptual foundation. Methodologies for measuring SES-related inequalities and methods for decomposition analysis are reviewed. Using the period between 2020-2024, the empirical review focused on socio-economic related inequalities in malaria. The 2016 and 2019 Ghana malaria indicator survey datasets were analysed using Stata 15. The outcome variable was malaria prevalence in under-five children, explanatory variables included socio-economic status (household wealth), age of child, mother's education, place of stay, region and a few others. Our study applied the concentration indices and curves to assess socioeconomic inequalities in malaria prevalence among under-five children and decomposing the concentration index to identify contributing socioeconomic factors.

Results

The 2019 concentration index was significantly negative (CI= -0.224; SE=0.059), indicating a higher prevalence of malaria in children from lower socioeconomic backgrounds. While the 2016 index was not statistically significant, it was still negative, suggesting a pro-poor bias in malaria prevalence (CI= -0.052; SE= 0.053). The decomposition analysis found that wealth index, region, and ethnicity were significant contributors to the observed inequalities, accounting for 59.28%, 23.51%, and 4.15% of them, respectively, in 2019.

Conclusion

There are pro-poor inequalities in malaria prevalence among under-five children in Ghana, with a higher burden on those from lower SES backgrounds. Malaria intervention programs should be tailored to target these vulnerable populations and regions that are disproportionately affected by the disease to effectively combat malaria and advance toward meeting the SDGs related to health and inequality.

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1 PART A: Research Protocol

1.1 Background

The World Health Organization (WHO) in partnership with its member countries plans to achieve the Sustainable Development Goal (SDG) 3 by the year 2030, which is promotion of healthy lives and well-being across different age groups WHO (2023b). Among the targets for SDG 3, is reducing the incidence of malaria and ceasing preventable deaths of new-borns and children under-five years of age to at least 25 cases per 1,000 live births (WHO, 2023b). With regards to global malaria control, a Global Technical Strategy (GTS) for malaria 2016-2030 was implemented in 2015 to expedite the global reduction of malaria to at least 90% of malaria incidence and mortalities (Patouillard *et.al.,*., 2017). Consequently, the use of notable malaria preventive measures such as the use of insecticide treated nets, antimalarial drugs as well as other measures have been increased globally in endemic countries (Patouillard *et.al.,*., 2017). These efforts notwithstanding, malaria incidence and related mortality continue to be a global health problem.

The global incidence of malaria was at 59 cases per 1,000 people at risk in 2021 as compared to 60 cases per 1,000 people at risk in 2015 (World Bank, 2023). In addition, in 2021, one third (3.2 billion people) of the global population were at risk of developing the disease as stated by the Centre for Diseases and Control (CDC, 2022). In 2021, malaria accounted for 247 million malaria cases and 619,000 deaths in almost 84 endemic countries (WHO, 2022). What is intriguing is that, although malaria can affect anyone irrespective of age, under-five children bear a disproportionate share of morbidity and mortality (WHO, 2022). They account for about 76% of all malaria deaths, resulting in one child dying nearly every other minute (UNICEF, 2023, Obasohan *et.al.,*., 2021). This poses a challenge in achieving universal health coverage (UHC) by 2030 and efforts to decrease prevalence of malaria in under-five children should be of utmost importance (UNICEF, 2023).

Within Africa, 95% of malaria cases (234 million cases) and 96% of deaths (593,000 deaths) with an incidence rate of (220.8 per 1,000 live births) were recorded in 2021 (WHO, 2022, World Bank, 2023). The majority of reported malaria cases, exceeding 90%, occur within the Sub-Saharan African (SSA) countries, with four countries in SSA contributing to half of the global cases: the Democratic Republic of Congo (12.3%), Nigeria (26.6%), Uganda (5.1%) and Mozambique (4.1%) (WHO, 2022). Moreover, in SSA, malaria stands as a primary contributor and cause of death in under-five mortalities due to their heightened susceptibility and lower immunity (Aheto, 2022,

Severe Malaria Observatory, 2023). Under-five mortalities were of over 80% in 2021in the African region (WHO, 2022, World Bank, 2023).

Similar to other SSA countries, malaria in Ghana is predominantly endemic throughout the country, with seasonal changes and variations across the country (Novignon and Nonvignon, 2012, Degarege *et.al.,*., 2019, Haileselassie *et.al.,*., 2023). Although, recent reports on malaria mortality rate in Ghana has shown a decline from 3% in 2019 to 2% in 2021, 4.8 million malaria cases were reported by the WHO in 2021 with an incidence rate of 164.4 per 1,000 people at risk (Aheto, 2022, WHO, 2022, Novignon *et.al.,*., 2023). Moreover, the Ghana Demographic and Health Survey of 2019 states that malaria related deaths and morbidities in pregnant women and children remains high and worrying (DHS, 2019).

The two leading parasites, that cause malaria are the *Plasmodium falciparum* and *plasmodium vivax* (CDC, 2022). The tropical climate in most malaria endemic regions like SSA favour the survival of these two major malaria parasites (Degarege *et.al.,*., 2019). Moreover, in Ghana and other SSA countries*, Plasmodium falciparum* is largely dominant with severe and devastating consequences on children and pregnant women, and has been noted as a major killer of infants in Africa (Obasohan *et.al.,*., 2021, Tuteja, 2007). The effects of these parasites do not only cause mortality but can lead to adverse pregnancy outcomes in women like low birthweight, maternal anaemia, and perinatal mortality (Desai *et.al.,*., 2007). Moreover, the long-term effect of malaria in children subsequently leads to cognitive impairment, poor developmental growth, and poor attendance in school (Nyarko and Cobblah, 2014). Studies conducted in Ghana recorded absenteeism in school among children who reported having malaria (Ge *et.al.,*., 2023, Nyarko and Cobblah, 2014).

In recent years, malaria prevalence in Ghana has been demonstrated to be associated with certain determinants relating to socioeconomic, demographic and contextual factors (Haileselassie *et.al.,*., 2023, Nyarko and Cobblah, 2014, Nkegbe *et.al.,*., 2017, Phelan *et.al.,*., 2010). The WHO in the 2021 world malaria report confirmed this assertion by indicating that in under-resourced settings like Ghana and other SSA countries, a critical lens must be focused on reduction of socioeconomic inequalities in malaria prevalence (WHO, 2022, Novignon and Nonvignon, 2012, Carrasco-Escobar *et.al.,*., 2021, Tusting *et.al.,*., 2013). Socioeconomic inequality in health is related with inequalities in socioeconomic status with respect to occupation, income, wealth, and education, among others (Pickett and Wilkinson, 2007, Tusting *et.al.,*., 2013). Over the years, the Ghana malaria indicator surveys have reported differences in malaria prevalence among different socioeconomic groups (DHS, 2019). This probably will be because of

high income households' ability to afford laboratory tests and better awareness to identify malaria symptoms early (Were *et.al.,*., 2018, Koram *et.al.,*., 1995).

For decades, the interplay between malaria and poverty has been portrayed as an endless loop, as discussed by where SES is a cause or effect of malaria infection in under-resourced settings (Were *et.al.,*., 2018, de Castro and Fisher, 2012). For instance, in Ghana, malaria prevalence in children was associated with socioeconomic status, with poor households constituting about 25% as compared to the rich households which account for 17% in the 2008 DHS (Nyarko and Cobblah, 2014). In addition, poor households suffer the consequences of time lost to work and thus hampers economic productivity (Nyarko and Cobblah, 2014, Lukwa *et.al.,*., 2020). Although, some studies have published on malaria prevalence in Ghana and SSA (Novignon and Nonvignon, 2012, Nyarko and Cobblah, 2014, Nkegbe *et.al.,*., 2017, Donkor *et.al.,*., 2021), less is reported on the inequalities and distribution of malaria prevalence across different socioeconomic groups and the determining factors driving socioeconomic status-related inequalities in malaria prevalence (Okoli *et.al.,*., 2021). The few studies from SSA revealed that malaria is disproportionately prevalent among people from the lower SES indicating inequalities (Barros *et.al.,*., 2010, Emadi *et.al.,*., 2021).

An increased understanding of socioeconomic status-related inequality in the prevalence of malaria in under-five children in Ghana is important to identify vulnerable groups that need targeting in malaria control strategies. It will offer insights on the disposition and pattern of inequalities in prevalence of malaria in children and determinants that contribute to the inequalities. Evidence of measurements of socioeconomic inequalities in prevalence of malaria in children under-five remains scanty, hence the study thus, aims to extend the literature by assessing socioeconomic inequalities in malaria prevalence in under-five children in Ghana for 2016 and 2019.

1.2 Problem Statement

Globally, under-five children account for 77% of malaria mortalities with close to 80% of these cases occurring in Africa (WHO, 2022).Being endemic in Ghana, malaria as of 2019, is part of the top ten killer diseases in children in the country and it accounts for over 20,000 child deaths annually, a quarter of whom are under-five years (Aheto, 2022). These high malaria mortality rates pose a great threat to achieving the Sustainable Development Goal (SDG) 3, especially Target 2.1 which stipulates that all countries including Ghana should strive to eradicate preventable deaths of new-borns and under-five years children, and decrease neonatal mortality to as low as

12 per 1,000 live births and under-five deaths to at as low as 25 per 1,000 live births by 2030 (WHO, 2023b).

As part of efforts to control malaria, Ghana has rolled out several malaria preventive policies and national programmes including the National Malaria Elimination Programme (NMEPM), the Accelerated Child Survival and Development (ACSD), the National Health Insurance Scheme (NHIS), Community-based Health Planning Services (CHPS), Child Health Policy and the Ghana Strategic Plan for Malaria Control (Asuming Opoku Patrick *et.al.,*, 2020, Ministry of Health, 2007, Aheto, 2022). Most recently, the Ghana Malaria Strategic Plan (2021-2025) was adopted to promote preventive interventions and reduce incidence and mortality to 50% and 90%, respectively (using 2019 as a baseline) by 2025 (PMI, 2022).

The NMEP which was established under the Ministry of Health targeted the utilization of insecticide-treated nets (ITNs), indoor residual spraying, preventive drugs and public education of malaria with the aim of reducing malaria ill health and death rate by 75% in 2020 (Ghana Health Service, 2023). Since its establishment, ITN use in under-five children has increased from 22% in 2006 to 54% in 2019. Moreover, malaria prevalence in under-five children has slowly declined from 27% in 2014, to 21% in 2016 and 14% in 2019 which shows a steady improvement (Aheto, 2022). Again, through the NHIS which encompasses about 95% of subsidised treatment of diseases including malaria for pregnant women and children under the age of 18 years, total outpatient department (OPD) malaria cases have declined from 6.1 million in 2019 to 5.2 million in 2022 (Ghana Statistical Services, 2023a, NHIS, 2023).

Despite gains made, there still exists epidemiological inequality in malaria to the disadvantage of the less-resourced members of the society (Aheto, 2019, Novignon and Nonvignon, 2012). Research shows that, there is a strong positive association between malaria prevalence and being poor (Awine *et.al.,*., 2017, Babalola *et.al.,*., 2020, Clouston *et.al.,*., 2015). Results from studies in Ghana which were found to be statistically significant, identified that prevalence of malaria is likely higher in mothers with no formal education and living in the rural area as compared to urban dwellers (Lukwa *et.al.,*., 2020, Nkegbe *et.al.,*., 2017). This evidence is further backed by the 2022 demographic health survey that reported that malaria prevalence in under-five children in rural areas (12.8%) is about three times higher than that of urban areas (4.3%) (Ghana Statistical Services, 2023a). These disparities highlight the epidemiological inequality of malaria as well as socioeconomic status (SES) as a potential driver of malaria prevalence.

However, such evidence on disparities in malaria prevalence is limited to association of malaria prevalence to demographic and socioeconomic characteristics of population. To the best of the researcher's knowledge, there is limited research on SES-related inequalities in malaria and contributing factors to such inequalities. Furthermore, temporal change in inequalities in malaria prevalence have not been documented. There is need for an increased understanding of SES-related inequalities as a driver of malaria prevalence to facilitate efficient malaria surveillance and targeted preventive initiatives, especially considering constrained health resources.

Examining health SES-related inequalities is important because it allows characterization of the magnitude and nature of inequalities among the various SES groups. This is vital for countries including Ghana as they strive to attain the Sustainable Development Goal (SDG) 10; to reduce inequalities so as to promote the economic, political and social inclusion of all irrespective of age, status, ethnicity, race, and sex (WHO, 2023b). The paucity of evidence in SSA and particularly Ghana on the SES-related inequalities with respect to malaria prevalence in children under-five justifies the need for this study. This study therefore seeks to examine socioeconomic inequalities in malaria prevalence in children under-five between 2016 and 2019.

1.3 Research Aim

To ascertain socioeconomic inequalities in malaria prevalence among children under-five years in Ghana between 2016 and 2019 towards a comprehensive malaria control.

1.4 Specific Objectives

1. To examine socioeconomic inequalities in under-five malaria prevalence in Ghana between 2016 and 2019.
2. To analyse the role of socioeconomic factors on the inequalities in malaria prevalence in children under-five in Ghana between 2016 and 2019.

1.5 Significance of the study

Ghana has made significant strides towards the eradication of malaria through the Ghana Health Sector Medium Term Development plan (SMTP) (2022-2025) and national malaria elimination programme as parts of efforts to attain Universal health coverage (UHC) by the year 2030. Over the years, most malaria control interventions and health policies have aided in decreasing malaria mortality and morbidity cases through indoor residual spraying, distribution of insecticides treated nets at health facilities and media education of malaria infection (Awine *et.al.,*., 2017). In addition, malaria prevalence in children under-five have declined from 26.7 % in 2014 to 8.6% in 2022 (Ghana Statistical Services, 2023a). Since malaria is endemic and prevalent in almost every part

of the country, most malaria intervention policies focus on the general population treatment and diagnosis with less emphasis on the environmental and social factors like socioeconomic status that affects malaria prevalence in the country (Coleman, 2022). Meanwhile, in accordance with the Ghana statistical service, evidence from the 2022 Ghana demographic health survey (DHS) , indicates variations of malaria prevalence across different regions and socioeconomic status (Ghana Statistical Services, 2023a).

Our study which seeks to address the distribution of malaria prevalence in under-five children across different socioeconomic groups will provide further evidence to the SMTP that is currently advocating for zero malaria and UHC by 2030 (Ghana Statistical Services, 2023a). The results of the study will also make useful contributions towards efforts at achieving SDG goal 3 by improving lives and reducing preventable mortalities and morbidities. Again, the contribution of study will be in tandem to policies and SDG 10 that aim at reducing inequalities thus reducing inequalities, ensuring equal opportunity of outcomes, and improving economic status in the society.

1.6 Brief Literature Review

The literature review section elaborates on the existing theories on how health inequalities are measured and analysed based on socioeconomic status. The other section of the review will be on empirical evidence of socioeconomic inequalities in malaria in under-five children in other settings.

1.6.1 Theoretical Literature Review

Health inequality, inequity and socioeconomic status (SES)-related health inequalities

Health inequality is mainly the disparities of health outcomes or health status in a given population irrespective of social positions or other contributing factors (Wagstaff *et.al.,*., 1991, Gakidou *et.al.,*., 2000). Health inequities on one hand are unfair inequalities in health emanating from some type injustice (Kawachi *et.al.,*., 2002). Whilst SES-related health inequality is defined as integral differences in the health of people occupying unequal positions in the society (McCartney *et.al.,*., 2013). It is characterized by a spectrum of social and demographical perspectives including social class, ethnicity, income, geography, deprivation, and caste (McCartney *et.al.,*., 2013). The root causes of health inequalities in recent years seems to be explained by structural differences relating to power, wealth, income, and access between the worse-off and better-off in the society (Marmot and Wilkinson, 2005, Solar and Irwin, 2010). Over the years since the Black report published in 1980 to identify the underlying theories behind socioeconomic health related inequalities, several research have been conducted using these theories to establish the

relationship of health behaviour and social economic status (Gray, 1982, Braveman *et.al.,*., 2000, Corna, 2013).

Socioeconomic status

Socioeconomic Status (SES) is indicated by income, education, occupation, expenditure and wealth in most living standards and demographic surveys to support health inequality related research and beyond (Wagstaff *et.al.,*., 2007). In the past two decades, SES has garnered attention from researchers in establishing the association of health and the complex nature of SES at both community levels and individual level (Adler and Ostrove, 1999, Cutler *et.al.,*., 2008).

1.7 Frameworks and theories of health inequalities

Understanding the complex nature of health inequalities necessitates a deep dive into the theoretical underpinnings that explain their persistence across societies. This section introduces and scrutinizes the pivotal theories that contribute to the discourse on health disparities. Firstly, this study explores the Selection Theory, challenging the conventional understanding by proposing that an individual's health may dictate their socioeconomic status, as opposed to vice versa (Smith *et.al.,*., 1990). This theory also touches on the concept of self-sorting in societal structures based on personal health preferences. This study then critiques the Artefact Theory, which attributes observed health inequalities to variances in data collection methods rather than actual differences in health outcomes by social status (Popham *et.al.,*., 2013, McCartney *et.al.,*., 2013). Lastly, the Structural Theory, akin to the life course theory, is presented, highlighting how disparities in wealth, power, and access across different socioeconomic groups influence health outcomes over an individual's lifespan, along with cultural and behavioural factors (McCartney *et.al.,*., 2013, Smith *et.al.,*., 1990). Each theory offers a unique lens through which to view health inequalities, from individual health-driven social mobility to methodological artefacts in data, to the ingrained structural determinants shaped by a lifetime of experiences.

1.7.1 Selection Theory

This selection theory explained in the Black report asserts that, individual’s health determines socioeconomic class status rather than socioeconomic status defining health (Smith *et.al.,*., 1990, Gray, 1982). This theory further explains that people tend to sort themselves into neighbourhoods, societal groups or clusters (Arcaya *et.al.,*., 2015). A typical situation is , people with high physical activity value may tend to relocate to areas with high walkability, while individuals with sedentary lifestyle may choose to stay in areas that are car dependent (Arcaya *et.al.,*., 2015). But caution is also given when assessing the extent of a causal relationship of data that suggest that physical

activity and residential areas with high walkability, and to what degree does it does reflects self-selection in vicinities (Arcaya *et.al.,*., 2015). This theory also propose that intelligence and meritocracy determine an individual's health through their socioeconomic status and early years of nurture (McCartney *et.al.,*., 2013). This theory argues that people with good genetics are likely to have quality health and high IQ. They are mostly highly educated, high income earners and generally healthier (Arcaya *et.al.,*., 2015). However, several research that investigate causal relationship of health and social factors have debunked this hypothesis, disputing exposures such as occupation, income, and neighbourhood poverty rather influence health (Braveman *et.al.,*., 2000).

1.7.2 Artefact Theory

The artefact theory explains that health inequalities exist based on data measurements and methods having the view that health inequalities really exist. It explains that the differences and size of health by socioeconomic status is as result of differences in data measurement tools (Popham *et.al.,*., 2013). However, this theory has been discarded since the Black report in 1980, because it fails to relate health inequalities by social status (McCartney *et.al.,*., 2013).

1.7.3 Structural Theory

The structural theory can also be explained as the life course theory (Smith *et.al.,*., 1990). This theory stipulates that, differences in socioeconomic backgrounds including, disparities in wealth, power, income, access and environment over their life course causes disparities in health outcomes (Arcaya *et.al.,*., 2015). Notwithstanding, the potential influence of cultural and behavioural factors as well. Individual habits like poor nutrition, poor exercise developed in their early years may impact the life course of one's health decisions. Again, earning low could have a greater impact on individuals health than for rich people. A prolonged effect of this creates health differences among different SES groups (McCartney *et.al.,*., 2013).

1.8 Methodology- Literature Review

Health inequality is measured by various approaches including the Gini index, relative index of inequality (RII) concentration index (CI), and Slope index of inequality (SII). However, the CI, RII and SII are the most widely used indices to explain the absolute and relative SES related inequalities in health outcomes (Kunst and Mackenbach, 1990, Regidor, 2004a, Regidor, 2004b, Wagstaff *et.al.,*., 1991). These approaches are used to quantify the magnitude as well as linear association between health outcomes and categorised socioeconomic groups (Kakwani *et.al.,*., 1997).

1.8.1 Relative Index of Inequality (RII)

The relative index of inequality is a composite measure that considers the relative socioeconomic status of the population and the population size. It is calculated as the fraction of the estimated health variable of the extreme groups in the SES hierarchy. A large RII means there is wide gap of inequality between the low and high SES groups (Mackenbach and Kunst, 1997). Moreover, the RII takes only positive figures. A value larger than one indicates a concentration of resources or morbidity in the socially advantaged and vice versa.

1.8.2 Concentration Index (CI)

The concentration index is explained as twice the area of the concentration curve and the line of equality (Kakwani *et.al.,*., 1997). The concentration curve plots the cumulative proportion of the health variable (y-axis) against the cumulative proportion of the population ranked by socioeconomic status, starting with the poorest to the richest (x-axis) (Kakwani *et.al.,*., 1997). As compared to the concentrative curve that gives a pictorial view of the pronounced differences of inequalities among socioeconomic groups, the CI measures the magnitude of such differences. The concentration index lies between -1 and +1. When the concentration index is 0, it means there is no socioeconomic-related inequality. When the index is negative, there is disproportionate concentration of health or disease among the poor and vice versa (Wagstaff *et.al.,*., 2007). The magnitude of the concentration index reflects the strength of the association between the health variable and ranks of the socioeconomic groups, and the degree of variability (Kakwani *et.al.,*., 1997).

1.8.3 Slope index of inequality (SII)

The slope index of inequality is a linear regression-based index that explains the relation between the frequency of a health problem and the given socioeconomic background (Wagstaff *et.al.,*., 1991). The slope index of inequality is computed by the mean of the health variable for each socioeconomic group and is hierarchically ranked on a social scale. It is measured in absolute terms, given that the highest economic status is 0 and the lowest economic status is 1. It measures the absolute change of health from the highest SES to the lowest SES (Regidor, 2004b). Nonetheless, the slope index of inequality is sensitive to the mean changes in population level (Regidor, 2004b), when there is a change in frequency of the health variable beyond different socioeconomic groups, the slope index changes but relative differences stay the same. The sensitivity of the SII therefore limits its use to assess trends of inequalities different populations.

1.9 Empirical Literature Review

The intricate relationship between socioeconomic factors and prevalence of malaria in under-five children is a pivotal area of study within public health. This empirical literature review section examines the wealth of research that has scrutinised this nexus, revealing a consistent pattern: socioeconomic status serves as a risk or protective factor for the infection of malaria. Notably, these studies highlighted those children from poorer households and regions, and those with less-educated mothers, faced heightened vulnerability to malaria. The review also explored the demographic nuances of malaria prevalence, with age emerging as a significant determinant of infection rates. Furthermore, the literature exposed the inequalities in malaria intervention coverage and the disparate impact on various socioeconomic groups, raising critical questions about the effectiveness of current public health strategies.

1.9.1 Socioeconomic Determinants of Malaria Prevalence

A meta-analysis by Anjorin *et.al.,*. (2023) established socioeconomic status as a risk/protective factor for malaria infection. Across 11 countries, children coming from richer households experienced 36% lower risk of being infected by malaria in relation to those in the poorer households (Anjorin *et.al.,*., 2023). From the same study, the level of maternal education, rural/ urban disparities, household wealth, the sex of household head and, living in the West African region as compared to Eastern and Central African countries showed a positive association with malaria prevalence (Anjorin *et.al.,*., 2023). Some studies in SSA have also established the association between malaria prevalence with these socioeconomic factors as well (Degarege *et.al.,*., 2019, Carrasco-Escobar *et.al.,*., 2021, Njau *et.al.,*., 2014).

The demonstration that poor households are disadvantaged in terms of malaria prevalence can be explained by disparities in education and knowledge of malaria which could translate into the acceptability and practice (or lack thereof) of malaria control interventions that reduce infection among under-five children in SSA (Babalola *et.al.,*., 2020). The socioeconomic disparities of malaria prevalence in under-five children could also be due to existing malaria interventions and treatments overlooking people's socioeconomic backgrounds and focusing mainly on the general population (Sarfo *et.al.,*., 2023). Sarfo *et.al.,*. (2023) recommended that policies in SSA should consider improving SES of individuals to help eradicate malaria in children.

The role of age in malaria prevalence has also been studied. Anjorin *et.al.,*. (2023) studies found that the prevalence of malaria infection increased as a child gains an additional year. Children between the ages of 6-11 months were 1.27 (95% CI = 1.16–1.40) times less likely to contract malaria (95% CI = 1.16–1.40) as compared to children between 24-35 months whilst children

between 48-59 months were 2.02 times as likely to develop the disease. The low malaria prevalence among 6-11 months-olds was explained by anti-bodies developed during pregnancy (Anjorin *et.al.,*., 2023). A systematic review in SSA countries by Sarfo *et.al.,*. (2023) revealed that, the risk of malaria infection is prevalent in under-five children who are older than 24 months. The same review also identified low household income, low maternal education, and variations between rural and urban areas as risk factors associated with malaria infection in children under-five.

Still on age, a study in Ghana by Nyarko and Cobblah (2014) revealed that the highest prevalence of malaria was found to be 26%, 24% and 16% of children among 12-23 months, 24-35 months, and 48-59 months respectively with children under 12 months reporting the lowest prevalence. Besides age, household wealth index, region of residence, maternal education, and ownership of mosquito nets were the major determinants of malaria cases in children under-five (Sarfo *et.al.,*., 2023). In summary, the wealth index, age of child, , sex of household head, place of residence and, maternal education are determinants of malaria prevalence in children and they present valuable opportunities for public health interventions (Nyarko and Cobblah, 2014).

1.9.2 Inequalities in Malaria Prevalence

In assessing inequalities of malaria infection globally, the level of inequality using the wealth index was a Gini index of 0.77 indicating a higher level of inequality relative to other non-communicable diseases as reported by Abeles and Conway (2020). In addition, the African region contributed to about 33% of the inequalities in malaria infection whilst sub-national inequalities in the four most endemic countries in West Africa was found to be 0.30, 0.25, 0.18 and 0.17 in Nigeria, Burkina Faso, Ghana, and Sierra Leone respectively (Abeles and Conway, 2020). These figures, explained the countries with the highest level of malaria infection inequalities in West Africa (Abeles and Conway, 2020). It is vital to note that, although this study examined inequalities using the Gini index, inequalities between the socioeconomic gradients were less reported on as well as in under-five children.

A meta-analysis by Barros *et.al.,*. (2010), showed inequalities in fever prevalence in SSA countries including Ghana. It is worth noting that although fever is a symptom of several diseases, it is one of the key symptoms and signs of malaria infection in children (Barros *et.al.,*., 2010). Wealth index was a proxy for SES indicator of which inequalities of fever prevalence was found to be concentrated in the poor in all the countries. Although evidence from this study indicated inequalities of fever prevalence among children in SSA, it did not assess factors that explain the differences in malaria prevalence. Hence, more research should focus on country specific data to

further explore the differences of disease prevalence in children with respect to wealth and SES (Barros *et.al.,*., 2010).

Socioeconomic inequalities cannot only be assessed by household wealth, indicators like maternal education, household income can also be used (Njau *et.al.,*., 2014, Zere *et.al.,*., 2012). Njau *et.al.,. (*2014) reported maternal education related inequalities in malaria prevalence in three African countries; Angola, Tanzania and Uganda using the decomposition analysis (Njau *et.al.,*., 2014). Children whose mother's educational level were above primary level were 4.7% less likely to develop malaria as compared to uneducated mothers. From this study, there was an 8% gap of inequalities in child malaria infections between educated mothers and uneducated mothers. 60% of this gap was interpreted jointly by 26% of household wealth, 21% of place of stay, 14% of malaria transmission intensities whilst 27% of this gap was explained by regional differences and media exposure (Njau *et.al.,*., 2014).

Still on childhood malaria infection and maternal education, Edwin *et.al.,*. (2021) studies in Nigeria reported that, the odds of prevalence of malaria in under-five children was lower among educated and wealthy mothers compared to non-educated mothers in the poorest population. From the study, younger mothers were less likely to report incidence of malaria infection in child compared to older mothers (Edwin *et.al.,*., 2021). As demonstrated in other studies, this can be attributed to the fact that young mothers are likely to be educated via mass media, through use of social media or have a secondary level of education compared to mothers with basic education (Erhun *et.al.,*., 2005, Kimbi *et.al.,*., 2014). However, after decomposition, a 34% gap of childhood malaria infection was reported between educated and non-educated mothers (Edwin *et.al.,*., 2021). These differential gaps were largely explained by household wealth (68%), age of child (1.03%) and region (0.06%) (Edwin *et.al.,*., 2021).

A decomposition analysis by Okoli *et.al.,*. (2021) revealed socioeconomic disparities in intermittent preventive treatment uptake of malaria in pregnant women. Whilst the wealth index was used as a proxy for SES, intermittent preventive treatment uptake was found to be pro-rich and concentrated among urban dwellers (Okoli *et.al.,*., 2021). Results from the study also identified a 66.7% significant gap of inequalities in the uptake of intermittent preventive treatment explained by the independent variables (Okoli *et.al.,*., 2021). Overall, geopolitical zone (67.4%), education (20.01%), more than 4 antenatal care visits (26.9%) and distance to health facilities (6.2%) as well as wealth index (-25.9%) were the main contributing factors for the explained inequalities in the country (Okoli *et.al.,*., 2021).

Inequalities in child undernutrition (i.e., underweight, wasting, and stunting) and, malaria risk/incidence were also analysed by Nankindu (2022). From the study, it was deduced that, all health outcomes including malaria are concentrated in the poor indicating a pro-poor inequality. A decomposition analysis revealed a 27.9% gap of inequalities in malaria risk in under-five children. These inequalities were jointly explained by mother's education, mosquito net, child's age, residence, and ethnicity playing a substantial role in the explaining the gap (Nankindu, 2022).

Given that reducing prevalence of malaria is important, assessing the socioeconomic inequalities in preventive and malaria control interventions are also important. A study by Hailu *et.al.,*. (2016) in Ethiopia found pro-rich inequality in Long Lasting Insecticide Nets (LLINs) ownership, whilst using wealth index as an indicator for Socioeconomic Position (SEP) (Hailu *et.al.,*., 2016). However, with regard to indoor residual spraying, there was not any substantial record of inequalities (Hailu *et.al.,*., 2016). In the decomposition analysis, inequalities in the LLINs were explained by wealth which amounted to about 90.77%. In addition, ethnicity, educational status, number of household members and mass media telecommunication contributed to the inequalities in utilising malaria interventions (Hailu *et.al.,*., 2016). The contribution of this study focused on the overall population with less emphasis on children.

A cross-sectional study by Carrasco-Escobar *et.al.,*. (2021) analysed spatial SES malaria inequalities in 13 sub-Saharan African countries that utilized the wealth index and highest level of education in mothers as a measure for socioeconomic status (Carrasco-Escobar *et.al.,*., 2021).In assessing spatial differences, both the absolute (Slope index of inequality) and relative (Relative index of inequality) measures were applied. The study revealed high absolute differences of malaria prevalence in the Eastern part of Africa in relation to wealth index and highest level of education in mothers (Carrasco-Escobar *et.al.,*., 2021). However, in the western part of Africa, low relative malaria prevalence in association with wealth index and highest level of education among mothers were observed in Burkina Faso indicating that, it is concentrated in the disadvantaged population (Carrasco-Escobar *et.al.,*., 2021). Although, the studies were conducted in SSA countries, Ghana was excluded.

With regards to trends of coverage of malaria intervention in most endemic countries, Galactionova *et.al.,*. (2017) found coverage of malaria interventions to be pro-poor in Ghana and 15 other countries out of 30 countries (Galactionova *et.al.,*., 2017). Utilisation of insecticide treated nets (ITNs) and indoor residual spraying predominantly favoured the poorest population (Galactionova *et.al.,*., 2017). Inequalities within and across countries were also revealed in the study with respect to utilisation of some interventions, as there were differences across countries.

For instance, the poorest population in Benin had access to ITNs usage better than the poorest population in Cote d'Ivoire (Galactionova *et.al.,*., 2017). Whilst, there were subtle improvements in the expansion of malaria intervention across countries with pro-poor policies and equitable distributions, malaria parasitaemia was still reported to be concentrated in poorer populations compared to the least poor in Ghana (Galactionova *et.al.,*., 2017).

From the brief literature above, most studies reviewed are situated in the SSA countries. Most of the studies showed an association of malaria prevalence and socioeconomic factors, malaria interventions and socioeconomic inequalities in malaria infection (Sarfo *et.al.,*., 2023, Akombi *et.al.,*., 2019, Carrasco-Escobar *et.al.,*., 2021, Novignon and Nonvignon, 2012, Edwin *et.al.,*., 2021, Tusting *et.al.,*., 2013, Galactionova *et.al.,*., 2017). To the best of my knowledge, most studies on inequalities in malaria prevalence were assessed in the general population and pregnant women, with no specific analysis on Ghana in under-five children. Hence it is not possible to tell the extent and nature of inequalities and its respective contributors of malaria prevalence in children under-five of which this study seeks to find.

1.10 Methodology

1.10.1 Data sources and data collection

Data from the Ghana malaria indicator survey (GMIS) for 2016 and 2019 will be used for the analyses (DHS, 2019). The MIS reports information at the national and regional levels and for urban and rural areas for all the indicators in the survey. The 2010 population and housing census sampling framework conducted by the Ghana statistical service was used for sampling recruitment for the MIS both in 2016 and 2019. Before 2016, Ghana had ten administrative regions comprising the Ashanti, Central, Brong Ahafo, Western, Eastern, Upper East, Upper West, Volta, Greater Accra, and the Northern regions. However, in 2019, six new administrative regions were created but the geographic boundaries were not defined in the survey. This study will only include the ten old administrative regions for analysis (DHS, 2019). A total sample size of 6000 households were recorded in 2016 and same in 2019. The sampling used were stratified and selected from the sampling frame in two stages. For both year periods, regions were divided according to rural and urban locations yielding to 20 stratums in the first stage. In the same period, Enumeration areas (EAs) which identify the geographical areas of households were selected from the 2o stratums. The second stage followed a selection of a fixed 30 households from the EAs to get a sample size of 6000 households. Information collected from the survey included demographic factors like age of child, and age of mother. Information on dwelling characteristics like building materials, toilet facilities, roofing and ownership of mosquito nets were also taken.

Wealth index and malaria test results for children between the ages of 6- 59 months were taken for both 2016 and 2019.

1.10.2 Study Population

Children aged 6-59 months with their parent's consent were included in the survey. The children were tested for malaria and anaemia by microscopy or by finger or heel testing. This was conducted by qualified lab technicians and microscopists. A total of 2323 (2016) and 1938 (2019) children aged 6-59 months were studied in the MIS survey.

1.10.3 Study Variables

Study variables were described as binary or categorical given the context and variables used. Categorical variables have two or more categories and have no specific order whilst binary variables have only two categories of response.

Dependent/ Outcome variable

With regards to the Demographic and health survey (DHS), blood samples were taken and tested via microscopy and rapid diagnostic test (RDT) (DHS, 2016, DHS, 2019).The outcome variable for the study is malaria prevalence. It is measured as a binary number and coded (yes) as positive and (no) as negative. Results of malaria blood tests and fever occurrence in the past two weeks will be used to generate the outcome variable. Fever occurrence in the past two weeks will be used to replace missing information in the results of malaria blood tests.

Independent Variables

The explanatory variables included in the study are education of the mother, socioeconomic status, occupation, ownership of insecticide treated nets, place of stay, child's age, knowledge on malaria, mother's age, regions. These variables were chosen based on literature (Okoli *et.al.,*., 2021, Koram *et.al.,*., 1995, Sarfo *et.al.,*., 2023, Babalola *et.al.,*., 2020).They will be used in the decomposition analysis to explain the inequalities accounted in the outcome variable (Malaria Prevalence). Table 1 describes the variables in the appendix.

1.10.4 Data Management and Analysis

Descriptive statistics was used to explain the number and percentage of under-five children with malaria among different social groups and base characteristics of all study variables. This was compared between 2016 and 2019. Socioeconomic inequalities in malaria prevalence among under-five children were measured using the concentration index and curve. The concentration

index and concentration curve were computed for both 2016 and 2019 MIS datasets. The concentration curve were used to identify whether socioeconomic inequality among malaria in children exists and pronounced at a specific point in time or another (Wagstaff *et.al.,*., 2007, Kakwani *et.al.,*., 1997), whilst the concentration index (CI) (Kakwani *et.al.,*., 1997) was used to identify the degree of inequality in malaria in children under-five overtime.

It also important to note that, for a binary variable, normalised CI was proposed by Wagstaff (2005) and Erreygers (2009a) since the CI is not bound by -1 and 1. However, such normalisation of the CI may give different results (Ataguba, 2022). Therefore, the standard concentration indices were estimated and decomposed in this study (Wagstaff, 2005). Decomposition analysis examined the contribution of inequalities in determining factors of malaria prevalence (e.g. age, ITN ownership, region) to socioeconomic inequalities in malaria prevalence. The mathematical expression of the CI is calculated as twice the covariance between the health variable and the fractional rank of the individual's economic status divided by the mean of the health variable (Kakwani *et.al.,*., 1997).

$$\text{CI}=\frac{2}{\mu}\ cov\ (Hi, Ri) \quad \ldots. (1)$$

Where *Hi* is the health variable (status of malaria), *Ri* is the fractional rank of the i^{th} child per living standards or economic status rank when the children are ranked from the poorest to the richest, μ is the mean of the health variable (malaria prevalence), and $cov\ (Hi, Ri)$ is the covariance between the health variable (status of malaria) and the fractional distribution of positions in living standards (Wagstaff *et.al.,*., 2007).

1.10.5 Decomposition Analysis

As explained by Wagstaff *et.al.,*. (2007), the concentration index can be decomposed into multiple contributing factors with respect to the socioeconomic -related health inequality (Wagstaff *et.al.,*., 2007). They identified that, given each factor, its contribution is the product of the sensitivity of the health variable and the degree of socioeconomic status inequality in that factor. A linear additive regression model of health outcome variable (y), against a set of k determinants, x_k was derived as follows,

$y = a + \sum_K \beta_K X_K + \varepsilon$ ….. (2),

Where the concentration index for y, CI y (y is malaria prevalence) is written as follows,

$$\text{CI}=\sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) c_k + GC_\varepsilon/\mu, \ldots. (3),$$

Where μ is the mean of y (malaria prevalence), c_k is the concentration index for the x_k determinants, and GC_ε is the generalized concentration index for the residual term (ε) which captures the wealth-related inequality that is not explained by systematic variations of determining factors across wealth groups (Wagstaff *et.al.,*., 2007). The residual should approach zero for a well-defined model (Wagstaff *et.al.,*., 2007), $\left(\frac{\beta_k \bar{x}_k}{\mu}\right)$ is the cumulative sum of the concentration indices of the x_k determinants, where weight of x_k represents the elasticity (n_k) the outcome variable (malaria prevalence) with respect to a change in the determinants x_k . All statistical analyses was conducted using Stata version 15 (Stata Corp, 2023).

1.11 Ethical Consideration

The study did not involve any primary data collection. The risk involved in this study is low since all personal information of participants has been de-identified in the dataset. In adherence to good ethical research practices, the study follows the principles of the declaration of Helsinki (World Medical Association, 2013) for quality ethical conduct and practices. For the MIS dataset, informed consent was sought before participants were recruited. Ethical approval was sought from the University of Cape Town, Faculty of Health Sciences, Human Research Ethics Committee.

1.12 Publication and Dissemination Policy

The study results will be submitted as a fulfilment for completing master's degree in public health, Health Economics. Again, a manuscript of this study will be published in a peer-reviewed journal.

1.13 Study Timeframe

Part A: Table 1: Study Timeframe

	July	Aug	Sep	Oct	Nov	Dec
Activity						
Protocol writes- up and ethics approval						
Literature review						
Manuscript writeup, data analysis and submissions of mini dissertation to supervisor						
Corrections on supervisor's comments						
Submission of mini thesis						

1.14 References

Abeles, J., & Conway, D. J. (2020). The Gini coefficient as a useful measure of malaria inequality among populations. *Malaria Journal*, *19*, 1-8.

Adler, N. E., & Ostrove, J. M. (1999). Socioeconomic status and health: what we know and what we don't. *Annals of the New York academy of Sciences*, *896*(1), 3-15.

Aheto, J. M. K. (2019). Predictive model and determinants of under-five child mortality: evidence from the 2014 Ghana demographic and health survey. *BMC public health*, *19*(1), 1-10.

Aheto, J. M. K. (2022). Mapping under-five child malaria risk that accounts for environmental and climatic factors to aid malaria preventive and control efforts in Ghana: Bayesian geospatial and interactive web-based mapping methods. *Malaria Journal*, *21*(1), 384.

Akombi, B. J., Agho, K. E., Renzaho, A. M., Hall, J. J., & Merom, D. R. (2019). Trends in socioeconomic inequalities in child undernutrition: Evidence from Nigeria Demographic and Health Survey (2003–2013). *PloS one*, *14*(2), e0211883.

Anjorin, S., Okolie, E., & Yaya, S. (2023). Malaria profile and socioeconomic predictors among under-five children: an analysis of 11 sub-Saharan African countries. *Malaria Journal*, *22*(1), 1-11.

Arcaya, M. C., Arcaya, A. L., & Subramanian, S. V. (2015). Inequalities in health: definitions, concepts, and theories. *Global health action*, *8*(1), 27106.

Asuming Opoku Patrick *et.al.,*. (2020). Preliminary findings: Health Systems Strengthening. Ghana Priorities: Maternal and Child Health. Available here https://copenhagenconsensus.com/publication/ghana-priorities-maternal-and-child-health.

Ataguba, J. E. (2022). A short note revisiting the concentration index: Does the normalization of the concentration index matter? *Health Economics*, *31*(7), 1506-1512.

Awine, T., Malm, K., Bart-Plange, C., & Silal, S. P. (2017). Towards malaria control and elimination in Ghana: challenges and decision making tools to guide planning. *Global health action*, *10*(1), 1381471.

Babalola, O. J., Ajumobi, O., & Ajayi, I. O. (2020). Rural–urban disparities and factors associated with delayed care-seeking and testing for malaria before medication use by mothers of under-five children, Igabi LGA, Kaduna Nigeria. *Malaria Journal*, *19*, 1-11.

Barros, F. C., Victora, C. G., Scherpbier, R., & Gwatkin, D. (2010). Socioeconomic inequities in the health and nutrition of children in low/middle income countries. *Revista de Saúde Pública*, *44*, 1-16.

Braveman, P., Krieger, N., & Lynch, J. (2000). Health inequalities and social inequalities in health. *Bulletin of the World Health Organization*, *78*(2), 232-235.

Carrasco-Escobar, G., Fornace, K., & Benmarhnia, T. (2021). Mapping socioeconomic inequalities in malaria in Sub-Sahara African countries. *Scientific Reports*, *11*(1), 15121.

CDC, C. f. D. C. a. P. (2022). Malaria programme. Available onhttps://www.cdc.gov/malaria/resources/pdf/fsp/cdc_malaria_program_2023b.pdf.

Clouston, S. A., Yukich, J., & Anglewicz, P. (2015). Social inequalities in malaria knowledge, prevention and prevalence among children under 5 years old and women aged 15–49 in Madagascar. *Malaria Journal*, *14*, 1-10.

Coleman, N. A. (2022). Rethinking district-level governance of malaria in Ghana: A narrative review. *PLOS Global Public Health*, *2*(7), e0000764.

Corna, L. M. (2013). A life course perspective on socioeconomic inequalities in health: A critical review of conceptual frameworks. *Advances in life course research*, *18*(2), 150-159.

Cutler, D. M., Lleras-Muney, A., & Vogl, T. (2008). Socioeconomic status and health: dimensions and mechanisms.

de Castro, M. C., & Fisher, M. G. (2012). Is malaria illness among young children a cause or a consequence of low socioeconomic status? Evidence from the United Republic of Tanzania. *Malaria Journal*, *11*(1), 1-12.

Degarege, A., Fennie, K., Degarege, D., Chennupati, S., & Madhivanan, P. (2019). Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. *PloS one*, *14*(1), e0211205.

Desai, M., Ter Kuile, F. O., Nosten, F., McGready, R., Asamoa, K., Brabin, B., & Newman, R. D. (2007). Epidemiology and burden of malaria in pregnancy. *The Lancet infectious diseases*, *7*(2), 93-104.

DHS. (2019). Demographic and health survey (DHS), Ghana Malaria report. https://dhsprogram.com/pubs/pdf/MIS35/MIS35.pdf

Donkor, E., Kelly, M., Eliason, C., Amotoh, C., Gray, D. J., Clements, A. C., & Wangdi, K. (2021). A Bayesian spatio-temporal analysis of malaria in the Greater Accra Region of Ghana from 2015 to 2019. *International journal of environmental research and public health*, *18*(11), 6080.

Edwin, O. A., Bedemi, Y. O., Felix, A. R., & Olushola, K. Y. (2021). An Extension of Blinder-Oaxaca Decomposition on Investigating the Correlation of Maternal Education and Childhood Malaria Infection in Nigeria. *International Journal of Innovative Research and Development*, *10*(3).

Emadi, M., Delavari, S., & Bayati, M. (2021). Global socioeconomic inequality in the burden of communicable and non-communicable diseases and injuries: an analysis on global burden of disease study 2019. *BMC public health*, *21*, 1-13.

Erhun, W., Agbani, E., & Adesanya, S. (2005). Malaria prevention: knowledge, attitude and practice in a Southwestern Nigerian community. *African Journal of Biomedical Research*, *8*(1), 25-29.

Erreygers, G. (2009). Correcting the concentration index. *Journal of health economics*, *28*(2), 504-515.

Gakidou, E. E., Murray, C. J., & Frenk, J. (2000). Defining and measuring health inequality: an approach based on the distribution of health expectancy. *Bulletin of the World Health Organization*, *78*, 42-54.

Galactionova, K., Smith, T. A., de Savigny, D., & Penny, M. A. (2017). State of inequality in malaria intervention coverage in sub-Saharan African countries. *BMC medicine*, *15*(1), 1-11.

Ge, Y., Liang, D., Cao, J., Gosling, R., Mushi, V., & Huang, J. (2023). How socioeconomic status affected the access to health facilities and malaria diagnosis in children under five years: findings from 19 sub-Saharan African countries. *Infectious Diseases of Poverty*, *12*(1), 1-10.

Ghana Health Service. (2023). National Malaria Elimination Programme. Available here: https://ghs.gov.gh/national-malaria-elimination-program-nmep/. https://ghs.gov.gh/national-malaria-elimination-program-nmep/

Ghana Statistical Services. (2023). Ghana Demographic and Health Survey Key Indicators. Available here https://statsghana.gov.gh/headlines.php?slidelocks=NTE0NjMyNjk3My40MTc1/headlines/qpono05033.

Gray, A. M. (1982). Inequalities in health. The Black Report: a summary and comment. *International Journal of Health Services*, *12*(3), 349-380.

Haileselassie, W., Adam, R., Habtemichael, M., David, R. E., Solomon, N., Workineh, S., Haider, J., Belachew, A., Deressa, W., & Yan, G. (2023). Socio-demographic and economic inequity in the use of insecticide-treated bed nets during pregnancy: a survey-based case study of four sub-Saharan African countries with a high burden of malaria. *Archives of Public Health*, *81*(1), 64.

Hailu, A., Lindtjørn, B., Deressa, W., Gari, T., Loha, E., & Robberstad, B. (2016). Equity in long-lasting insecticidal nets and indoor residual spraying for malaria prevention in a rural South Central Ethiopia. *Malaria Journal*, *15*, 1-11.

Kakwani, N., Wagstaff, A., & Van Doorslaer, E. (1997). Socioeconomic inequalities in health: measurement, computation, and statistical inference. *Journal of econometrics*, *77*(1), 87-103.

Kimbi, H. K., Nkesa, S. B., Ndamukong-Nyanga, J. L., Sumbele, I. U., Atashili, J., & Atanga, M. (2014). Knowledge and perceptions towards malaria prevention among vulnerable groups in the Buea Health District, Cameroon. *BMC public health*, *14*(1), 1-9.

Koram, K., Bennett, S., Adiamah, J., & Greenwood, B. (1995). Socio-economic risk factors for malaria in a peri-urban area of The Gambia. *Transactions of the royal society of tropical medicine and hygiene*, *89*(2), 146-150.

Kunst, A. E., & Mackenbach, J. P. (1990). Measuring socioeconomic inequalities in health. In *Measuring socioeconomic inequalities in health* (pp. 115-115).

Lukwa, A. T., Atta-Obeng, C., Kaseke, T. W., Aggrey, S., & Alaba, O. (2020). Malaria finance, household mosquito net ownership & use, intermittent preventive treatment in pregnancy (IPTp) in Ghana; a socioeconomic comparative analysis.

Mackenbach, J. P., & Kunst, A. E. (1997). Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Social science & medicine*, *44*(6), 757-771.

Marmot, M., & Wilkinson, R. (2005). *Social determinants of health*. Oup Oxford.

McCartney, G., Collins, C., & Mackenzie, M. (2013). What (or who) causes health inequalities: theories, evidence and implications? *Health Policy*, *113*(3), 221-227.

Ministry of Health. (2007). Under five's child health policy :2007-2015.

Nankindu, S. (2022). *Determinants of inequity in undernutrition, anemia and malaria in children under five (5) years in Uganda* Makerere University].

NHIS, G. N. H. I. S. (2023). The National Health Insurance Scheme. Available here https://www.nhis.gov.gh/about, .

Njau, J. D., Stephenson, R., Menon, M. P., Kachur, S. P., & McFarland, D. A. (2014). Investigating the important correlates of maternal education and childhood malaria infections. *The American journal of tropical medicine and hygiene*, *91*(3), 509.

Nkegbe, P. K., Kuunibe, N., & Sekyi, S. (2017). Poverty and malaria morbidity in the Jirapa District of Ghana: A count regression approach. *Cogent Economics & Finance*, *5*(1), 1293472.

Novignon, J., Aryeetey, G., Nonvignon, J., Malm, K., Peprah, N. Y., Agyemang, S. A., Amon, S., & Aikins, M. (2023). Efficiency of malaria service delivery in selected district-level hospitals in Ghana. *Health Systems*, *12*(2), 198-207.

Novignon, J., & Nonvignon, J. (2012). Socioeconomic status and the prevalence of fever in children under age five: evidence from four sub-Saharan African countries. *BMC research notes*, *5*, 1-7.

Nyarko, S. H., & Cobblah, A. (2014). Sociodemographic determinants of malaria among under-five children in Ghana. *Malaria research and treatment*, *2014*.

O'Donnell, O., Van Doorslaer, E., Wagstaff, A., & Lindelow, M. (2019). Analyzing health equity using household survey data: a guide to techniques and their implementation. Washington: World Bank; 2008. In.

Obasohan, P. E., Walters, S. J., Jacques, R., & Khatab, K. (2021). A scoping review of selected studies on predictor variables associated with the malaria status among children under five years in sub-Saharan Africa. *International journal of environmental research and public health*, *18*(4), 2119.

Okoli, C. I., Hajizadeh, M., Rahman, M. M., & Khanam, R. (2021). Decomposition of socioeconomic inequalities in the uptake of intermittent preventive treatment of malaria in pregnancy in Nigeria: evidence from Demographic Health Survey. *Malaria Journal*, *20*(1), 300.

Patouillard, E., Griffin, J., Bhatt, S., Ghani, A., & Cibulskis, R. (2017). Global investment targets for malaria control and elimination between 2016 and 2030. *BMJ global health*, *2*(2), e000176.

Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *Journal of health and social behavior*, *51*(1_suppl), S28-S40.

Pickett, K. E., & Wilkinson, R. G. (2007). Child wellbeing and income inequality in rich societies: ecological cross sectional study. *Bmj*, *335*(7629), 1080.

PMI, U. S. P. S. M. I. (2022). Ghana malaria profile. Available here: https://www.pmi.gov/?s=ghana+malaria+profile.

Popham, F., Dibben, C., & Bambra, C. (2013). Are health inequalities really not the smallest in the Nordic welfare states? A comparison of mortality inequality in 37 countries. *J Epidemiol Community Health*, *67*(5), 412-418.

Regidor, E. (2004a). Measures of health inequalities: part 1. *Journal of epidemiology and community health*, *58*(10), 858.

Regidor, E. (2004b). Measures of health inequalities: part 2. *Journal of epidemiology and community health*, *58*(11), 900.

Sarfo, J. O., Amoadu, M., Kordorwu, P. Y., Adams, A. K., Gyan, T. B., Osman, A.-G., Asiedu, I., & Ansah, E. W. (2023). Malaria amongst children under five in sub-Saharan Africa: a scoping review of prevalence, risk factors and preventive interventions. *European Journal of Medical Research*, *28*(1), 80.

Severe Malaria Observatory. (2023). Ghana. Facts on Malaria. Available : https://www.severemalaria.org/countries/ghana#:~:text=Malaria%20is%20endemic%20and%20perennial,which%20there%20is%20little%20transmission.

Smith, G. D., Bartley, M., & Blane, D. (1990). The Black report on socioeconomic inequalities in health 10 years on. *BMJ: British Medical Journal*, *301*(6748), 373.

Solar, O., & Irwin, A. (2010). *A conceptual framework for action on the social determinants of health*.

Tusting, L. S., Willey, B., Lucas, H., Thompson, J., Kafy, H. T., Smith, R., & Lindsay, S. W. (2013). Socioeconomic development as an intervention against malaria: a systematic review and meta-analysis. *The Lancet*, *382*(9896), 963-972.

Tuteja, R. (2007). Malaria− an overview. *The FEBS journal*, *274*(18), 4670-4679.

UNICEF. (2023). Malaria in Africa. Available online :https://data.unicef.org/topic/child-health/malaria/

Wagstaff, A. (2005). The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. *Health Economics*, *14*(4), 429-432.

Wagstaff, A., Paci, P., & Van Doorslaer, E. (1991). On the measurement of inequalities in health. *Social science & medicine*, *33*(5), 545-557.

Were, V., Buff, A. M., Desai, M., Kariuki, S., Samuels, A., Ter Kuile, F. O., Phillips-Howard, P. A., Patrick Kachur, S., & Niessen, L. (2018). Socioeconomic health inequality in malaria indicators in rural western Kenya: evidence from a household malaria survey on burden and care-seeking behaviour. *Malaria Journal*, *17*(1), 1-10.

WHO. (2022). world malaria report https://www.who.int/publications/i/item/9789240064898. https://www.who.int/publications/i/item/9789240064898

WHO, W. H. O. (2023). Sustainable development goals, themes. Available here https://www.who.int/data/gho/data/themes/sustainable-development-goals.

World Bank. (2023). Facts and figures of malaria. available here https://data.worldbank.org/indicator/SH.MLR.INCD.P3. https://data.worldbank.org/indicator/SH.MLR.INCD.P3

World Medical Association. (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *Jama*, *310*(20), 2191-2194.

Zere, E., Kirigia, J. M., Duale, S., & Akazili, J. (2012). Inequities in maternal and child health outcomes and interventions in Ghana. *BMC public health*, *12*(1), 1-10.

2 PART B: Literature Review

2.1 Introduction

This chapter is sectioned into three broad parts, theoretical, methodological, and empirical review. The first section is a theoretical review that will explain the concepts of health inequalities and socioeconomic status (SES)-related inequalities, conceptual frameworks underpinning the link between health inequalities and socioeconomic status, and an economic background of the burden of malaria. The second part of the chapter will delve into the methodologies and theoretical arguments of measuring and assessing socioeconomic inequalities in health. The last part of the chapter focuses on the empirical review and discusses the existing literature on socioeconomic inequalities in malaria prevalence in sub-Saharan Africa (SSA) and Ghana. The empirical review goes further to critically analyse and to identify gaps, limitations and provide knowledge from previous empirical literature on socioeconomic inequalities in malaria prevalence in under-five children.

2.2 Theoretical Review

2.2.1 Background of economic burden of malaria in Ghana

Malaria is a disease caused by two main parasites, Plasmodium vivax and Plasmodium falciparum, and it is both preventable and curable (CDC, 2022). The prevalence of malaria is widespread in Asia, the Middle East, and largely in Africa, where 95% of cases and 96% of deaths were reported in 2021 (WHO, 2022). Beyond the health impact, malaria has global consequences, including out-of-pocket expenses, lost days at work or school, and hindrances to economic growth (Andrade *et.al.,*., 2022, Gallup and Sachs, 2000, Morel *et.al.,*., 2008, Tawiah *et.al.,*., 2016). According to Haakenstad *et.al.,*. (2019), the global expenditure on malaria, encompassing government and out-of-pocket expenses from 2000 to 2016, amounted to US$ 4.3 billion. This estimation was derived from the national accounts of 106 countries prone to malaria (Andrade *et.al.,*., 2022). Additionally, the average household costs for malaria treatment in 2017 varied across different countries, ranging from US$ 8.7 in Afghanistan to US$ 254.7 in Colombia, with households experiencing productivity losses (Devine *et.al.,*., 2019). In sub-Saharan African (SSA) countries, the economic implication of malaria is catastrophic and pushing households further below the poverty line (Castillo-Riquelme *et.al.,*., 2008). On average, households' catastrophic expenditure that exceeded their income threshold between 2001 and 2017 in SSA countries due to malaria were found to be 17.80% in Sudan and 22.5% in Zimbabwe (Andrade *et.al.,*., 2022, Castillo-Riquelme *et.al.,*., 2008).

The geographic and warm climatic nature in Ghana makes malaria transmission endemic in every region. Despite the roll out of malaria interventions (i.e., insecticide treated nets (ITNs), Indoor residual spraying (IRS), Artemisinin-combination treatment (ACT) and Intermittent prevention treatment (IPTs)) to reduce malaria prevalence, malaria still contributes to about 40% of the overall outpatient department (OPD) cases as at 2017 with under-five children and pregnant women bearing a larger share (Adum *et.al.,*., 2023). Aside the burden of the disease on individuals, the economic impediment of malaria cannot be overlooked with its complications on economic productivity and growth (Nonvignon *et.al.,*., 2016). Although, Ghana implemented the National Health Insurance Scheme (NHIS) in 2003 to reduce financial burden of healthcare and ensure health equity, it's coverage in the overall population in 2014 stood at 40% (Ayanore *et.al.,*., 2019).

Ayanore *et.al.,*. (2019) found that, rural dwellers and poorer households who sought for malaria treatments, were less covered with reasons of non-affordability for subscriptions, poor knowledge, and benefits of NHIS, as well as mistrust in the NHIS. Another economic burden experienced, is the indirect costs and financial strain incurred by rural dwellers through transportation to health facilities due to spatial distance to health centres (Ayanore *et.al.,*., 2019, Novignon *et.al.,*., 2023). In the Upper west region where poverty is at its highest, households still reported an average of US$ 4.76 dollars for insured under-five malaria treatment as of 2016 compared to US$ 5.88 dollars for uninsured children (Dalaba *et.al.,*., 2018). Households reported catastrophic payments for malaria treatment due to distance to health centres and informal costs not covered under the NHIS (Dalaba *et.al.,*., 2018). These socioeconomical challenges create health inequalities between different socioeconomic backgrounds and impede on Ghana's sustainable efforts to attain Universal health coverage and eradicate malaria by 2030.

2.2.2 Conceptualization of Inequalities

The concept of inequalities spans back from ages, embedded in our societies and resulting into disparities in income, age, gender, race, sexual orientation, religion, ethnicity and economic status (Carpentier *et.al.,*., 2014, UN, 2018). The spillover effect not only distort sustained economic growth and development but it also increases social vices, poor or no education in under-resourced settings, environmental degradation and diseases in the society (Carpentier *et.al.,*., 2014). In a report by the United Nations, inequality since 1990 has grown by more than 70 percent (two-thirds) in the global population as at 2018 despite changes in policies in WHO member countries (UN, 2020). As most countries are trying to realize their Sustainable Development Goals

(SDGs) by the year 2030, it is important to promote SDG goal 10 (reducing inequalities) and ensuring that there are country specific policies targeted at reducing inequalities through targeted health interventions, equitable distribution of resources and promotion of education and skills development in countries with extreme inequalities, so as to promote social and economic growth leaving no one behind (UN, 2023).

2.2.3 Health Inequalities

In the past years, the concept of health inequalities has been defined in different contexts in literature (Braveman *et.al.,*., 2000, Kawachi *et.al.,*., 2002, Arcaya *et.al.,*., 2015, Harper and Lynch, 2006). According to Whitehead (1992), health inequalities are unjust and unfair disparities in health that can be avoidable. According to Kawachi *et.al.,*. (2002), health inequalities reflect the dimensional distribution of variations and disparities in a group or an individual's health status. A simple understanding of such disparities in health is explained by the differences in social class, race, gender and ethnicity as stated by Braveman and Gruskin (2003). Furthermore, differences in health status in a population are also characterised as inequalities. For instance, across continents, under-five mortalities are eight times higher in Africa than in the European Region (WHO, 2023a). The measurement of health inequalities, however, have different ways of being examined. On one account, health inequalities can be measured according to individual's health status in a population (i.e., ill-health or good health). Then again, health inequalities can be measured by the variations of social-economic status (i.e., low-income status/high-income status and ability to pay for healthcare) (Kawachi *et.al.,*., 2002).

2.2.4 Socioeconomic Status-Related Inequality in Health

SES- related inequality in health has been explained as structural differences in the health of people occupying unequal positions in society (McCartney *et.al.,*., 2013). It is characterized by a range of social and demographical dimensions including social class, ethnicity, income, geography, deprivation, and caste (McCartney *et.al.,*., 2013). The root causes of health inequalities in recent years seems to be explained by structural differences relating to power, wealth, education, income, and access between the worse-off and better-off in the society (Singh and Siahpush, 2006). In developed countries, it is evident through data that, developing disease or death were systematically higher in those with low level of education and income (Mackenbach and Howden-Chapman, 2003, Mackenbach *et.al.,*., 1997). Moreover, in developing countries, SES-related inequalities in health are clearly present and widening across the socioeconomic gradient (i.e., low, and high-income levels) (Ataguba *et.al.,*., 2011, Barros *et.al.,*., 2010, Tusting *et.al.,*., 2016). Considering the Black report was published in 1980 to identify the underlying

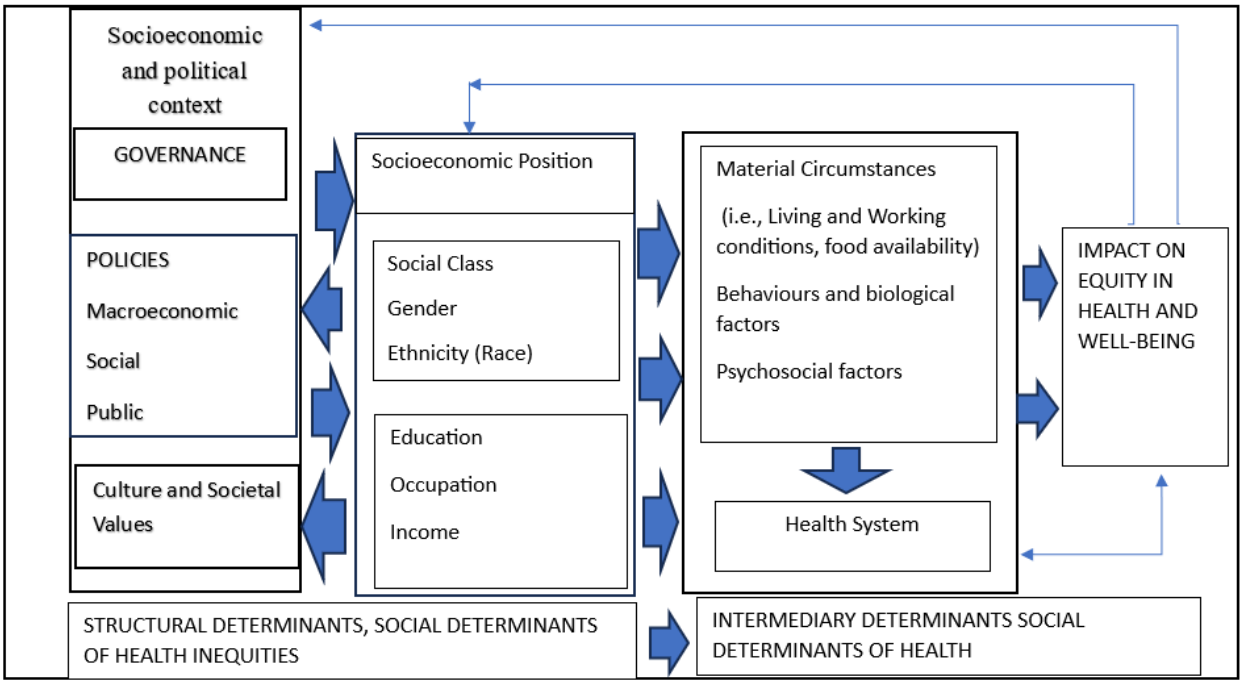
theories (outlined in **part one**) behind socioeconomic status-related inequalities in health, several studies have been conducted using these theories and frameworks to establish the relationship of health behaviours and social economic status (Gray, 1982, Braveman *et.al.,*., 2000, Corna, 2013).

2.3 Conceptual Frameworks

This section will discuss existing frameworks that have been used overtime to explain the social mechanisms that affect health, create inequalities, and also inform policy decisions (Solar and Irwin, 2010). The quest to unravel the intricate web of factors influencing health outcomes led the study to review conceptual frameworks that serve as analytical tools for understanding health disparities.

2.3.1 The Commission of Social Determinants of Health Framework

*Par*t B: Figure 1: A conceptual framework for social determinants of health



Source: (WHO, 2023a, Solar and Irwin, 2010)

The Social Determinants of Health (SDoH) is explained as non-medical conditions that may influence health outcomes positively or negatively (Solar and Irwin, 2010, Marmot and Wilkinson, 2005). These conditions, including where people live, grow, work, are born and age, are derived from a set of forces and systems including, social policies, economic and political policies, and developmental agendas (Solar and Irwin, 2010, WHO, 2023a). For instance, in systems or countries where social and economic policies are not well guided, people's education and

perceptions about their health status are affected. Highly educated individuals are conscious of their health choices compared to the uneducated. Moreover, environmental exposure in early life development affects childrens' nutrition and growth which influences a person's economic productivity and health behaviour (Elder Jr, 1998).To reduce such health inequalities influenced by SDoH, the Commission on Social Determinants of Health framework (CSDH) was developed by the World Health Organization in 2005 to explain how these systemic conditions give rise to different socioeconomic status (income, education, gender, and ethnicity) and in turn affect people's health status (Solar and Irwin, 2010, WHO, 2023a, Marmot and Wilkinson, 2005). The backbone of this CSDH framework is centred on health equity and equality with its primary components as the Socioeconomic and political context, structural determinants of health inequities and intermediary determinants of health. **Part B: Figure 1** depicts an illustration of the SDoH framework.

2.3.2 Social Determinants of Health

The structural determinants of health inequities emphasize the interconnection of socioeconomic and political context and systemic mechanisms including education, income, occupation, social class, ethnicity and how they result into social stratification and socioeconomic positions among the society (Solar and Irwin, 2010). Correspondingly, these mechanisms directly affect individuals' health outcomes with respect to socioeconomic status hierarchies which are influenced by access to resources, prestige, and power. Socioeconomic position, could be measured from different dimensions, from adulthood or infancy of which different time points and exposures are characterized and linked to individual's health (Lahelma *et.al.,*., 2004, Krieger *et.al.,*., 1993). In the same vein, the CSDH posits that peoples' social class, race/ethnicity and gender play an important role in disparities in socioeconomic positions and health inequalities (Krieger *et.al.,*., 1993).

The socioeconomic and political context in the framework can be referred to as a scope of factors in the society that evolves around the structural, functional and cultural aspects of the social system and influence the social stratification and patterns of people's health outcomes (Solar and Irwin, 2010). According to Raphael (2006) governance and public policies, affect the distribution of social determinants of health across the population (Solar and Irwin, 2010). These contexts also influence how certain health issues or conditions are prioritized in the society.

Governance in this context is defined as the needs, civil society participation, patterns of discrimination and the accountability of public administration. It serves as a forum for policy implementation and decision making (Solar and Irwin, 2010). With regards to policies that

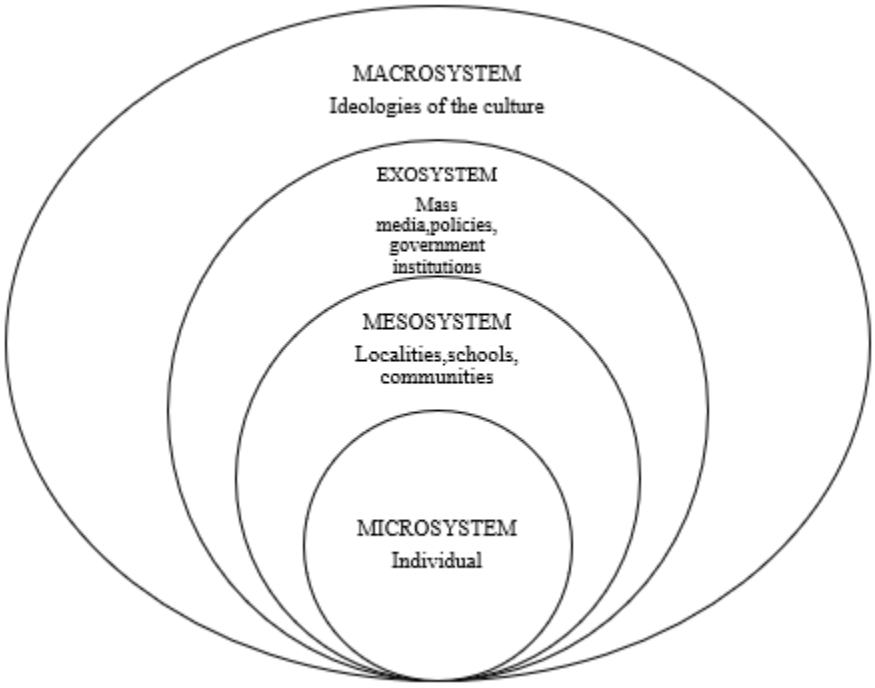
influence health, they are characterized by macro-economic policies, social policies, and public policies. These policies in relation to macro-economic policies influence the fiscal, monetary, and structures of the labour market (Solar and Irwin, 2010). Social policies influencing social welfare, labour, land and housing distribution whilst public policy influence people's education, medical care, and water and sanitation (Solar and Irwin, 2010). The contribution of cultural and social values in this context also have a vital role to play in the achieving a proper health system. Although, the value a society attaches to health can be varied at certain degrees, the level where, health is prioritized on the governmental or societal agenda determines the resources allocated for health (Solar and Irwin, 2010).

The other core element, intermediary determinants of health are individual influences characterized by biological and behavioural factors, psychosocial factors, material conditions that are experienced by individuals as result of their underlying social stratification as stated by Solar and Irwin (2010). The CSDH model assumes individuals with poor living material conditions (i.e., housing materials, farmlands) tend to have poor health outcomes than the privileged in the society creating disparities among different socioeconomic backgrounds (Irwin *et.al.,*., 2006). Behavioural and psychosocial factors, including and not limited to negative life events, stressful living conditions, excessive alcohol consumption, diet and smoking, directly impacts on people's health (Elder Jr, 1998, Solar and Irwin, 2010). Given the core components of the framework, the study adopted the framework in identifying its socioeconomic variables at household level and how they impact on children's health.

2.3.3 Socio-Ecological Model Framework

The Socioecological model (SEM) was introduced by Bronfenbrenner (1979). It serves as a conceptual model for understanding human development (Kilanowski, 2017). The model is characterized by multiple levels of systems centred around individuals in the society (Bronfenbrenner, 1979). There are four systems in the model, specifically the microsystem, mesosystem, exosystem and macrosystem. The adaptation of SEM in health, broadly defines the interaction of individual's environment, community, interpersonal, organizational and political factors that influence their health (Kilanowski, 2017). The microsystem constitutes the immediate exposure and local surroundings whilst the mesosystem is characterized by individual's direct exposure in the workplace, school, church, communities. The exosystem and macrosystem indirectly affect individual's health negatively and positively. The latter are characterized by the exposure of policies, societal norms, religious and cultural beliefs in the community (Bronfenbrenner, 1979, Kilanowski, 2017). The SEM framework has been adapted and used by

the Centres for Disease and Control and Prevention (CDC) in public health promotion, cases like domestic and sexual violence as well as malaria control interventions (Kilanowski, 2017, Nyaaba *et.al.,*., 2021, Awuah *et.al.,*., 2018). However, its application in health inequality related cases is not recognised in literature as compared to the Social Determinants of health (SDH). **Part B: Figure 2** illustrates a conceptual framework for socioecological model.



Part B: Figure 2: A conceptual framework for Socioecological model

Source : Bronfenbrenner (1979)

2.4 Methodological Review

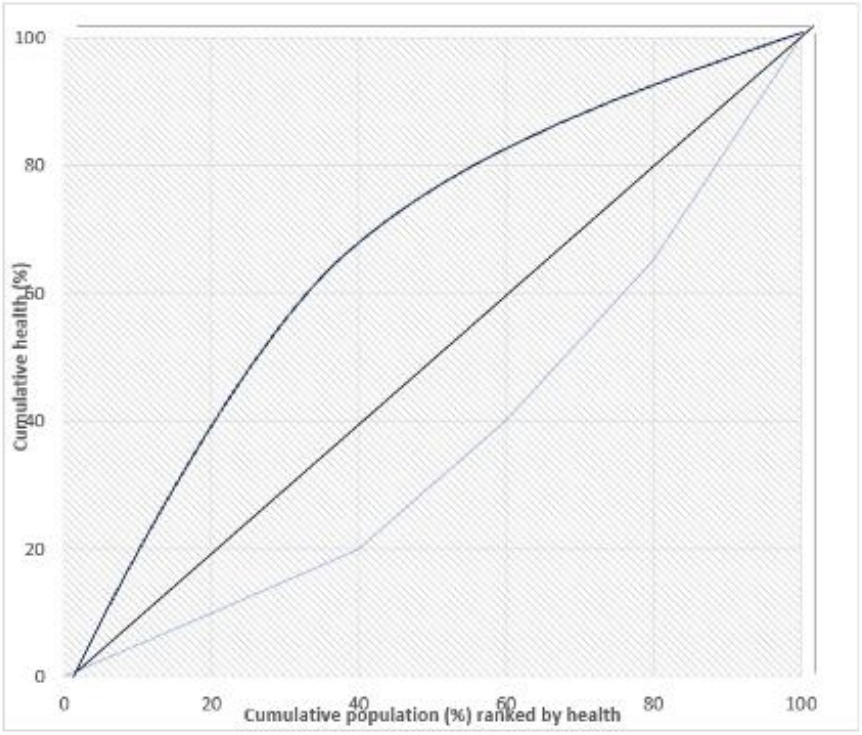
There have been several methodologies that have been established in evaluating inequalities in health and healthcare utilisation. These methodologies including the range, concentration index and concentration curve ,slope and relative index of inequality, Lorenz curve, Gini coefficient, and index of dissimilarity measure health inequalities either in relative or absolute terms (Wagstaff *et.al.,*., 1991). In the context of health economics, these methods are applied to examine socioeconomic status-related inequalities in health. These methods are presented and explained according to their strengths and limitations in this section.

2.4.1 The Range

The range is the simplest and frequently used measure of assessing health inequalities. It differentiates the experiences of the bottom poorest and the top wealthiest socioeconomic individuals or groups (Wagstaff *et.al.,*., 1991). The ratio between the two extreme ends of the population explains the related inequalities in health. Although, the range is one of the simplest measure of health inequalities, it does come with some flaws when using it as discussed by Braveman *et.al.,*. (2000) and Wagstaff *et.al.,*. (1991). Firstly, the range does not consider the sizes of the groups being compared thus, may lead to incorrect or misleading results, especially when comparisons are done across countries or over time (Wagstaff *et.al.,*., 1991). Secondly, the range does not consider the intermediate socioeconomic groups and overlooks changes reflected therein, whether changes are increasing (decreasing) (Wagstaff *et.al.,*., 1991).

2.4.2 The Gini coefficient and Lorenz curve

The Lorenz curve and Gini coefficient were both developed in the early 1900s (Sitthiyot and Holasut, 2020, Wagstaff *et.al.,*., 1991). The Lorenz curve is applied to illustrate the cumulative proportion of the population on the $x\ axis$ (beginning from the sickest person to the healthiest) against the cumulative proportion of health on the $y\ axis$ (Wagstaff *et.al.,*., 1991). The Lorenz curve lies above or below the line of equality (45℃ line), if there is an unequal distribution of health, whilst the curve falls directly or diagonally on the line of equality when there is an equal distribution of health (Regidor, 2004a). The further away the curve, the larger the degree of inequality. The Gini coefficient is computed as twice the area between the Lorenz curve and line of equality (Wagstaff *et.al.,*., 1991). The Gini coefficient ranges between 0 (which denotes complete equality) and 1 (complete inequality, where all the cumulated population health is concentrated in one person) (Wagstaff *et.al.,*., 1991). Compared with range that reflects health outcomes of two extreme socioeconomic groups, the Lorenz curve accounts for all individual experiences. However, the simplicity of computing the Gini index and Lorenz curve does not come with limitations, both are insensitive to the socioeconomic dimensions of health inequalities as established by Wagstaff *et.al.,*. (1991) and Kunst and Mackenbach (1990). The Lorenz curve is illustrated in Part B: Figure 3.



Part B: Figure 3: Lorenz curve, a hypothetical example

2.4.3 The Pseudo-Gini coefficient and Pseudo Lorenz curve

The pseudo-Lorenz and the pseudo-Gini coefficient uses group data to assess inequalities (Wagstaff *et.al.,*., 1991). In terms of analysis, occupational classes are employed in place of health classes and are ranked by health against their level of mortality (Wagstaff *et.al.,*., 1991). Regardless of ranking groups according to their health, the Pseudo- Lorenz curve and pseudo-Gini coefficient fail to consider the socioeconomic differences of inequalities in health (Wagstaff *et.al.,*., 1991). In other words, it fails to differentiate which socioeconomic groups or individuals are the sickest or wealthiest in the population (Wagstaff *et.al.,*., 1991).

2.4.4 Index of Dissimilarity (ID)

Index of dissimilarity (ID) measures the extent to which a group's share of health (s_j^h) varies from its population health (s_j^p) (Wagstaff *et.al.,*., 1991). The more distinct difference between (s_j^h) and (s_j^p), the greater the degree of health inequality (Regidor, 2004a). The mathematical formula of the ID is expressed below,

$$ID = \frac{1}{2} * \sum_j (S_j^h - S_j^p)$$

The ID, alongside with the pseudo-Gini coefficient and Lorenz curve fail to recognize the socioeconomic dimensions of inequalities in health as criticised by (Regidor, 2004a) and (Wagstaff *et.al.,*., 1991). It only reflects each socioeconomic group's share of the population's health compared to its population share and not how this difference compares with the socioeconomic status of these groups.

2.4.5 Slope and Relative Index of Inequality (SII & RII)

The slope and relative indices of inequality, in contrast to the range, Lorenz curve and pseudo-Lorenz curve show the dimensions of socioeconomic inequalities in health and the experiences of the entire population (Wagstaff *et.al.,*., 1991). The SII is a linear regression-based index that explains the relation between estimating the mean health status of socioeconomic groups or individuals ranked by their socioeconomic status. (Regidor, 2004b).It can be measured in absolute terms, such that it can be ranked from the lowest socioeconomic class to the highest (Wagstaff *et.al.,*., 1991). However, the SII is sensitive to the mean changes in population level (Regidor, 2004a). Given a change in the frequency of the health variable across the socioeconomic status distribution, the SII changes but relative differences stay the same.

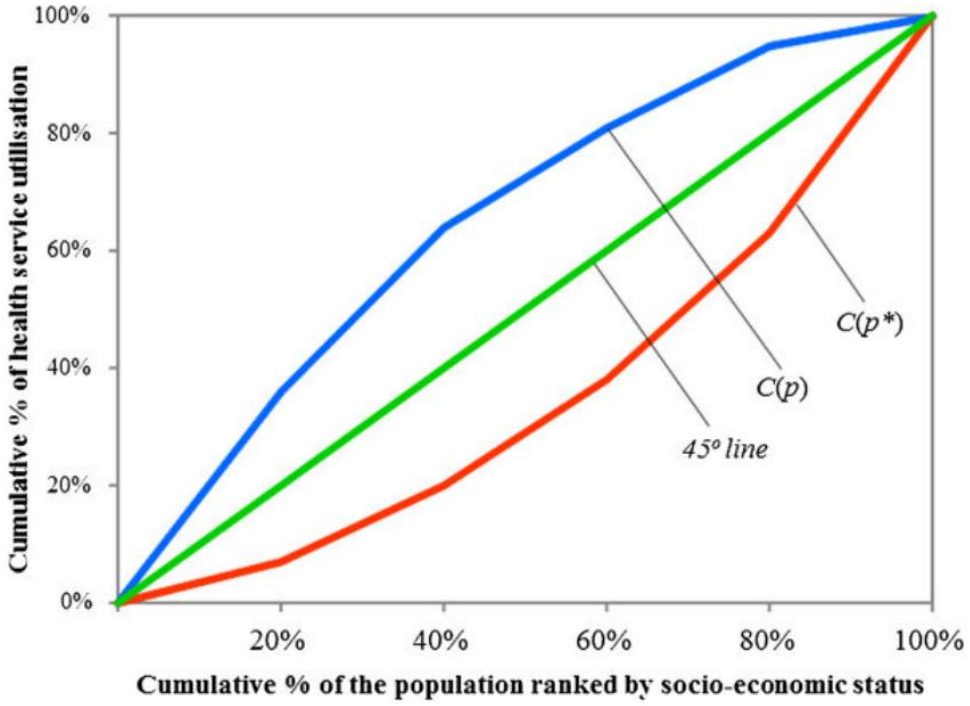
The sensitivity of the SII to mean changes in population health therefore limits its use to assess trends of inequalities in different populations (Wagstaff *et.al.,*., 1991). Alternatively, the RII is a complex measure that considers the relative socioeconomic status of the population and the population size. It is calculated as the fraction of the estimated health variable of the extreme groups in the SES hierarchy. A large RII means there is wide gap of inequality between the low and high SES (Kunst and Mackenbach, 1990). Moreover, the RII takes only positive figures. Notably, the RII has limitations with its interpretations and can be viewed as a measure of association (i.e., frequency ratio or odds ratio) as indicated by Regidor (2004b).

2.4.6 Concentration Curve and Index (CC &CI)

The concentration curve and index are considered to be one of the robust measures in evaluating socioeconomic inequalities in health as described by Kakwani *et.al.,*. (1997),Erreygers (2009b) and Wagstaff *et.al.,*. (1991).The concentration curve (CC) plots the cumulative proportion of the health variable (y-axis) against the cumulative proportion of the population ranked by socioeconomic status, starting with the poorest to the richest (x-axis) (Kakwani *et.al.,*., 1997). The concentration curve gives a pictorial view of health inequalities ranked by socioeconomic status. Where the CC is diagonal to the 45^0 line (line of equality), it indicates the presence of no inequalities. However, when the CC falls below (above) the 45℃ line, it indicates a pro-rich and pro-poor inequalities respectively. Pro-poor indicates that inequalities are present among the

poorest population and vice versa (Ataguba *et.al.,*., 2016). However, the limitation that comes with the concentration curve is that it can only show the differences of inequalities of health or health care across socioeconomic status but cannot measure the extent of its magnitude of inequalities across countries, or a given period (Kakwani *et.al.,*., 1997).

The concentration index (CI) is defined as twice the area between the concentration curve and the line of equality and estimate the magnitude of socioeconomic-related inequalities (Kakwani *et.al.,*., 1997, Wagstaff *et.al.,*., 2007). The standard theoretical value of the CI lies between -1 and +1. When the CI is 0, it means there is no socioeconomic-related inequality or health (ill-health) is evenly distributed along the socioeconomic status ranks, or the concentration curve perfectly aligns with the line of equality (Ataguba *et.al.,*., 2011, Wagstaff *et.al.,*., 2007). When the index assumes a negative (positive) figure, it implies that there is a disproportionate concentration of health or disease among the poorest population (wealthiest) (Wagstaff *et.al.,*., 2007). The magnitude of the CI reflects the strength of the association between the health variable and ranks of the socioeconomic groups, and the degree of variability (Kakwani *et.al.,*., 1997). Figure 2 below illustrates an example of a concentration curve.



Part B: Figure 4: An example of concentration curve

Source: (Phiri and Ataguba, 2014)

It also important to note that, for a binary variable like status of malaria prevalence, the normalised CI was proposed by Wagstaff (2005) and Erreygers (2009a) since the CI is not bound by -1 and 1 but relies on the mean of the outcome variable. Where μ is the mean of the health variable, the normalized concentration index falls within the range of (μ -1) and (1- μ) for large samples, as stated by Wagstaff (2005) such that the interval shrinks when the mean of the outcome variable rises. Nonetheless, such normalisation of the CI may give different results when interpretating for policy implications (Ataguba, 2022). A mathematical illustration of the concentration index is shown below,

CI= $\frac{2}{\mu}\ cov\ (Hi, Ri)$ …. Equation 1

Where μ, *is* the mean of the outcome variable, Hi is the health variable (Malaria prevalence), Ri is the rank of living standards of individuals and *cov* is the covariance between Hi and $Ri.$

2.4.7 Decomposition of the Concentration Index

The concentration curve and index show the nature and magnitude of inequalities. However, further analysis can be done to explain the contributing factors that account for these inequalities. Evaluating and addressing these causes does not only aid in decision making in health policies that aim at improving health status but also subsequently help to improve socioeconomic status. This can be done by decomposing the concentration index. The decomposition analysis reveals the extent of inequalities in health explained by the contributions of each chosen socioeconomic variables (Wagstaff *et.al.,*., 2007). For our study, the CI for malaria prevalence in under-five children in Ghana will be decomposed and identify factors that contribute to the observed inequalities in malaria prevalence.

According to Wagstaff *et.al.,*. (2007), the concentration index (C_H) can be decomposed into multiple contributing factors with respect to the socioeconomic status-related inequality in health(Wagstaff *et.al.,*., 2007). They identified that, given a specific factor, its contribution amounts to the product of the sensitivity of the health variable and the degree of socioeconomic status inequality in that factor. A linear additive regression model of health outcome variable (y) (malaria status), against a set of k determinants, x_k (explanatory variables) was derived as follows,

$y = a + \sum_K \beta_K X_K + \varepsilon$ …...equation 2,

Where the concentration index C_H for y (malaria status) is written as follows,

$C_H = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu_H}\right) c_k + GC_\varepsilon/\mu_H$…. equation 3,

Whereμ_H is the mean of y (malaria prevalence), c_k is the concentration index for the x_k determinants, and GC_ε is the generalized concentration index for the residual term (ε) which captures the wealth-related inequality that is not explained by systematic variations of determining factors across wealth groups (Wagstaff *et.al.,*., 2007). The residual should approach zero for a well-defined model (Wagstaff *et.al.,*., 2007). $\left(\frac{\beta_k \bar{x}_k}{\mu_H}\right)$ is the elasticity (n_k) of the outcome variable (malaria prevalence) with respect to a change in the determinants x_k. The standard errors for the decomposed concentration index will be obtained by bootstrapping (1000 replications) (Doorslaer *et.al.,*., 2004).

2.4.8 Conclusion

In conclusion, the concentration index and the slope index of inequality are the only indices that have shown to efficiently analyse socioeconomic status-related inequalities in health (Ataguba *et.al.,*., 2011, Wagstaff *et.al.,*., 1991). As compared to other measures stated above, both the concentration index and slope index are responsive to the ranking units among socioeconomic status backgrounds. The changes in distribution of population across different socioeconomic backgrounds and reflects changes in health (ill-health) across socioeconomic backgrounds (Wagstaff *et.al.,*., 1991, Kakwani *et.al.,*., 1997, Ataguba *et.al.,*., 2016). Therefore, for the purpose of the study, the concentration curve and index will be used to examine socioeconomic inequalities of malaria prevalence. The concentration index will be decomposed to outline the contributing factors that explains any inequalities identified. Standard errors and confidence intervals will also be computed to indicate the statistical significance of the study.

2.5 Empirical Review

The importance of empirical review gives the reader an already established knowledge on the study topic as well as the gaps. This section reviews studies that have examined associations of malaria infection and social determinants. It also includes studies that have examined the inequalities of malaria infection with regards to socioeconomic status (SES) distribution in the population. The literature included in this Literature review between 2010 and 2023 was drawn from the following electronic databases: GOOGLE SCHOLAR, ECONLIT, AFRICAN WIDE INFORMATION, SCOPUS, PUBMED, WEB OF SCIENCE, BIOMED CENTRAL PLOS ONE and SPRINGER LINKS. The search terms used for the review were “socioeconomic inequalities”, “inequalities”, “inequities”, “SES-related inequalities” and “malaria infection” or “malaria prevalence” or “malaria incidence” or “malaria knowledge” or “malaria prevention” or “malaria

control" or "malaria survival" and "decomposition analysis". Studies were also manually searched for, from articles reviewed. The Endnote reference manager was used to import all references. In total, 18 studies were reviewed with most studies situated in sub-Saharan African countries. All the studies are summarised in **Part B: Table 1**.

2.5.1 Inclusion and Exclusion Criteria

Exclusion criteria for the study focused on 1.) Studies inaccessible to full text, 2.) Studies that did not meet the study objectives, 3.) Studies not selected within the time frame for the study. The studies on socioeconomic inequalities in malaria prevalence, studies that assessed social determinants and inequalities of malaria prevalence, malaria infection, malaria incidence were included. Studies that met the objective of the study spanning from inequalities of coverage of malaria interventions, risk of developing malaria, and malaria prevalence were included.

2.5.2 Introduction

The empirical review showed the breath of socioeconomic and health inequalities in malaria prevalence in under-five children as well as the general population in Sub-Saharan African (SSA) countries and in Lower-Middle Income Countries (LMICs) (Barros *et.al.,*., 2010, Hailu *et.al.,*., 2016, Carrasco-Escobar *et.al.,*., 2021, Abeles and Conway, 2020). In SSA, most the studies were mostly situated in the western and eastern parts of Africa (Njau *et.al.,*., 2014, Krefis *et.al.,*., 2010, Novignon and Nonvignon, 2012, Anjorin *et.al.,*., 2023, Edwin *et.al.,*., 2021, Sonko *et.al.,*., 2014).These inequalities were driven by socioeconomic status (SES) (i.e., household wealth and maternal education), income, malaria preventive interventions, and rural/urban areas in the reviewed studies. Malaria infection/prevalence was strongly associated with socioeconomic status and household wealth of which poor households were more likely to have or develop malaria infection (Alawode *et.al.,*., 2012, Tusting *et.al.,*., 2013, Carrasco-Escobar *et.al.,*., 2021, Galactionova *et.al.,*., 2017).

2.5.3 Evidence on Inequalities in Malaria Prevalence

The nature and distribution of socioeconomic status-related inequalities in malaria prevalence varied from use and access to malaria interventions, maternal education, and geographical disparities (Alawode *et.al.,*., 2012, Njau *et.al.,*., 2014, Abeles and Conway, 2020, Edwin *et.al.,*., 2021). Other studies went further ahead to explicitly decompose the variables in the analysis that explained the observed inequalities or disparities. Most studies used the concentration index and curves for the analysis, conversely other measurements like the Gini Index, and Relative and Slope indices were also represented (Abeles and Conway, 2020, Carrasco-Escobar *et.al.,*., 2021). With regards to SES measurement, most studies used household wealth as an indicator

(Tusting *et.al.,*., 2013, Njau *et.al.,*., 2014, Hailu *et.al.,*., 2016) with some few studies using maternal education as an indicator (Njau *et.al.,*., 2014, Edwin *et.al.,*., 2021).

From a global perspective, malaria was concentrated in the socially disadvantaged (Abeles and Conway, 2020). The Gini Index which can be used to examine health inequalities was used to establish disparities in the six (6) World Health Organization (WHO) regions (Africa, Europe, Americas, Pacific, Middle East and, Asia). Devoid of using wealth as indicator for the Gini index, the study reported a Gini index of 0.77 across the WHO regions. The Gini index was applied to calculate the inequality of malaria burden compared to other diseases globally. This implied that, malaria burden were concentrated in almost every part the WHO regions (Abeles and Conway, 2020). More of these inequalities were found in the WHO African, Asian or the Pacific region constituting 33% and 40% share respectively in the observed Gini index. Notably these inequalities were also concentrated in the poor in these regions.

The same study found Ghana, Burkina Faso, Sierra Leone, and Nigeria to be the highest contributors of malaria burden in the African region (Abeles and Conway, 2020). Other studies also found regional differences of malaria prevalence in SSA countries with the Eastern part of Africa bearing the largest burden of malaria prevalence compared to West Africa (Carrasco-Escobar *et.al.,*., 2021). In addition, this same study found the nature of inequalities in malaria prevalence in the general population to be pro-poor, meaning they were predominantly concentrated in the poorest population (Carrasco-Escobar *et.al.,*., 2021). To note, these studies reviewed only identified inequalities in the general population with less emphasis on under-five children aside this study by Barros *et.al.,*. (2010) that found the distribution of malaria prevalence in children to be pro-poor in LMICs countries (Barros *et.al.,*., 2010). The Barros *et.al.,*. (2010) study also found anti-malarial treatment of fever in under-five children to be concentrated in the better-off relative to the poor.

2.5.4 Evidence of driving factors of SES-related Malaria Inequalities

In the extensive analysis of the various studies reviewed, several key determinants emerged as significant factors in breaking down the socioeconomic inequalities observed in malaria prevalence. These determinants encompassed access to formal healthcare services, levels of maternal education, the efficacy of malaria treatment and control interventions, residential settings (whether urban or rural), the age of the affected child, household wealth, and geographic regions. These contributing factors were extensively analysed in multiple studies, including those by Edwin *et.al.,*. (2021),Njau *et.al.,*. (2014), Hailu *et.al.,*. (2016), and Okoli *et.al.,*. (2021).

For instance, Njau *et.al.,*. (2014) examined the prevalence of under-five childhood malaria infections in Angola, Tanzania, and Uganda in relation to maternal education. Their research uncovered disparities in malaria infection rates between mothers with varying levels of education. It was observed that children born to mothers with no formal education had a higher likelihood of contracting malaria compared to those born to mothers with post-primary education. Furthermore, the study's analysis revealed an 8% disparity in childhood malaria infection rates between educated and non-educated mothers(Njau *et.al.,*., 2014). The study also identified several influential factors contributing to the inequalities in childhood malaria infections. These factors included household wealth, rural residence, malaria transmission intensities, and exposure to media.

While this study highlighted the presence of disparities in under-five children, it's essential to note that the extent and distribution of these inequalities were not thoroughly examined. Consequently, a country-specific analysis focusing on Ghana is warranted to better inform malaria intervention policies. Another study by Edwin *et.al.,*. (2021) found a 34% gap of inequalities in under-five childhood malaria infection among uneducated and educated mothers in Nigeria. The decomposition analysis indicated inequalities in childhood malaria infections to be largely explained by household wealth (68%), region (30%), child's age (1.03%) and 0.06% of Insecticide treated nets ownership (Edwin *et.al.,*., 2021). Like the study above, the nature of inequality in childhood malaria infection were not addressed.

Still on under-five malaria infection, Nawa *et.al.,*. (2019) studies in Zambia found rural locations and child's age to positively contributing to the prevalence of malaria by 2.2 % and 2.3% respectively (Nawa *et.al.,*., 2019). The same study noted that insecticide treated nets and indoor residual spraying use during the period of study (2010-2015) aided in reducing malaria prevalence significantly -by 0.2% and - 0.3% respectively. In contrast to the study not examining SES-inequalities in malaria prevalence, the demographics of the population (i.e., place of residence, age of child) largely contributed to an increase in malaria prevalence in under-five children (Nawa *et.al.,*., 2019).

Under-five malaria prevalence was also examined by Owoeye *et.al.,*. (2018) in Nigeria, the study found place of residence, maternal education, ITN ownership, and utilisation to be statistically associated with childhood malaria infection. A further analysis found ITN ownership and utilization to be the largest contributor to malaria reduction in under-five children by 92% and 13.3% respectively (Owoeye *et.al.,*., 2018). Although under-five children were not assessed in this study by Okoli *et.al.,*. (2021), a decomposition analysis found socioeconomic inequalities of uptake of

Intermittent Preventive Treatment (IPT) among pregnant women in Nigeria. Given that, IPT was of pro-rich inequality, the decomposition analysis identified geopolitical zones (67.4%), education (20.01%), 4 ≥ antenatal visits (26.9%) and distance to health facilities to be the largest contributors to the socioeconomic inequalities in IPTs among pregnant women (Okoli *et.al.,*., 2021).

Similarly, Hailu *et.al.,*. (2016) conducted a study in Ethiopia that shed light on socioeconomic inequalities in the ownership of long-lasting insecticidal nets (LLIN) within the general population. Their research identified key factors contributing to these disparities, with household wealth accounting for a significant 90.77% of the observed inequality, followed by 4.25% in ethnicity, 2.63% in religion, and 3.4% in educational status. These findings emphasize the multifaceted nature of socioeconomic inequalities in malaria prevalence affected by households, highlighting the need to addressing these disparities and to promote better public health outcomes.

2.5.5 Conclusion

It is observed in the review, socioeconomic status affects malaria prevalence and disease incidence negatively mostly in SSA countries and LMICs countries. Evidence from the studies examined, indicated inequalities in both malaria interventions and prevalence whilst majority of these studies showed pro-poor inequality concerning malaria prevalence and incidence. There were mixed methodologies applied in identifying socioeconomic inequalities in malaria prevalence in under-five children, some studies relied on concentration indices and decomposition analysis while other studies employed slope/relative indices and the Gini index. Factors such as household wealth, ethnicity, maternal education, place of residence, and ownership of ITNs were found to be prominent drivers of socioeconomic inequalities in prevalence of malaria in under-five children. In the review, most studies were found to be in SSA (Edwin *et.al.,*., 2021, Okoli *et.al.,*., 2021, Njau *et.al.,*., 2014, Nawa *et.al.,*., 2019) and focused on associations of malaria prevalence and malaria interventions utilisation. Some studies (Edwin *et.al.,*., 2021, Nawa *et.al.,*., 2019) partly explained factors that contribute to the socioeconomic inequalities in malaria prevalence with less focus the distribution and nature of inequality in the population. In the context of Ghana, limited evidence, based on nationally sourced data, exists to inform policies aimed at addressing socioeconomic inequalities in malaria prevalence and incidence. Recognizing the factors that underpin these disparities not only strengthen the healthcare system but also ensures that policies are effectively tailored to enhance malaria surveillance and intervention strategies for under-five children in Ghana.

2.6 Reference

Abeles, J., & Conway, D. J. (2020). The Gini coefficient as a useful measure of malaria inequality among populations. *Malaria Journal*, *19*, 1-8.

Adler, N. E., & Ostrove, J. M. (1999). Socioeconomic status and health: what we know and what we don't. *Annals of the New York academy of Sciences*, *896*(1), 3-15.

Adum, P., Agyare, V. A., Owusu-Marfo, J., & Agyeman, Y. N. (2023). Knowledge, attitude and practices of malaria preventive measures among mothers with children under five years in a rural setting of Ghana. *Malaria Journal*, *22*(1), 1-12.

Aheto, J. M. K. (2019). Predictive model and determinants of under-five child mortality: evidence from the 2014 Ghana demographic and health survey. *BMC public health*, *19*(1), 1-10.

Aheto, J. M. K. (2022). Mapping under-five child malaria risk that accounts for environmental and climatic factors to aid malaria preventive and control efforts in Ghana: Bayesian geospatial and interactive web-based mapping methods. *Malaria Journal*, *21*(1), 384.

Akombi, B. J., Agho, K. E., Renzaho, A. M., Hall, J. J., & Merom, D. R. (2019). Trends in socioeconomic inequalities in child undernutrition: Evidence from Nigeria Demographic and Health Survey (2003–2013). *PloS one*, *14*(2), e0211883.

Alawode, A., Uthman, O. A., & Yahaya, I. (2012). Socio-economic inequity in accessing malaria control interventions in Nigeria: analysis of changes between 2003 and 2008. *Malaria Journal*, *11*(1), 1-2.

Andrade, M. V., Noronha, K., Diniz, B. P., Guedes, G., Carvalho, L. R., Silva, V. A., Calazans, J. A., Santos, A. S., Silva, D. N., & Castro, M. C. (2022). The economic burden of malaria: a systematic review. *Malaria Journal*, *21*(1), 283.

Anjorin, S., Okolie, E., & Yaya, S. (2023). Malaria profile and socioeconomic predictors among under-five children: an analysis of 11 sub-Saharan African countries. *Malaria Journal*, *22*(1), 1-11.

Arcaya, M. C., Arcaya, A. L., & Subramanian, S. V. (2015). Inequalities in health: definitions, concepts, and theories. *Global health action*, *8*(1), 27106.

Asuming Opoku Patrick *et.al.,*. (2020). Preliminary findings: Health Systems Strengthening. Ghana Priorities: Maternal and Child Health. Available here https://copenhagenconsensus.com/publication/ghana-priorities-maternal-and-child-health.

Ataguba, J. E. (2022). A short note revisiting the concentration index: Does the normalization of the concentration index matter? *Health Economics*, *31*(7), 1506-1512.

Ataguba, J. E., Akazili, J., & McIntyre, D. (2011). Socioeconomic-related health inequality in South Africa: evidence from General Household Surveys. *International Journal for Equity in Health*, *10*, 1-10.

Ataguba, J. E., Ojo, K. O., & Ichoku, H. E. (2016). Explaining socio-economic inequalities in immunization coverage in Nigeria. *Health policy and planning*, *31*(9), 1212-1224.

Awine, T., Malm, K., Bart-Plange, C., & Silal, S. P. (2017). Towards malaria control and elimination in Ghana: challenges and decision making tools to guide planning. *Global health action*, *10*(1), 1381471.

Awuah, R. B., Asante, P. Y., Sakyi, L., Biney, A. A., Kushitor, M. K., Agyei, F., & de-Graft Aikins, A. (2018). Factors associated with treatment-seeking for malaria in urban poor communities in Accra, Ghana. *Malaria Journal*, *17*(1), 1-8.

Ayanore, M. A., Pavlova, M., Kugbey, N., Fusheini, A., Tetteh, J., Ayanore, A. A., Akazili, J., Adongo, P. B., & Groot, W. (2019). Health insurance coverage, type of payment for health insurance, and reasons for not being insured under the National Health Insurance Scheme in Ghana. *Health economics review*, *9*, 1-15.

Babalola, O. J., Ajumobi, O., & Ajayi, I. O. (2020). Rural–urban disparities and factors associated with delayed care-seeking and testing for malaria before medication use by mothers of under-five children, Igabi LGA, Kaduna Nigeria. *Malaria Journal*, *19*, 1-11.

Barros, F. C., Victora, C. G., Scherpbier, R., & Gwatkin, D. (2010). Socioeconomic inequities in the health and nutrition of children in low/middle income countries. *Revista de Saúde Pública*, *44*, 1-16.

Braveman, P., & Gruskin, S. (2003). Defining equity in health. *Journal of Epidemiology & Community Health*, *57*(4), 254-258.

Braveman, P., Krieger, N., & Lynch, J. (2000). Health inequalities and social inequalities in health. *Bulletin of the World Health Organization*, *78*(2), 232-235.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard university press.

Carpentier, C. L., Kozul-Wright, R., & Passos, F. D. (2014). Goal 10-why addressing inequality matters. *UN Chronicle*, *51*(4).

Carrasco-Escobar, G., Fornace, K., & Benmarhnia, T. (2021). Mapping socioeconomic inequalities in malaria in Sub-Sahara African countries. *Scientific Reports*, *11*(1), 15121.

Castillo-Riquelme, M., McIntyre, D., & Barnes, K. (2008). Household burden of malaria in South Africa and Mozambique: is there a catastrophic impact? *Tropical medicine & international health*, *13*(1), 108-122.

CDC, C. f. D. C. a. P. (2022). Malaria programme. Available onhttps://www.cdc.gov/malaria/resources/pdf/fsp/cdc_malaria_program_2023b.pdf.

Clouston, S. A., Yukich, J., & Anglewicz, P. (2015). Social inequalities in malaria knowledge, prevention and prevalence among children under 5 years old and women aged 15–49 in Madagascar. *Malaria Journal*, *14*, 1-10.

Coleman, N. A. (2022). Rethinking district-level governance of malaria in Ghana: A narrative review. *PLOS Global Public Health*, *2*(7), e0000764.

Corna, L. M. (2013). A life course perspective on socioeconomic inequalities in health: A critical review of conceptual frameworks. *Advances in life course research*, *18*(2), 150-159.

Cutler, D. M., Lleras-Muney, A., & Vogl, T. (2008). Socioeconomic status and health: dimensions and mechanisms.

Dalaba, M. A., Welaga, P., Oduro, A., Danchaka, L. L., & Matsubara, C. (2018). Cost of malaria treatment and health seeking behaviour of children under-five years in the Upper West Region of Ghana. *PloS one*, *13*(4), e0195533.

de Castro, M. C., & Fisher, M. G. (2012). Is malaria illness among young children a cause or a consequence of low socioeconomic status? Evidence from the United Republic of Tanzania. *Malaria Journal*, *11*(1), 1-12.

Degarege, A., Fennie, K., Degarege, D., Chennupati, S., & Madhivanan, P. (2019). Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. *PloS one*, *14*(1), e0211205.

Desai, M., Ter Kuile, F. O., Nosten, F., McGready, R., Asamoa, K., Brabin, B., & Newman, R. D. (2007). Epidemiology and burden of malaria in pregnancy. *The Lancet infectious diseases*, *7*(2), 93-104.

DHS. (2019). Demographic and health survey (DHS), Ghana Malaria report. https://dhsprogram.com/pubs/pdf/MIS35/MIS35.pdf

Donkor, E., Kelly, M., Eliason, C., Amotoh, C., Gray, D. J., Clements, A. C., & Wangdi, K. (2021). A Bayesian spatio-temporal analysis of malaria in the Greater Accra Region of Ghana from 2015 to 2019. *International journal of environmental research and public health*, *18*(11), 6080.

Doorslaer, E. v., Koolman, X., & Jones, A. M. (2004). Explaining income-related inequalities in doctor utilisation in Europe. *Health Economics*, *13*(7), 629-647.

Edwin, O. A., Bedemi, Y. O., Felix, A. R., & Olushola, K. Y. (2021). An Extension of Blinder-Oaxaca Decomposition on Investigating the Correlation of Maternal Education and Childhood Malaria Infection in Nigeria. *International Journal of Innovative Research and Development*, *10*(3).

Elder Jr, G. H. (1998). The life course as developmental theory. *Child development*, *69*(1), 1-12.

Emadi, M., Delavari, S., & Bayati, M. (2021). Global socioeconomic inequality in the burden of communicable and non-communicable diseases and injuries: an analysis on global burden of disease study 2019. *BMC public health*, *21*, 1-13.

Erhun, W., Agbani, E., & Adesanya, S. (2005). Malaria prevention: knowledge, attitude and practice in a Southwestern Nigerian community. *African Journal of Biomedical Research*, *8*(1), 25-29.

Erreygers, G. (2009a). Correcting the concentration index. *Journal of health economics*, *28*(2), 504-515.

Erreygers, G. (2009b). Correcting the concentration index: a reply to Wagstaff. *Journal of health economics*, *28*(2), 521-524.

Gakidou, E. E., Murray, C. J., & Frenk, J. (2000). Defining and measuring health inequality: an approach based on the distribution of health expectancy. *Bulletin of the World Health Organization*, *78*, 42-54.

Galactionova, K., Smith, T. A., de Savigny, D., & Penny, M. A. (2017). State of inequality in malaria intervention coverage in sub-Saharan African countries. *BMC medicine*, *15*(1), 1-11.

Ge, Y., Liang, D., Cao, J., Gosling, R., Mushi, V., & Huang, J. (2023). How socioeconomic status affected the access to health facilities and malaria diagnosis in children under five years: findings from 19 sub-Saharan African countries. *Infectious Diseases of Poverty*, *12*(1), 1-10.

Ghana Health Service. (2023). National Malaria Elimination Programme. Available here: https://ghs.gov.gh/national-malaria-elimination-program-nmep/. https://ghs.gov.gh/national-malaria-elimination-program-nmep/

Ghana Statistical Services. (2023). Ghana Demographic and Health Survey Key Indicators. Available here, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/World%20Malaria%20Day%20Press%20Release%20from%20GSS.pdf.

Gray, A. M. (1982). Inequalities in health. The Black Report: a summary and comment. *International Journal of Health Services*, *12*(3), 349-380.

Haileselassie, W., Adam, R., Habtemichael, M., David, R. E., Solomon, N., Workineh, S., Haider, J., Belachew, A., Deressa, W., & Yan, G. (2023). Socio-demographic and economic inequity in the use of insecticide-treated bed nets during pregnancy: a survey-based case study of four sub-Saharan African countries with a high burden of malaria. *Archives of Public Health*, *81*(1), 64.

Hailu, A., Lindtjørn, B., Deressa, W., Gari, T., Loha, E., & Robberstad, B. (2016). Equity in long-lasting insecticidal nets and indoor residual spraying for malaria prevention in a rural South Central Ethiopia. *Malaria Journal*, *15*, 1-11.

Harper, S., & Lynch, J. (2006). Measuring health inequalities. *Methods in social epidemiology*, *1*, 134.

Irwin, A., Valentine, N., Brown, C., Loewenson, R., Solar, O., Brown, H., Koller, T., & Vega, J. (2006). The commission on social determinants of health: tackling the social roots of health inequities. *PLoS medicine*, *3*(6), e106.

Kakwani, N., Wagstaff, A., & Van Doorslaer, E. (1997). Socioeconomic inequalities in health: measurement, computation, and statistical inference. *Journal of econometrics*, *77*(1), 87-103.

Kawachi, I., Subramanian, S. V., & Almeida-Filho, N. (2002). A glossary for health inequalities. *Journal of Epidemiology & Community Health*, *56*(9), 647-652.
Kilanowski, J. F. (2017). Breadth of the socio-ecological model. *Journal of agromedicine*, *22*(4), 295-297.
Kimbi, H. K., Nkesa, S. B., Ndamukong-Nyanga, J. L., Sumbele, I. U., Atashili, J., & Atanga, M. (2014). Knowledge and perceptions towards malaria prevention among vulnerable groups in the Buea Health District, Cameroon. *BMC public health*, *14*(1), 1-9.
Koram, K., Bennett, S., Adiamah, J., & Greenwood, B. (1995). Socio-economic risk factors for malaria in a peri-urban area of The Gambia. *Transactions of the royal society of tropical medicine and hygiene*, *89*(2), 146-150.
Krefis, A. C., Schwarz, N. G., Nkrumah, B., Acquah, S., Loag, W., Sarpong, N., Adu-Sarkodie, Y., Ranft, U., & May, J. (2010). Principal component analysis of socioeconomic factors and their association with malaria in children from the Ashanti Region, Ghana. *Malaria Journal*, *9*(1), 1-7.
Krieger, N., Rowley, D. L., Herman, A. A., Avery, B., & Phillips, M. T. (1993). Racism, sexism, and social class: implications for studies of health, disease, and well-being. *American journal of preventive medicine*, *9*(6), 82-122.
Kunst, A. E., & Mackenbach, J. P. (1990). Measuring socioeconomic inequalities in health. In *Measuring socioeconomic inequalities in health* (pp. 115-115).
Lahelma, E., Martikainen, P., Laaksonen, M., & Aittomäki, A. (2004). Pathways between socioeconomic determinants of health. *Journal of Epidemiology & Community Health*, *58*(4), 327-332.
Lukwa, A. T., Atta-Obeng, C., Kaseke, T. W., Aggrey, S., & Alaba, O. (2020). Malaria finance, household mosquito net ownership & use, intermittent preventive treatment in pregnancy (IPTp) in Ghana; a socioeconomic comparative analysis.
Mackenbach, J. P., & Howden-Chapman, P. (2003). New perspectives on socioeconomic inequalities in health. *Perspectives in biology and medicine*, *46*(3), 428-444.
Mackenbach, J. P., & Kunst, A. E. (1997). Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Social science & medicine*, *44*(6), 757-771.
Mackenbach, J. P., Kunst, A. E., Cavelaars, A. E., Groenhof, F., & Geurts, J. J. (1997). Socioeconomic inequalities in morbidity and mortality in western Europe. *The Lancet*, *349*(9066), 1655-1659.
Marmot, M., & Wilkinson, R. (2005). *Social determinants of health*. Oup Oxford.
McCartney, G., Collins, C., & Mackenzie, M. (2013). What (or who) causes health inequalities: theories, evidence and implications? *Health Policy*, *113*(3), 221-227.
Ministry of Health. (2007). Under five's child health policy :2007-2015.
Nankindu, S. (2022). *Determinants of inequity in undernutrition, anemia and malaria in children under five (5) years in Uganda* Makerere University].
Nawa, M., Hangoma, P., Morse, A. P., & Michelo, C. (2019). Investigating the upsurge of malaria prevalence in Zambia between 2010 and 2015: a decomposition of determinants. *Malaria Journal*, *18*, 1-10.
NHIS, G. N. H. I. S. (2023). The National Health Insurance Scheme. Available here https://www.nhis.gov.gh/about, .
Njau, J. D., Stephenson, R., Menon, M. P., Kachur, S. P., & McFarland, D. A. (2014). Investigating the important correlates of maternal education and childhood malaria infections. *The American journal of tropical medicine and hygiene*, *91*(3), 509.
Nkegbe, P. K., Kuunibe, N., & Sekyi, S. (2017). Poverty and malaria morbidity in the Jirapa District of Ghana: A count regression approach. *Cogent Economics & Finance*, *5*(1), 1293472.

Nonvignon, J., Aryeetey, G. C., Malm, K. L., Agyemang, S. A., Aubyn, V. N., Peprah, N. Y., Bart-Plange, C. N., & Aikins, M. (2016). Economic burden of malaria on businesses in Ghana: a case for private sector investment in malaria control. *Malaria Journal*, *15*(1), 1-10.

Novignon, J., Aryeetey, G., Nonvignon, J., Malm, K., Peprah, N. Y., Agyemang, S. A., Amon, S., & Aikins, M. (2023). Efficiency of malaria service delivery in selected district-level hospitals in Ghana. *Health Systems*, *12*(2), 198-207.

Novignon, J., & Nonvignon, J. (2012). Socioeconomic status and the prevalence of fever in children under age five: evidence from four sub-Saharan African countries. *BMC research notes*, *5*, 1-7.

Nyaaba, G. N., Olaleye, A. O., Obiyan, M. O., Walker, O., & Anumba, D. O. (2021). A socio-ecological approach to understanding the factors influencing the uptake of intermittent preventive treatment of malaria in pregnancy (IPTp) in South-Western Nigeria. *PloS one*, *16*(3), e0248412.

Nyarko, S. H., & Cobblah, A. (2014). Sociodemographic determinants of malaria among under-five children in Ghana. *Malaria research and treatment*, *2014*.

O'Donnell, O., Van Doorslaer, E., Wagstaff, A., & Lindelow, M. (2019). Analyzing health equity using household survey data: a guide to techniques and their implementation. Washington: World Bank; 2008. In.

Obasohan, P. E., Walters, S. J., Jacques, R., & Khatab, K. (2021). A scoping review of selected studies on predictor variables associated with the malaria status among children under five years in sub-Saharan Africa. *International journal of environmental research and public health*, *18*(4), 2119.

Okoli, C. I., Hajizadeh, M., Rahman, M. M., & Khanam, R. (2021). Decomposition of socioeconomic inequalities in the uptake of intermittent preventive treatment of malaria in pregnancy in Nigeria: evidence from Demographic Health Survey. *Malaria Journal*, *20*(1), 300.

Owoeye, D. O., Akinyemi, J. O., & Yusuf, O. B. (2018). Decomposition of changes in malaria prevalence amongst under-five children in Nigeria. *MalariaWorld Journal*, *9*.

Patouillard, E., Griffin, J., Bhatt, S., Ghani, A., & Cibulskis, R. (2017). Global investment targets for malaria control and elimination between 2016 and 2030. *BMJ global health*, *2*(2), e000176.

Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *Journal of health and social behavior*, *51*(1_suppl), S28-S40.

Phiri, J., & Ataguba, J. E. (2014). Inequalities in public health care delivery in Zambia. *International Journal for Equity in Health*, *13*(1), 1-9.

Pickett, K. E., & Wilkinson, R. G. (2007). Child wellbeing and income inequality in rich societies: ecological cross sectional study. *Bmj*, *335*(7629), 1080.

PMI, U. S. P. S. M. I. (2022). Ghana malaria profile. Available here: https://www.pmi.gov/?s=ghana+malaria+profile.

Popham, F., Dibben, C., & Bambra, C. (2013). Are health inequalities really not the smallest in the Nordic welfare states? A comparison of mortality inequality in 37 countries. *J Epidemiol Community Health*, *67*(5), 412-418.

Raphael, D. (2006). The social determinants of health: what are the three key roles for health promotion?-editorial. *Health promotion journal of Australia: official journal of Australian Association of Health Promotion Professionals*, *17*(3).

Regidor, E. (2004a). Measures of health inequalities: part 1. *Journal of epidemiology and community health*, *58*(10), 858.

Regidor, E. (2004b). Measures of health inequalities: part 2. *Journal of epidemiology and community health*, *58*(11), 900.

Sarfo, J. O., Amoadu, M., Kordorwu, P. Y., Adams, A. K., Gyan, T. B., Osman, A.-G., Asiedu, I., & Ansah, E. W. (2023). Malaria amongst children under five in sub-Saharan Africa: a scoping review of prevalence, risk factors and preventive interventions. *European Journal of Medical Research*, *28*(1), 80.

Severe Malaria Observatory. (2023). Ghana. Facts on Malaria. Available : https://www.severemalaria.org/countries/ghana#:~:text=Malaria%20is%20endemic%20and%20perennial,which%20there%20is%20little%20transmission.

Singh, G. K., & Siahpush, M. (2006). Widening socioeconomic inequalities in US life expectancy, 1980–2000. *International journal of epidemiology*, *35*(4), 969-979.

Sitthiyot, T., & Holasut, K. (2020). A simple method for measuring inequality. *Palgrave Communications*, *6*(1), 1-9.

Smith, G. D., Bartley, M., & Blane, D. (1990). The Black report on socioeconomic inequalities in health 10 years on. *BMJ: British Medical Journal*, *301*(6748), 373.

Solar, O., & Irwin, A. (2010). *A conceptual framework for action on the social determinants of health*.

Sonko, S. T., Jaiteh, M., Jafali, J., Jarju, L., D'Alessandro, U., Camara, A., Komma-Bah, M., & Saho, A. (2014). Does socio-economic status explain the differentials in malaria parasite prevalence? Evidence from The Gambia. *Malaria Journal*, *13*(1), 1-12.

Tusting, L. S., Rek, J. C., Arinaitwe, E., Staedke, S. G., Kamya, M. R., Bottomley, C., Johnston, D., Lines, J., Dorsey, G., & Lindsay, S. W. (2016). Measuring socioeconomic inequalities in relation to malaria risk: a comparison of metrics in rural Uganda. *The American journal of tropical medicine and hygiene*, *94*(3), 650.

Tusting, L. S., Willey, B., Lucas, H., Thompson, J., Kafy, H. T., Smith, R., & Lindsay, S. W. (2013). Socioeconomic development as an intervention against malaria: a systematic review and meta-analysis. *The Lancet*, *382*(9896), 963-972.

Tuteja, R. (2007). Malaria− an overview. *The FEBS journal*, *274*(18), 4670-4679.

UNICEF. (2023). Malaria in Africa. Available online :https://data.unicef.org/topic/child-health/malaria/

United Nation. (2018). Reduced Inequalities: Why it matters| Sustainable Development. Available here: file:///C:/Users/Marian%20Edusei/OneDrive/Documents/malaria%20proposal/ethics/10_Why-It-Matters-2020.pdf.

United Nation. (2020). Rising inequality affecting more than two-thirds of the globe, but it's not inevitable: new UN report. Available here: https://news.un.org/en/story/2020/01/1055681#:~:text=Inequality%20is%20growing%20for%20more,by%20the%20UN%20on%20Tuesday.

United Nation. (2023). Sustainable Development Goals | Reducing Inequalities| Goal 10. Available here: https://www.un.org/sustainabledevelopment/inequality/.

Wagstaff, A. (2005). The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. *Health Economics*, *14*(4), 429-432.

Wagstaff, A., O'Donnell, O., Van Doorslaer, E., & Lindelow, M. (2007). *Analyzing health equity using household survey data: a guide to techniques and their implementation*. World Bank Publications.

Wagstaff, A., Paci, P., & Van Doorslaer, E. (1991). On the measurement of inequalities in health. *Social science & medicine*, *33*(5), 545-557.

Were, V., Buff, A. M., Desai, M., Kariuki, S., Samuels, A., Ter Kuile, F. O., Phillips-Howard, P. A., Patrick Kachur, S., & Niessen, L. (2018). Socioeconomic health inequality in malaria indicators in rural western Kenya: evidence from a household malaria survey on burden and care-seeking behaviour. *Malaria Journal*, *17*(1), 1-10.

WHO. (2022). world malaria report https://www.who.int/publications/i/item/9789240064898. https://www.who.int/publications/i/item/9789240064898

WHO, W. H. O. (2023). Sustainable development goals, themes. Available here https://www.who.int/data/gho/data/themes/sustainable-development-goals.

World Bank. (2023). Facts and figures of malaria. available here https://data.worldbank.org/indicator/SH.MLR.INCD.P3. https://data.worldbank.org/indicator/SH.MLR.INCD.P3

World Health Organization. (2023). Social determinants of health. Available here: https://www.who.int/health-topics/social-determinants-of-health#tab=tab_3.

World Medical Association. (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *Jama*, *310*(20), 2191-2194.

Zere, E., Kirigia, J. M., Duale, S., & Akazili, J. (2012). Inequities in maternal and child health outcomes and interventions in Ghana. *BMC public health*, *12*(1), 1-10.

3 PART C: Journal Manuscript

Proposed Journal: International Journal of Equity in Health

Socioeconomic inequalities in malaria prevalence among under-five children in Ghana between 2016 and 2019.

Marian Yaa Abrafi Edusei [1*]

[1]*School of Public Health, Health Economics Unit, Faculty of Health and Sciences, University of Cape Town.*

***Corresponding author**: Marian Y.A. Edusei, Health Economics Unit, School of Public Health, Faculty of Health and Sciences, University of Cape Town, Anzio Road, Observatory, 7925.*

Email Address: marianedusei.yaa@gmail.com

3.1 Abstract

Background

Malaria is ranked among the top ten killer diseases in Ghana. Each year, almost 20,000 children in Ghana of whom 25% are under-five years die as a result of malaria. Whilst some studies have established the association of socioeconomic factors (i.e., education, household wealth, income) and malaria prevalence in under-five children, evidence on socioeconomic inequality in malaria prevalence is sparse in Ghana. Such evidence would inform targeted malaria prevention interventions in line with the Ghana Malaria Strategic Plan (2021-2025), which is advocating for malaria eradication by 2030. Therefore, our study examined the socioeconomic inequalities of prevalence of malaria and contributing factors in under-five children in Ghana.

Methods

The 2016 (N=2323) and 2019 (N=1,938) Ghana malaria indicator survey (GMIS) datasets were utilized for this study. Information on household socioeconomic factors and malaria tests in under-five children were used and analysed with Stata version 15. The outcome variable was malaria prevalence in under-five whilst the wealth index was used as proxy for socioeconomic status. Concentration indices and curves were utilized to assess the magnitude and socioeconomic inequalities in malaria prevalence in under-five years children. For 2019, the concentration index was decomposed to identify the socioeconomic factors contributing to the inequalities of prevalence in malaria.

Results

Malaria prevalence was 8% and 10% in 2016 and 2019 respectively. The concentration index for 2019 (CI= -0.224; SE=0.059) was statistically significant and negative indicating greater malaria prevalence in low socioeconomic status under-five children. Just like 2019, the concentration index for 2016 was pro-poor (CI= -0.052, SE=0.053) although it was not statistically significant. After decomposition socioeconomic status, region, and ethnicity contributed to 59.28%, 23.51%, and 4.15% respectively of the socioeconomic inequalities observed in 2019.

Conclusion

The study reveals a persistent pro-poor inequality in malaria prevalence in children under five years in Ghana, underscoring the importance for targeted malaria control interventions. These interventions should prioritize socioeconomically disadvantaged groups and high-risk areas to align with the national goal of eradicating malaria by 2030.

Key words: Malaria, Socioeconomic inequalities, children under-five, Ghana, Sub-Sahara Africa

3.2 Background

Malaria is a preventable and treatable infectious disease primarily caused by the parasites *plasmodium vivax* and *plasmodium falciparum* (CDC, 2022). It remains a pressing global public health problem significantly affecting under-five children and pregnant women worldwide. In 2021, about one-third (3.2 billion people) of the global population were at risk of developing the disease (WHO, 2022). Malaria accounted for 619,000 deaths globally, with majority occurring in 84 endemic countries. In 2021, under-five years children accounted for 76% of all malaria cases (WHO, 2022, UNICEF, 2023).

The African continent, particularly Sub-Saharan Africa (SSA), bore the brunt of the burden with 90% of malaria cases and 96% of deaths in 2021 (WHO, 2022). In the same year, children under five in Africa represented 80% of all malaria-related deaths (WHO, 2022, World Bank, 2023). Beyond mortality, malaria can impede children's cognitive and developmental growth, school attendance, economic productivity and its associated with adverse pregnancy outcomes such as low birth weight and maternal anaemia (Ge *et.al.,*., 2023, Nyarko and Cobblah, 2014, Obasohan *et.al.,*., 2021, Desai *et.al.,*., 2007). In Ghana, the impact of malaria is profound, with the disease accounting for nearly 40% of all outpatient department cases and about 47% of under-five fatalities in 2016 (Ghana Health Service, 2023, Afoakwah *et.al.,*., 2018).

Research has consistently indicated SES as a determinant of malaria prevalence. Systematic reviews and studies confirm the influence of various socioeconomic dimensions, such as household wealth, education, and income, on malaria prevalence in children under five in SSA (Nkegbe *et.al.,*., 2017, Tusting *et.al.,*., 2013, Degarege *et.al.,*., 2019). Compared with high SES defined by household wealth, the odds of malaria infection in under-five increased with low socioeconomic status in these studies. In Ghana, similar associations have been reported, with lower SES linked to increased malaria risk in children (Habermann, 2022, Krefis *et.al.,*., 2010). Educational levels of mothers, for example, have been linked as a protective factor against childhood malaria in Angola and Uganda (Njau *et.al.,*., 2014), while household wealth has shown a strong correlation with malaria incidence in studies from Tanzania and Madagascar (Clouston *et.al.,*., 2015, de Castro and Fisher, 2012). The economic impediment of malaria in Ghana cannot be overstated with its complications on economic growth (Nonvignon *et.al.,*., 2016). Despite the implementation of the national health insurance scheme (NHIS), rural dwellers and poorer households who seek for malaria treatments are challenged with issues of insurance subscriptions, indirect costs and financial strain due to transportation to health facilities, accommodation and lost man hours (Ayanore *et.al.,*., 2019, Novignon *et.al.,*., 2023). Moreover,

regions that are majorly affected by the disease are also faced with high poverty incidence (Aboagye-Attah, 2019). Specifically, the northern regions including the Upper East, Northern and Upper West with a poverty incidence of 44.4, 50.4 and 70.7 percent respectively in 2013 compared to urban regions namely Greater Accra that had a poverty incidence of 5.6 percent in 2013 (Aboagye-Attah, 2019).

The inequalities and factors contributing to malaria (i.e., prevalence, access to interventions and services) in under-five children, have also been identified in SSA countries including Nigeria (Okoli *et.al.,*., 2021), Ethiopia (Hailu *et.al.,*., 2016) and Kenya (Were *et.al.,*., 2018). These studies found malaria prevalence to be concentrated in poorer populations (pro-poor inequalities) and malaria interventions utilisation to be concentrated in richer populations (pro-rich inequalities). However, there is limited evidence on these SES-related inequalities in Ghana, particularly concerning their impact on under-five children. By 2022, the Ghana Statistical Services reported 5.2 million malaria outpatient cases. The National Malaria Elimination Programme (NMEP) has implemented measures such as distribution of ITNs and indoor residual spraying (IRS), which have markedly increased ITN usage among under-five children from 22% in 2006 to 54% in 2019 (Ghana Statistical Services, 2023a). It is important to note that, the effectiveness of the ITNs use should not be overlooked as some studies in Ghana found ITNs being used for nursing seedlings, animal fencing and other purposes aside its use which can lead to inequalities in malaria prevalence (Diema *et.al.,*., 2017). Nonetheless, the 2022 Demographic and Health Survey highlighted a significant socioeconomic status (SES)-related disparity in malaria prevalence in this age group, with prevalence thrice higher in rural areas than urban areas (Ghana Statistical Services, 2023a).

The interplay of socioeconomic development, including improved housing, employment, and education, may complement traditional malaria control measures and aid in reducing malaria-associated poverty in low- and middle-income countries (LMICs) (WHO, 2022, Carrasco-Escobar *et.al.,*., 2021, Tusting *et.al.,*., 2013). The lack of evidence on SES-related inequalities in prevalence of malaria prevalence in under-five children in Ghana prompted this study, which aims to assess the intertemporal socioeconomic inequalities in malaria prevalence between 2016 and 2019. This research aims to identify populations that are disproportionately affected by malaria based on their socioeconomic status. Additionally, it supports Ghana's efforts at achieving the Sustainable Development Goals (SDGs) by reducing inequalities (SDG 10) and combatting infectious diseases to decrease neonatal and child mortality (SDG 3, targets 3.2 and 3.3) by 2030. The findings will be instrumental in enhancing malaria surveillance and the implementation of targeted prevention measures.

3.3 Methods

3.3.1 Data source

The study used the Ghana Malaria Indicator Survey (GMIS) conducted in 2016 and 2019 for the analyses (Ghana Statistical Services, 2023a, DHS, 2019). The GMIS is all-inclusive data, it consists of national and regional levels as well as urban and rural area indicators in the survey. The GMIS main outcomes are to determine the utilization and ownership of mosquito bed nets, estimate malaria prevalence and anaemia in pregnant women and children aged 6-59 months and to provide vital malaria indicators to assist in policies and strategies for malaria control in the country (DHS, 2019). The survey employed the 2010 Population and Housing Census as a sampling framework. Before 2016, Ghana had ten administrative regions, six new regions were created in 2019. Nonetheless, this study focused exclusively on the original ten administrative regions (Ashanti, Central, Brong Ahafo, Western, Eastern, Upper East, Upper West, Volta, Greater Accra and Northern), as the geographic boundaries of the newly established regions were not defined at the time in the GMIS survey of 2016 and 2019 (DHS, 2019).

A sample size of 6,000 households were recorded in 2016 as well as 2019. The sampling process was stratified and executed in two stages. For both year periods, regions were divided according to rural and urban locations yielding to 20 stratums in the first stage. In the same period, Enumeration areas (EAs) which identify the geographical areas of households were selected from the 2o stratums. The second stage followed a selection of a fixed 30 households from the EAs to get a sample size of 6000 households. The survey included various types of information regarding malaria treatment, prevention, and prevalence. Specifically, information such as age of child and mother, sex, maternal education, regions, place of residence, household wealth, and the relationship of household members to the head of the household. Moreover, information on dwellings characteristics including building materials, toilet facilities, roofing, ownership, and coverage of Insecticide Treated Mosquito Nets (ITNs), Intermittent Preventive Treatment (IPT) and Indoor residual spraying and knowledge of malaria were collected using the household questionnaire, women's questionnaire, and biomarker questionnaire (Ghana Statistical Services, 2023a). All datasets were available publicly from the Demographic and Health Survey programme (DHS, 2019).

3.3.2 Study Population

Under-five children aged 6-59 months were chosen for the analysis, given that they are the most affected in Ghana. A total of 2,323 (2016) and 1,938 (2019) under-five children with exclusion of missing variables were included for the study.

Study Variables

Outcome Variable

The Ghana malaria Indicator Survey (GMIS) collects malaria results by rapid diagnostic tests (RDT) and by microscopy testing. For microscopy which is considered the gold standard by the Centre for Disease Control and Prevention (CDC), thick blood smear samples are taken and diagnosed in the laboratory by microscopists for the presence of *Plasmodium* parasites. Due to limited trained microscopists in the field, RDT is also conducted with blood samples taken and diagnosed by a standard packaged sample applicator (DHS, 2019, DHS, 2016). The outcome variable used, was a binary variable indicating whether a child is diagnosed with positive =1 or negative = 0 malaria results. Two variables (results of malaria blood tests and fever occurrence in the past two weeks) were combined to generate the outcome variable (Malaria prevalence). Fever occurrence in the past two weeks was used to replace missing malaria blood tests results). This conclusion was justified based on fever being a necessary component of malaria infection in children (Novignon and Nonvignon, 2012, Barros *et.al.,*., 2010, Aheto, 2022, Owoeye *et.al.,*., 2018). Again, in epidemiology the concept of incidence and prevalence are used interchangeably for disease statistics with each having distinct interpretations. Prevalence was chosen because of the data and time used in 2016 and 2019. Prevalence looks at new cases and existing cases as compared to incidence which only indicates the rate at which a disease is occurring overtime. Whilst prevalence indicates a snapshot of the population affected by the disease at a given time.

The outcome variable (Malaria prevalence) was generated based on these 3 questions.

- If fever occurrence is reported negative = 0 and malaria blood test result is not reported, then, the outcome variable (malaria prevalence) = 0 because, the absence of fever indicates no presence of malaria in child.
- If fever occurrence is reported positive = 1 and malaria blood test result is not reported, then, the observation of positive fever is dropped because, the presence of fever without diagnosis could mean other diseases (e.g. Anaemia).
- Outcome variable (malaria prevalence) is = 0 if malaria blood test result is negative and outcome variable is = 1 if malaria blood test result is positive.

Explanatory Variables

The explanatory variables were chosen given the background of the study as well as based on the similar variables found in other empirical review in literature (Babalola *et.al.,*., 2020, Koram

et.al.,., 1995, Okoli *et.al.,*., 2021, Sarfo *et.al.,*., 2023, Novignon and Nonvignon, 2012, Adum *et.al.,*., 2023, Aheto, 2019, Owoeye *et.al.,*., 2018). The Commission of social determinants of health framework (CSDH) developed by Solar and Irwin (2010) also served as a backbone to determine the choice of socioeconomic variables. Socioeconomic status (wealth index), Place of residence and mother's age, ethnicity, child's age, mother's education, National health insurance coverage for child are a select few of the explanatory variables. **Part C: Table 1** describes the variables and how they are labelled in detail.

Wealth Index description

Household wealth index was computed based on household's assts and possessions ranging from television, bicycles or automobiles, housing characteristics like ceilings and floorings (DHS, 2019). The GMIS survey used the principal component analysis (PCA) to grade households by allotting each with a score (DHS, 2019). By dividing the household's population into quintiles, each household is ranked from poorest to richest households based on their score (DHS, 2019).

Part C: Table 1: Description of study variables

Variables	**Description**
Outcome variable	
Malaria prevalence (binary variable)	Malaria variable was coded as 0 = Negative 1= positive results
Explanatory variables	
Socioeconomic status (wealth index) (categorical variable)	Household wealth grouped into quintiles. Coded as 0= poorest, 1= poorer, 2=middle, 3= richer, 4= richest
Ethnicity (categorical variable)	To which ethnicity group do you belong? Coded Akan =0, Ga/Dangme=1, Ewe=2, Guan=3, Mole-Dagbani=4, Grusi=5, Gurma=6, Mande=7
Age of child (categorical)	What is the child's age in months?

National Health Insurance Scheme coverage for child (NHIS) (binary variable)	Is the child currently covered by any health insurance? Coded 0= No yes = 1
Under-five sleeping in treated net in the previous night. (Categorical variable)	Did the child sleep under an insecticide net. Coded as 0 as No and 1 as yes
Ownership of household net (binary variable)	Does your household have any mosquito nets? Coded 0= No and 1= Yes
Maternal education (categorical variable)	What is the highest level of school you attended. Coded 0= no formal education, 1= primary education, 2= secondary education, 3= higher education
Mother's age (categorical)	How old were you at your last birthday?
Place of residence (binary variable)	What is your type of residence? Coded 0= rural 1= urban
Regions (categorical variable)	Region location. Coded 0= western, 1= central, 2= greater Accra, 3= volta, 4= eastern, 5= Ashanti, 6= Brong Ahafo, 7= northern, 8= upper east, 9= upper west

3.3.3 Data Analysis

Measuring socioeconomic (SES)-related inequality in malaria prevalence using the Concentration indices and curves

The concentration indices and curves were utilized to assess SES-related inequalities in malaria prevalence in under-five children, how the inequality changes between 2016 and 2019 and which SES population is vulnerable (Wagstaff, 2005, Kakwani *et.al.,*., 1997). Wealth index was used to measure socioeconomic status. SES-related inequalities in malaria prevalence in under-five children, were measured using the concentration curves (CC) and indices (CI). The CC and CI measures how inequalities in health prevails in one population and its change between years (Kakwani *et.al.,*., 1997, Wagstaff, 2005). The concentration curve plots the cumulative proportion

of malaria (y-axis) against the cumulative proportion of households, ranked by their socio-economic status beginning from the poorest to the richest household (x-axis) (Kakwani *et.al.,*., 1997). There is pro-poor (pro-rich) inequality when the curve lies above (below) the line of equality (45℃), implying that malaria is largely concentrated among the poorest (richest) (Wagstaff, 2005).

The concentration index (CI) for a health variable (i.e., malaria) is computed as twice the area between the concentration curve and line of equality (45℃). Ideally the CI falls within the boundaries of -1 and +1, with a negative and positive value indicating a disproportionate concentration of malaria in the poorest (pro-poor inequality) or richest (pro-rich inequality) population respectively. When the CI is 0, there is no presence of inequality, or the concentration curve lies on top of the 45℃ line (Wagstaff *et.al.,*., 2007). Mathematical expression of the CI is given as,

$$\text{CI} = \frac{2}{\mu}\, cov\,(Hi, Ri) \quad \ldots. (1)$$

Where, CI is the concentration index of the health variable, Hi, is the health vaariable, Ri is the fractional rank of the living standards distribution of individuals, *μ* is the mean of the health variable and *cov* is the covariance between the health variable and the fractional rank of living standards of individuals.

However, for a binary outcome variable (i.e., like malaria prevalence =1, 0= otherwise), the CI may not fall within the normal boundaries, but between the range (*μ* -1) and (1- *μ),* where μ is the mean of the health variable (malaria prevalence).Wagstaff (2005) and Erreygers (2009b) proposed the normalisation of the CI for binary health outcomes. However, recently, it has been shown that such normalization of the CI may give different results when applied to policy interpretation (Ataguba, 2022). The standard concentration index (non-normalized) was used for this study.

Decomposition of the concentration index of prevalence of malaria in under-five children

Decomposition analysis unveils the proportion of health inequalities that can be attributed to variations in selected socioeconomic variables (Wagstaff *et.al.,*., 2007). In our study, decomposition was used to explain inequality in malaria prevalence among children under-five years of age. The concentration index (CI_H) can be decomposed into multiple contributing factors to socioeconomic-related health disparities (Wagstaff *et.al.,*., 2007). The contribution of each explanatory variable (e.g., sex, age, etc) to malaria status inequality, was calculated as the

product of the sensitivity (elasticity) of malaria to the explanatory variable and the degree of socioeconomic status inequality in the explanatory variable.

A linear additive regression model of health outcome variable (y) (malaria status), against a set of K determinants, X_K (ownership of bed nets, maternal education, regions, place of residence, socioeconomic status, child's age, health insurance) can be expressed as follows,

$y = a + \sum_K \beta_K X_K + \varepsilon$ …...equation [2],

Where the concentration index CI_H for y (malaria status) is written as follows,

$CI_H = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu_H}\right) CI_k + \frac{GCI_\varepsilon}{\mu_H}$…. equation [3],

Where μ_H represents the mean of y, denoting malaria prevalence, CI_k signifies the concentration index associated with the x_k determinants and GCI_ε corresponds to the generalized concentration index for the residual term (ε). This error (residual) term captures wealth-related inequality not accounted for by systematic variations in determinants across different wealth groups, as outlined by Wagstaff *et.al.,*. (2007). For a well-defined model, it is expected that the residual term approaches zero (Wagstaff *et.al.,*., 2007).

The expression $\left(\frac{\beta_k \underline{x}_k}{\mu_H}\right)$, where the weights of x_k reflects the elasticity (n_k) of the outcome variable (malaria prevalence) with respect to changes in the determinants x_k.

Descriptive statistics was conducted to assess the demographic characteristics of study respondents for both years. All analysis and data management were conducted using the Stata software version 15 (Stata Corp, 2023). To estimate standard errors and ensure statistical accuracy for the decomposed concentration index, Efron and Tibshirani (1986) bootstrapping technique was employed with 1,000 replications.

3.4 Ethical Considerations

The DHS datasets are publicly accessible and available. Although, for good ethical conducts, ethical approval was sought from the Faculty of Health Sciences, Human Research Ethics Committee (HREC) at the University of Cape Town with reference number: *770/2023.*

3.5 Study Results

3.5.1 Socio-demographic characteristics of study population

A total of 2,323 and 1,998 under-five children, were tested for malaria in 2016 and 2019 respectively. The prevalence of malaria among the children increased from 8% in 2016 to 10% in 2019. 30.05% (2016) and 28.01% (2019) of the study population belonged to the poorest quintile whilst 15% (2016) and 14.81% (2019) were in the richest quintile. For both years, close to 70% of the participants resided in the rural areas. The percentage of mothers with no formal education decreased from 41% in 2016 to 34% in 2019. Northern region recorded the highest respondents 24.11% in 2016 and 21.42% in 2019 whilst Western region reported the least, 0.68% in 2016 to 0.91% in 2019. Among the ethnic groups, higher percentage of respondents were found in the Mole Dagbani's (39.35%) in 2016 and 53.84% in 2019. Children between 0-12 months were the highest participants, 23.13% in 2016 and 25.29% in 2019 (Table 2).

Part C: Table 2: Socio-demographic characteristics of study sample between 2016 and 2019

Variables characteristics	Headcount 2016 N=2,323 (%)	Headcount 2019 N=1,938 (%)
Malaria prevalence		
Positive	8.95	10.53
Negative	91.05	89.47
Socioeconomic status (wealth index)		
poorest	30.05	28.01
Poorer	22.39	23.89
Middle	17.51	17.87
Richer	15.06	15.42
Richest	15	14.81
Ethnicity		
Akan	23.23	20.28
Ga/Dangme	2.65	3.18

Ewe	7.81	8.26
Guan	4.66	2.98
Mole Dagbani	39.35	53.84
Grusi	7.3	5.71
Gurma	12.67	4.63
Mande	2.33	1.14
Maternal education		
No formal education	41.46	34.56
Primary	19.74	21.2
Secondary	33.24	38.95
Higher	5.56	5.29
Place of residence		
Rural	68.16	67.48
Urban	31.84	32.52
National health insurance scheme (Nhis) coverage of child		
Yes	69.67	64.51
No	30.33	35.49
Regions		
Western	0.68	0.91
Ashanti	10.32	10.23
Eastern	6.63	6.72
Central	1.85	2.37

Brong Ahafo	11.35	10.1
Northern	24.11	21.42
Volta	7.25	5.85
Greater Accra	4.01	3.98
Upper East	18.39	18.23
Upper West	15.41	20.18
Ownership of household insecticide net		
No	9.1	10.4
Yes	90.9	89.6
Under-five slept under insecticide net previous night		
Yes	68.86	71.68
No	31.14	28.32
Mother's age		
15-24yrs	20.89	21.45
25-34yrs	49.96	49.51
35-44yrs	26.56	26.67
45-49yrs	2.58	2.37
Child's age		
0-12 months	23.13	25.29
13-24 months	19.39	20.62
25-36 months	20.99	19.24
36-48 months	18.53	17.38
49-59 months	17.96	17.46

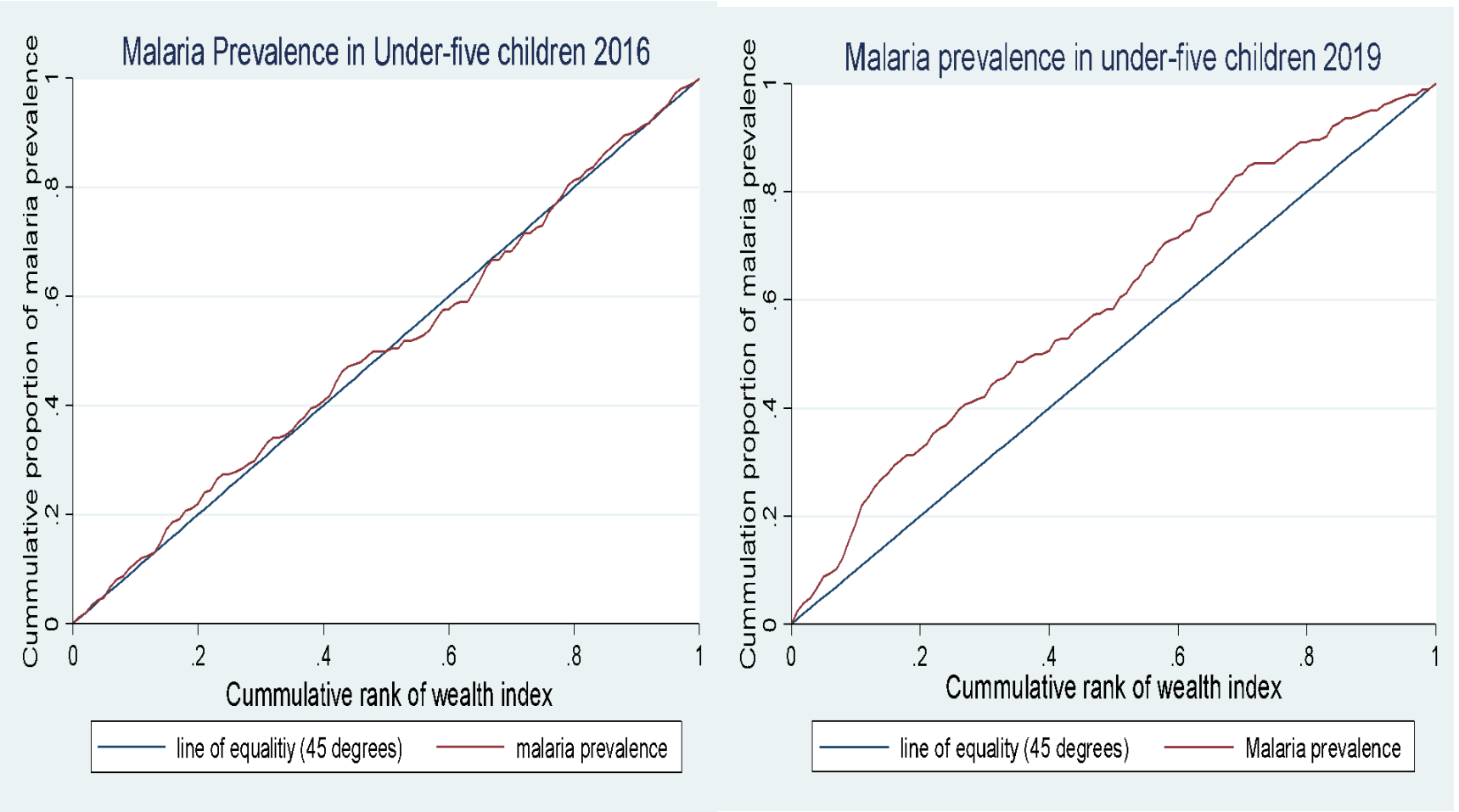
3.5.2 Concentration indices and curves

In 2016, the concentration curve crossed the line of equality, which did not show clear evidence of inequality. The concentration index for 2016 (Table 3) was also found to be negative (CI= -0.05, SE= 0.05), indicating an overall pro-poor inequality. However, this result was not statistically significant. In 2019, the concentration curve lies above the line of equality, indicating a pronounced concentration of malaria in the poorer population. In the same year, the concentration index (Table 3) was negative (CI= -0.22, SE=0.06) and 99% statistically significant indicating an overall pro-poor inequality. Thus, malaria is disproportionately prevalent among under-five children of low socioeconomic status. **Part C: Figure 1** gives a graph of concentration curves in 2016 and 2019.

Part C: Table 3: Concentration indices for prevalence of malaria in children under-five years in Ghana for 2016 and 2019

Year	Observations	Concentration Index	Standard Error	P-value
2016	2323	-0.05	0.05	0.32
2019	1938	-0.22	0.06	0.00***

*Note: *** significant at 99% confidence interval based on bootstrap standard errors with 1000 replications*



Part C: Figure 1: Diagram A and B, Concentration curves for prevalence of malaria in children under-five years in Ghana for 2016 and 2019

3.5.3 Factors explaining the socioeconomic inequalities in prevalence of malaria in children under-five years.

Part C: Table 4 illustrates the decomposition analysis, which gives the elasticities and concentration indices of the socioeconomic factors contributing to inequality in malaria prevalence in children under-five in 2019. Overall, socioeconomic status (wealth), region and ethnicity were statistically significant and largest contributors to inequality in malaria prevalence in 2019 with each contributed to 59.28%, 23.51% and 4.15% respectively of the overall inequality. Ownership of insecticide treated nets (ITNs), NHIS coverage of child, total contribution of mother's education, child's age and mother's age contributed to 0.80%, 1.56 %, 7.14%, -1.20% and 2.98% respectively. The unexplained factors captured in the residual contributed to the inequalities by 7.76%, however it was not statistically significant. The concentration index of malaria prevalence for 2016 was not decomposed because it was found to be not statistically significant.

Part C: Table 4: Decomposition of Concentration Index for Malaria Prevalence for Under-Five Children in Ghana,2019

Explanatory variables	Elasticities	Concentration indices	Contributions	Total contributions	Percentage of total contribution
Socioeconomic status (wealth)				**-0.1329**	**59.28%**
Poorest quintile (ref)					
Poorer quintile	-0.098*** (0.058)	-0.200* (0.023)	0.0197 (0.012)		
Middle quintile	-0.065 (0.045)	0.217* (0.021)	-0.0139 (0.009)		
Richer quintile	-0.075*** (0.041)	0.549* (0.017)	-0.0414*** (0.022)		
Richest quintile	-0.114* (0.041)	0.852* (0.008)	-0.0973* (0.035)		
Household net ownership	0.129 (0.194)	-0.014* (0.005)	-0.0018 (0.003)	**-0.0018**	**0.80%**
Under-five net use	-0.043 (0.126)	-0.094* (0.009)	0.0041 (0.012)	0.0041	-1.83%
National health insurance coverage	-0.084 (0.099)	0.041* (0.011)	-0.0035 (0.004)	**-0.0035**	**1.56%**
Residence				**0.0093**	**-4.15%**
Rural	-0.038 (0.113)	-0.243* (0.011)	0.0093 (0.028)		

Urban (ref)					
Education				**-0.016**	**7.14%**
Maternal primary education	0.018 (0.049)	-0.099* (0.028)	-0.0019 (0.005)		
Maternal secondary education	-0.093 (0.077)	0.218* (0.018)	-0.0203 (0.017)		
Maternal higher education	0.008 (0.015)	0.739* (0.032)	0.0062 (0.011)		
No formal education (ref)					
Ethnicity				**-0.0093**	**4.15%**
Ga/Dangme	-0.002 (0.009)	0.485* (0.057)	-0.0008 (0.004)		
Ewe	-0.018 (0.021)	0.346* (0.033)	-0.0063 (0.007)		
Guan	-0.023** (0.009)	0.078 (0.061)	-0.0018 (0.002)		
Mole Dagbani	0.001 (0.133)	-0.219* (0.013)	-0.0002 (0.029)		
Grusi	-0.039**(0.017)	-0.185* (0.055)	0.0072***(0.004)		
Gurma	0.034 (0.021)	-0.194* (0.055)	-0.0066 (0.005)		
Mande	-0.012* (0.004)	0.066 (0.179)	-0.0008 (0.002)		
Akan (ref)					
Regions				**-0.0527**	**23.51%**
Central	-0.013 (0.008)	0.346* (0.034)	-0.0045 (0.003)		
Greater Accra	-0.041* (0.013)	0.782* (0.017)	-0.0319* (0.010)		
Volta	-0.030 (0.025)	0.171* (0.038)	-0.0052 (0.004)		
Eastern	-0.059** (0.023)	0.393* (0.034)	-0.0234** (0.009)		
Ashanti	-0.095* (0.033)	0.552* (0.026)	-0.0525* (0.018)		
Brong Ahafo	-0.077** (0.038)	0.148* (0.033)	-0.0114*** (0.006)		
Northern	-0.189** (0.080)	-0.097* (0.026)	0.0184*** (0.009)		

Upper East	- 0.008 (0.075)	-0.385* (0.032)	0.0031 (0.028)		
Upper West	-0.185** (0.083)	-0.295* (0.028)	0.0547** (0.025)		
Western (ref)					
Age of Child				**0.0027**	**-1.20%**
0-12 months (ref)					
13-24 months	0.163* (0.040)	0.003 (0.028)	0.0004 (0.004)		
25-36 months	0.156* (0.039)	0.037 (0.030)	0.0057 (0.005)		
36-48 months	0.064*** (0.034)	-0.025 (0.031)	-0.0016 (0.002)		
49-59 months	0.051 (0.031)	-0.035 (0.033)	-0.0018 (0.002)		
Age of Mother				**-0.0067**	**2.98%**
15-24 yrs. (ref)					
25-34 yrs	-0.048 (0.087)	0.068* (0.015)	-0.0032 (0.006)		
35-44 yrs	-0.028 (0.055)	-0.033 (0.026)	0.0009 (0.002)		
45-49yrs	0.019 (0.015)	-0.226** (0.091)	-0.0044 (0.005)		
Residual			-0.0174 (0.014)	**-0.0174**	**7.76%**
Total				**-0.2242**	**100%**

Note: estimated sample was 1938; standard errors in parenthesis boostraped using 1000 replications.

p<0.1 *** p<0.05**; p<0.01* indicate the statistical significance

3.6 Discussion

This study examined socioeconomic (SES)-related inequalities in the prevalence of malaria in Ghana in children under-five years in 2016 and 2019. Overall, results of the study indicated pro-poor inequalities in the prevalence of malaria in under-five children. We found that prevalence of malaria in under-five years children in Ghana during 2019 exhibited a pro-poor inequality. This was in agreement with findings from a multi-country analysis in 30 endemic sub-Saharan African (SSA) countries with Ghana included by Galactionova *et.al.,*. (2017). The study showed that malaria is disproportionately prevalent in the socioeconomically disadvantaged under-five children in a trend analysis from 2003 to 2016. This was also the case in a research conducted by Barros *et.al.,*. (2010) in low- and middle-income countries (LMIC). The study found poor people in endemic regions at risk of increased malaria infection than the better-off. From the observation of previous studies and per the findings from our study, there are repetitive patterns of malaria prevalence being pro-poor in endemic regions. These inequalities could be explained by reasons due to poor knowledge to use the preventive interventions (e.g. insecticides nets), household wealth, region, and maternal education. Again, housing units and locations that are characterised by slums and breeding units of mosquitoes increases the risk of the poor developing malaria infection frequently (Barros *et.al.,*., 2010, Tusting *et.al.,*., 2015).

In the decomposition analysis, that we conducted, factors that contributed largely to the pro-poor inequalities observed in 2019 were socioeconomic status (wealth), maternal education, ethnicity, regions, and rural residence. These findings are not different from Edwin *et.al.,*. (2021) in Nigeria and Njau *et.al.,*. (2014) in three SSA countries. Regional differences, maternal education, household wealth and rural residence were established in these studies explaining the gaps of inequalities in malaria infection faced by disadvantaged populations. Wealth index contributed largely to the inequalities. For instance, Njau *et.al.,*. (2014) study's in Angola, Tanzania and Uganda, found household wealth contributing to 26% of the childhood malaria inequalities between educated and uneducated mothers. In the same vein, place of stay in these countries contributed to 21% of the inequalities (Njau *et.al.,*., 2014). Moreover, a study by Edwin *et.al.,*. (2021) in Nigeria found household wealth explaining 68% of under-five malaria infection inequalities with respect to maternal education. The inequalities gap was explained by 6% of region of mothers with under-five children (Edwin *et.al.,*., 2021). Socioeconomically, mothers are better positioned to provide accommodation and clothing to reduce child's exposure to the malaria parasite. These factors form the basis of the social determinants of health and are vital in the reducing health inequalities and outcomes (Ataguba *et.al.,*., 2015).

In our findings, rural areas contributed to the inequalities observed. In agreement with Pond (2013) and Afoakwah *et.al.,*. (2018) findings, compared to urban settlements, rural locations are characterized by unfavourable environments that breeds mosquitos. For instance, Afoakwah *et.al.,*. (2018) in Ghana, found that vector transmission and malaria prevalence in under-five children in urban cities was twice as low than in rural areas. A similar study in Tanzania by Edwin (2018) also indicated that, the number of malaria cases in rural areas were higher than in urban locations. Again, the differences of housing materials between rural areas and urban cities could also be a potential factor influencing socioeconomic inequalities in malaria prevalence in endemic areas (Tusting *et.al.,*., 2015). Higher socioeconomic status individuals are likely to afford building materials that inhibits mosquito breading and promote vector control. From the Tusting *et.al.,*. (2015) study, findings indicated higher odds of malaria parasitaemia in houses with thatch and mud walls, which is mostly characterised in the rural settings compared to houses with screened windows, cements, and fitted ceilings,

Ethnicity in Ghana is mostly associated with place of stay and region. This study findings agreed with Kreuels *et.al.,*. (2008) studies, that found differences of malaria risks in children with northern and southern ethnicities in Ghana. The northern region is characterised by the Grusis and Mole Dagbanis ethnic groups whilst, the southern regions are characterised by the Akans and Ga/Dangmes (Ghana statistical Services, 2023b). It is important to note that, the southern regions are more developed than the northern regions in terms of road infrastructure, economic activities, health and educational infrastructure (Ghana statistical Services, 2023b). Moreover, per a 2015 report by the Ghana statistical service, the northern region which is susceptible to droughts and floods, recorded the highest fertility and illiteracy rate among women (Ghana statistical Services, 2023b). This likely denotes that, households in these ethnic groups in the north, lack the educative and malaria preventive measures to protect their children from contracting the disease. Another study from Bangladesh also found that vector distribution and the prevalence of malaria increased in ethnic tribes that stayed in places characterised by extensive rainfall and forest density compared to populations with less forest density (Haque *et.al.,*., 2011). Additionally, with regards to region, Nyarko and Cobblah (2014) in Ghana found significant relationships of malaria infections in under-five children and regional location. The Ashanti, Central, Volta, Upper East and West regions had higher odds of reporting malaria cases than the Greater Accra and Western regions. In a spatial analysis of measuring climatic influence on malaria prevalence in Ghana by Adu-Prah and Tetteh (2015) and Aheto (2022), regions that were experiencing high rainfall and high humidity had a positive association with malaria prevalence and incidence.

Maternal education was the third highest contributor to the observed inequalities in malaria prevalence in children in this study. Already, mother's educational background is established to be significantly associated with childhood malaria infection in endemic regions (Edwin *et.al.,*., 2021) (Siri, 2014). The work of Siri (2014) in nine SSA countries found that, the odds of malaria prevalence in children is likely to be low with mothers who at least, have had six years of schooling. In Ghana, Afoakwah *et.al.,*. (2018) and Sarkodie (2021) also found lower rates of malaria infection in children whose mothers had at least a secondary education. Education is therefore an important lever to support the quest and ongoing activities in controlling malaria and ultimately eradicating it. In the 2015 report by the Ghana statistical services, the Northern region recorded the highest illiteracy rate among women (Ghana statistical Services, 2023b). In the same vein, the Northern region reported the highest respondents of under-five children for both years in this study. This highlights the importance of properly educating mothers in these high-risk settings how to use malaria interventions (i.e insecticide mosquito nets). This could be done through frequent community engagement by the health facilities or local health ministries. Again, mothers could be educated on the importance of family planning to reduce unwanted pregnancies. This allows mothers to effectively take care of their children, economically and health wise.

With regards to socioeconomic status (wealth index), our study found it to be the largest contributor to the observed inequalities in malaria prevalence in children under-five years. In Afoakwah *et.al.,*. (2018) study in Ghana, malaria in children below five years were likely to be low in richer households, compared to poorer households. In other context, Siri (2014) and Edwin *et.al.,*. (2021) in Nigeria found similar findings, where malaria prevalence in children under-five years were relatively low in richer households compared to poorer households. These reasons could be attributed to richer households being able to afford basic healthcare needs and provision of conducive environments (eg. Housing, indoor residual spraying, protective clothing) for their children. This should inform works on malaria surveillance programmes when considering the distribution of malaria interventions in the country. Vulnerable populations should be of priority first.

This paper contributed to the growing body of literature by offering policy relevant insights as to the nature and magnitude of socioeconomic inequalities in prevalence of malaria in under-five children in Ghana. It also supports two of the sustainable development goals of promoting health and wellbeing, SDG 3 and reduction of all forms of inequalities, SDG 10. The study employed the recent available datasets of the Ghana Malaria indicator surveys, which gives a good

representation of the present information of malaria indicators and evidence. These datasets are also context specific to Ghana providing a nationally representattive results and specific recommendations for policies. It is also one of the few papers to examine the socioeconomic inequalities in malaria prevalence using the concentration index and decomposition methodological approach to identify factors contributing to the disease. The methodology provided a clear understanding of which specific socio-economic factors are triggering the inequalities identified in the study.

Conversely, this study was not without limitations . One of the challenges was operationalizing the outcome variable. Both datasets from 2016 and 2019 had inadequate information on results of malaria parasitaemia by microscopy testing. This challenge was addressed by generating a proxy outcome variable from fever occurrence in the past two weeks and results of malaria blood tests by rapid diagnostic tests. Additionally, most responses from the GMIS are self-reported (i.e., wealth, fever occurance in the past two weeks) and this may have inadvertantly caused recall bias. Again, the use of wealth index as a measure of socio-economic status was as results of available data in the dataset. Although, maternal education and household income could also be used as a measure for socio-economic status but these indicators are limiting in use because of inadequate and incomplete information when assessed in surveys. Considering that the variables that were used to assess socioeconomic status limited to household wealth and the fact that some of the information can be affected by recall bias. There is some degree of limitation in attempt to generalise the study findings given that our study is secondary and made use of the available sample size.This notwithstanding, the study is still useful to serve as guide for a more detailed and elaborate future primary research.

3.7 Conclusion and Recommendations

Our research found trends of pro-poor inequalities in malaria prevalence in under-five children, highlighting the significant role played by socioeconomic status, maternal education, regional disparities, and rural residency. These findings align with the objectives of Ghana's malaria strategic plan (2021-2025), which is targeting a zero-malaria incidence and in the same vein aligns with the broader commitment to achieving SDG 3 by 2030. While progress has been made through the deployment of malaria vaccines and the distribution of insecticide-treated nets (Ghana Health Service, 2023), there remains a crucial need to integrate these health initiatives with social policies that address the underlying socioeconomic determinants of malaria prevalence.

To bridge the inequality gap, it is imperative to tailor malaria control efforts to the needs of high-risk and underserved populations. This approach should harmonize epidemiological control

measures with sustainable social and developmental policies. For instance, enhancing malaria education and awareness, particularly in high-risk areas such as the North and Savannah regions, is essential. Furthermore, the improvement of water, sanitation, and housing conditions using quality materials in rural areas could significantly mitigate the risk of malaria transmission (WHO, 2022).

Specifically, this study proposes the following recommendations:

1. Developmental initiatives should focus on the infrastructural advancement of rural and remote areas identified as high-risk zones to reduce the socioeconomic disparities in malaria prevalence. This will have a beneficial ripple effect across various demographic groups, beyond just under-five children.
2. Expanding the coverage of the National Health Insurance Scheme will ensure broader access to malaria prevention and treatment services, particularly for those in lower socioeconomic strata.
3. Intensify educational campaigns on malaria, especially targeting mothers in regions with high prevalence rates. Enhanced knowledge and awareness are critical in promoting the effective use of malaria interventions and the timely recognition of symptoms in children, thus averting potential fatalities.
4. Malaria control and eradication programs must be selectively directed towards populations that not only exhibit a higher risk but also possess the most significant need for these interventions.

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3.10 Ethical approval

Ethical approval was granted from the University of Cape Town, Human Research Ethics Committee (HREC). (Reference no: 770/2023)

3.11 Competing Interests

None declared.

3.12 Data Availabiltiy

Data is available upon request at the Demographic and health survey website.https://dhsprogram.com/data/dataset_admin/login_main.cfm?CFID=56262097&CFTOKEN=6937ffa0db78b551-7AA1FD16-9B2C-99D2-E5A2C5FAB09B71C8

3.13 Author's contribution

M.Y.E compiled the study, wrote the paper, analysed results, reviewed the paper and submitted it for publication, A.O and O.A reviewed the paper and assisted in the analysis.

3.14 References

ABELES, J. & CONWAY, D. J. 2020. The Gini coefficient as a useful measure of malaria inequality among populations. *Malaria journal,* 19**,** 1-8.

ABOAGYE-ATTAH, K. 2019. *Socioeconomic correlates of poverty in Ghana using Ghana Living Standards Survey round 6 and 7.* Norwegian University of Life Sciences, Ås.

ADLER, N. E. & OSTROVE, J. M. 1999. Socioeconomic status and health: what we know and what we don't. *Annals of the New York academy of Sciences,* 896**,** 3-15.

ADU-PRAH, S. & TETTEH, E. K. 2015. Spatiotemporal analysis of climate variability impacts on malaria prevalence in Ghana. *Applied Geography,* 60**,** 266-273.

ADUM, P., AGYARE, V. A., OWUSU-MARFO, J. & AGYEMAN, Y. N. 2023. Knowledge, attitude and practices of malaria preventive measures among mothers with children under five years in a rural setting of Ghana. *Malaria Journal,* 22**,** 1-12.

AFOAKWAH, C., DENG, X. & ONUR, I. 2018. Malaria infection among children under-five: the use of large-scale interventions in Ghana. *BMC public health,* 18**,** 1-13.

AHETO, J. M. K. 2019. Predictive model and determinants of under-five child mortality: evidence from the 2014 Ghana demographic and health survey. *BMC public health,* 19**,** 1-10.

AHETO, J. M. K. 2022. Mapping under-five child malaria risk that accounts for environmental and climatic factors to aid malaria preventive and control efforts in Ghana: Bayesian geospatial and interactive web-based mapping methods. *Malaria Journal,* 21**,** 384.

AKOMBI, B. J., AGHO, K. E., RENZAHO, A. M., HALL, J. J. & MEROM, D. R. 2019. Trends in socioeconomic inequalities in child undernutrition: Evidence from Nigeria Demographic and Health Survey (2003–2013). *PloS one,* 14**,** e0211883.

ALAWODE, A., UTHMAN, O. A. & YAHAYA, I. 2012. Socio-economic inequity in accessing malaria control interventions in Nigeria: analysis of changes between 2003 and 2008. *Malaria Journal,* 11**,** 1-2.

ANDRADE, M. V., NORONHA, K., DINIZ, B. P., GUEDES, G., CARVALHO, L. R., SILVA, V. A., CALAZANS, J. A., SANTOS, A. S., SILVA, D. N. & CASTRO, M. C. 2022. The economic burden of malaria: a systematic review. *Malaria journal,* 21**,** 283.

ANJORIN, S., OKOLIE, E. & YAYA, S. 2023. Malaria profile and socioeconomic predictors among under-five children: an analysis of 11 sub-Saharan African countries. *Malaria Journal,* 22**,** 1-11.

ARCAYA, M. C., ARCAYA, A. L. & SUBRAMANIAN, S. V. 2015. Inequalities in health: definitions, concepts, and theories. *Global health action,* 8**,** 27106.

ASUMING OPOKU PATRICK *ET.AL.,* 2020. Preliminary findings: Health Systems Strengthening. Ghana Priorities: Maternal and Child Health. Available here

https://copenhagenconsensus.com/publication/ghana-priorities-maternal-and-child-health.
ATAGUBA, J. E.-O., DAY, C. & MCINTYRE, D. 2015. Explaining the role of the social determinants of health on health inequality in South Africa. *Global health action,* 8**,** 28865.
ATAGUBA, J. E. 2022. A short note revisiting the concentration index: Does the normalization of the concentration index matter? *Health Economics,* 31**,** 1506-1512.
ATAGUBA, J. E., AKAZILI, J. & MCINTYRE, D. 2011. Socioeconomic-related health inequality in South Africa: evidence from General Household Surveys. *International journal for equity in health,* 10**,** 1-10.
ATAGUBA, J. E., OJO, K. O. & ICHOKU, H. E. 2016. Explaining socio-economic inequalities in immunization coverage in Nigeria. *Health policy and planning,* 31**,** 1212-1224.
AWINE, T., MALM, K., BART-PLANGE, C. & SILAL, S. P. 2017. Towards malaria control and elimination in Ghana: challenges and decision making tools to guide planning. *Global health action,* 10**,** 1381471.
AWUAH, R. B., ASANTE, P. Y., SAKYI, L., BINEY, A. A., KUSHITOR, M. K., AGYEI, F. & DE-GRAFT AIKINS, A. 2018. Factors associated with treatment-seeking for malaria in urban poor communities in Accra, Ghana. *Malaria journal,* 17**,** 1-8.
AYANORE, M. A., PAVLOVA, M., KUGBEY, N., FUSHEINI, A., TETTEH, J., AYANORE, A. A., AKAZILI, J., ADONGO, P. B. & GROOT, W. 2019. Health insurance coverage, type of payment for health insurance, and reasons for not being insured under the National Health Insurance Scheme in Ghana. *Health economics review,* 9**,** 1-15.
BABALOLA, O. J., AJUMOBI, O. & AJAYI, I. O. 2020. Rural–urban disparities and factors associated with delayed care-seeking and testing for malaria before medication use by mothers of under-five children, Igabi LGA, Kaduna Nigeria. *Malaria journal,* 19**,** 1-11.
BARROS, F. C., VICTORA, C. G., SCHERPBIER, R. & GWATKIN, D. 2010. Socioeconomic inequities in the health and nutrition of children in low/middle income countries. *Revista de Saúde Pública,* 44**,** 1-16.
BRAVEMAN, P. & GRUSKIN, S. 2003. Defining equity in health. *Journal of Epidemiology & Community Health,* 57**,** 254-258.
BRAVEMAN, P., KRIEGER, N. & LYNCH, J. 2000. Health inequalities and social inequalities in health. *Bulletin of the World Health Organization,* 78**,** 232-235.
BRONFENBRENNER, U. 1979. *The ecology of human development: Experiments by nature and design*, Harvard university press.
CARPENTIER, C. L., KOZUL-WRIGHT, R. & PASSOS, F. D. 2014. Goal 10-why addressing inequality matters. *UN Chronicle,* 51.
CARRASCO-ESCOBAR, G., FORNACE, K. & BENMARHNIA, T. 2021. Mapping socioeconomic inequalities in malaria in Sub-Sahara African countries. *Scientific Reports,* 11**,** 15121.
CASTILLO-RIQUELME, M., MCINTYRE, D. & BARNES, K. 2008. Household burden of malaria in South Africa and Mozambique: is there a catastrophic impact? *Tropical medicine & international health,* 13**,** 108-122.
CDC 2022. Malaria programme. Available onhttps://www.cdc.gov/malaria/resources/pdf/fsp/cdc_malaria_program_2023b.pdf.
CLOUSTON, S. A., YUKICH, J. & ANGLEWICZ, P. 2015. Social inequalities in malaria knowledge, prevention and prevalence among children under 5 years old and women aged 15–49 in Madagascar. *Malaria journal,* 14**,** 1-10.
COLEMAN, N. A. 2022. Rethinking district-level governance of malaria in Ghana: A narrative review. *PLOS Global Public Health,* 2**,** e0000764.
CORNA, L. M. 2013. A life course perspective on socioeconomic inequalities in health: A critical review of conceptual frameworks. *Advances in life course research,* 18**,** 150-159.
CUTLER, D. M., LLERAS-MUNEY, A. & VOGL, T. 2008. Socioeconomic status and health: dimensions and mechanisms.

DALABA, M. A., WELAGA, P., ODURO, A., DANCHAKA, L. L. & MATSUBARA, C. 2018. Cost of malaria treatment and health seeking behaviour of children under-five years in the Upper West Region of Ghana. *PLoS One,* 13**,** e0195533.

DE CASTRO, M. C. & FISHER, M. G. 2012. Is malaria illness among young children a cause or a consequence of low socioeconomic status? Evidence from the United Republic of Tanzania. *Malaria Journal,* 11**,** 1-12.

DEGAREGE, A., FENNIE, K., DEGAREGE, D., CHENNUPATI, S. & MADHIVANAN, P. 2019. Improving socioeconomic status may reduce the burden of malaria in sub Saharan Africa: A systematic review and meta-analysis. *PloS one,* 14**,** e0211205.

DESAI, M., TER KUILE, F. O., NOSTEN, F., MCGREADY, R., ASAMOA, K., BRABIN, B. & NEWMAN, R. D. 2007. Epidemiology and burden of malaria in pregnancy. *The Lancet infectious diseases,* 7**,** 93-104.

DHS 2016. Demographic and health survey. Available here: https://dhsprogram.com/pubs/pdf/MIS26/MIS26.pdf.

DHS 2019. Demographic and health survey (DHS), Ghana Malaria report.

DIEMA, K. K., DODAM, K. K., AARAH-BAPUAH, M. & ASIBI, A. J. 2017. Barriers to sustained use of the insecticide treated bed net in the upper east region of Ghana. *Int J Community Med Public Health,* 4**,** 500-5.

DONKOR, E., KELLY, M., ELIASON, C., AMOTOH, C., GRAY, D. J., CLEMENTS, A. C. & WANGDI, K. 2021. A Bayesian spatio-temporal analysis of malaria in the Greater Accra Region of Ghana from 2015 to 2019. *International journal of environmental research and public health,* 18**,** 6080.

DOORSLAER, E. V., KOOLMAN, X. & JONES, A. M. 2004. Explaining income-related inequalities in doctor utilisation in Europe. *Health economics,* 13**,** 629-647.

EDWIN, O. A., BEDEMI, Y. O., FELIX, A. R. & OLUSHOLA, K. Y. 2021. An Extension of Blinder-Oaxaca Decomposition on Investigating the Correlation of Maternal Education and Childhood Malaria Infection in Nigeria. *International Journal of Innovative Research and Development,* 10.

EDWIN, P. 2018. Prevalence and socio-demographic factors associated with malaria infection among children under five years in Tanzania. *Journal of Public Health and Epidemiology,* 10**,** 387-394.

EFRON, B. & TIBSHIRANI, R. 1986. Bootstrap methods for standard errors, confidence intervals, and other measures of statistical accuracy. *Statistical science***,** 54-75.

ELDER JR, G. H. 1998. The life course as developmental theory. *Child development,* 69**,** 1-12.

EMADI, M., DELAVARI, S. & BAYATI, M. 2021. Global socioeconomic inequality in the burden of communicable and non-communicable diseases and injuries: an analysis on global burden of disease study 2019. *BMC public health,* 21**,** 1-13.

ERHUN, W., AGBANI, E. & ADESANYA, S. 2005. Malaria prevention: knowledge, attitude and practice in a Southwestern Nigerian community. *African Journal of Biomedical Research,* 8**,** 25-29.

ERREYGERS, G. 2009a. Correcting the concentration index. *Journal of health economics,* 28**,** 504-515.

ERREYGERS, G. 2009b. Correcting the concentration index: a reply to Wagstaff. *Journal of Health Economics,* 28**,** 521-524.

GAKIDOU, E. E., MURRAY, C. J. & FRENK, J. 2000. Defining and measuring health inequality: an approach based on the distribution of health expectancy. *Bulletin of the world health organization,* 78**,** 42-54.

GALACTIONOVA, K., SMITH, T. A., DE SAVIGNY, D. & PENNY, M. A. 2017. State of inequality in malaria intervention coverage in sub-Saharan African countries. *BMC medicine,* 15**,** 1-11.

GALLUP, J. L. & SACHS, J. D. 2000. The economic burden of malaria. *CID Working Paper Series*.

GE, Y., LIANG, D., CAO, J., GOSLING, R., MUSHI, V. & HUANG, J. 2023. How socioeconomic status affected the access to health facilities and malaria diagnosis in children under five years: findings from 19 sub-Saharan African countries. *Infectious Diseases of Poverty,* 12**,** 1-10.

GHANA HEALTH SERVICE 2023. National Malaria Elimination Programme. Available here: https://ghs.gov.gh/national-malaria-elimination-program-nmep/.

GHANA STATISTICAL SERVICES 2023a. Ghana Demographic and Health Survey Key Indicators. Available here, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/World%20Malaria%20Day%20Press%20Release%20from%20GSS.pdf.

GHANA STATISTICAL SERVICES 2023b. Ghana factSheet. Available here; https://statsghana.gov.gh/ghfactsheet.php

GRAY, A. M. 1982. Inequalities in health. The Black Report: a summary and comment. *International Journal of Health Services,* 12**,** 349-380.

HAAKENSTAD, A., HARLE, A. C., TSAKALOS, G., MICAH, A. E., TAO, T., ANJOMSHOA, M., COHEN, J., FULLMAN, N., HAY, S. I. & MESTROVIC, T. 2019. Tracking spending on malaria by source in 106 countries, 2000–16: an economic modelling study. *The Lancet infectious diseases,* 19**,** 703-716.

HABERMANN, T. 2022. *Behavioural and socio-economic risk factors and pathways associated with malaria in children in Ghana: A mediation analysis.* Hochschule für Angewandte Wissenschaften Hamburg.

HAILESELASSIE, W., ADAM, R., HABTEMICHAEL, M., DAVID, R. E., SOLOMON, N., WORKINEH, S., HAIDER, J., BELACHEW, A., DERESSA, W. & YAN, G. 2023. Socio-demographic and economic inequity in the use of insecticide-treated bed nets during pregnancy: a survey-based case study of four sub-Saharan African countries with a high burden of malaria. *Archives of Public Health,* 81**,** 64.

HAILU, A., LINDTJØRN, B., DERESSA, W., GARI, T., LOHA, E. & ROBBERSTAD, B. 2016. Equity in long-lasting insecticidal nets and indoor residual spraying for malaria prevention in a rural South Central Ethiopia. *Malaria journal,* 15**,** 1-11.

HAQUE, U., SOARES MAGALHÃES, R. J., MITRA, D., KOLIVRAS, K. N., SCHMIDT, W.-P., HAQUE, R. & GLASS, G. E. 2011. The role of age, ethnicity and environmental factors in modulating malaria risk in Rajasthali, Bangladesh. *Malaria Journal,* 10**,** 1-7.

HARPER, S. & LYNCH, J. 2006. Measuring health inequalities. *Methods in social epidemiology,* 1**,** 134.

IRWIN, A., VALENTINE, N., BROWN, C., LOEWENSON, R., SOLAR, O., BROWN, H., KOLLER, T. & VEGA, J. 2006. The commission on social determinants of health: tackling the social roots of health inequities. *PLoS medicine,* 3**,** e106.

KAKWANI, N., WAGSTAFF, A. & VAN DOORSLAER, E. 1997. Socioeconomic inequalities in health: measurement, computation, and statistical inference. *Journal of econometrics,* 77**,** 87-103.

KAWACHI, I., SUBRAMANIAN, S. V. & ALMEIDA-FILHO, N. 2002. A glossary for health inequalities. *Journal of Epidemiology & Community Health,* 56**,** 647-652.

KILANOWSKI, J. F. 2017. Breadth of the socio-ecological model. *Journal of agromedicine,* 22**,** 295-297.

KIMBI, H. K., NKESA, S. B., NDAMUKONG-NYANGA, J. L., SUMBELE, I. U., ATASHILI, J. & ATANGA, M. 2014. Knowledge and perceptions towards malaria prevention among vulnerable groups in the Buea Health District, Cameroon. *BMC Public Health,* 14**,** 1-9.

KORAM, K., BENNETT, S., ADIAMAH, J. & GREENWOOD, B. 1995. Socio-economic risk factors for malaria in a peri-urban area of The Gambia. *Transactions of the royal society of tropical medicine and hygiene,* 89**,** 146-150.

KREFIS, A. C., SCHWARZ, N. G., NKRUMAH, B., ACQUAH, S., LOAG, W., SARPONG, N., ADU-SARKODIE, Y., RANFT, U. & MAY, J. 2010. Principal component analysis of socioeconomic factors and their association with malaria in children from the Ashanti Region, Ghana. *Malaria Journal,* 9**,** 1-7.

KREUELS, B., KOBBE, R., ADJEI, S., KREUZBERG, C., VON REDEN, C., BÄTER, K., KLUG, S., BUSCH, W., ADJEI, O. & MAY, J. 2008. Spatial variation of malaria incidence in young children from a geographically homogeneous area with high endemicity. *The Journal of infectious diseases,* 197**,** 85-93.

KRIEGER, N., ROWLEY, D. L., HERMAN, A. A., AVERY, B. & PHILLIPS, M. T. 1993. Racism, sexism, and social class: implications for studies of health, disease, and well-being. *American journal of preventive medicine,* 9**,** 82-122.

KUNST, A. E. & MACKENBACH, J. P. 1990. Measuring socioeconomic inequalities in health. *Measuring socioeconomic inequalities in health.*

LAHELMA, E., MARTIKAINEN, P., LAAKSONEN, M. & AITTOMÄKI, A. 2004. Pathways between socioeconomic determinants of health. *Journal of Epidemiology & Community Health,* 58**,** 327-332.

LUKWA, A. T., ATTA-OBENG, C., KASEKE, T. W., AGGREY, S. & ALABA, O. 2020. Malaria finance, household mosquito net ownership & use, intermittent preventive treatment in pregnancy (IPTp) in Ghana; a socioeconomic comparative analysis.

MACKENBACH, J. P. & HOWDEN-CHAPMAN, P. 2003. New perspectives on socioeconomic inequalities in health. *Perspectives in biology and medicine,* 46**,** 428-444.

MACKENBACH, J. P. & KUNST, A. E. 1997. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. *Social science & medicine,* 44**,** 757-771.

MACKENBACH, J. P., KUNST, A. E., CAVELAARS, A. E., GROENHOF, F. & GEURTS, J. J. 1997. Socioeconomic inequalities in morbidity and mortality in western Europe. *The lancet,* 349**,** 1655-1659.

MARMOT, M. & WILKINSON, R. 2005. *Social determinants of health*, Oup Oxford.

MCCARTNEY, G., COLLINS, C. & MACKENZIE, M. 2013. What (or who) causes health inequalities: theories, evidence and implications? *Health Policy,* 113**,** 221-227.

MINISTRY OF HEALTH 2007. Under five's child health policy :2007-2015.

MOREL, C. M., THANG, N. D., XA, N. X., HUNG, L. X., THUAN, L. K., VAN KY, P., ERHART, A., MILLS, A. J. & D'ALESSANDRO, U. 2008. The economic burden of malaria on the household in south-central Vietnam. *Malaria Journal,* 7**,** 1-7.

NANKINDU, S. 2022. *Determinants of inequity in undernutrition, anemia and malaria in children under five (5) years in Uganda.* Makerere University.

NAWA, M., HANGOMA, P., MORSE, A. P. & MICHELO, C. 2019. Investigating the upsurge of malaria prevalence in Zambia between 2010 and 2015: a decomposition of determinants. *Malaria journal,* 18**,** 1-10.

NHIS, G. N. H. I. S. 2023. The National Health Insurance Scheme. Available here https://www.nhis.gov.gh/about, .

NJAU, J. D., STEPHENSON, R., MENON, M. P., KACHUR, S. P. & MCFARLAND, D. A. 2014. Investigating the important correlates of maternal education and childhood malaria infections. *The American journal of tropical medicine and hygiene,* 91**,** 509.

NKEGBE, P. K., KUUNIBE, N. & SEKYI, S. 2017. Poverty and malaria morbidity in the Jirapa District of Ghana: A count regression approach. *Cogent Economics & Finance,* 5**,** 1293472.

NONVIGNON, J., ARYEETEY, G. C., MALM, K. L., AGYEMANG, S. A., AUBYN, V. N., PEPRAH, N. Y., BART-PLANGE, C. N. & AIKINS, M. 2016. Economic burden of malaria on businesses in Ghana: a case for private sector investment in malaria control. *Malaria journal,* 15**,** 1-10.

NOVIGNON, J., ARYEETEY, G., NONVIGNON, J., MALM, K., PEPRAH, N. Y., AGYEMANG, S. A., AMON, S. & AIKINS, M. 2023. Efficiency of malaria service delivery in selected district-level hospitals in Ghana. *Health Systems,* 12**,** 198-207.

NOVIGNON, J. & NONVIGNON, J. 2012. Socioeconomic status and the prevalence of fever in children under age five: evidence from four sub-Saharan African countries. *BMC research notes,* 5**,** 1-7.

NYAABA, G. N., OLALEYE, A. O., OBIYAN, M. O., WALKER, O. & ANUMBA, D. O. 2021. A socio-ecological approach to understanding the factors influencing the uptake of intermittent preventive treatment of malaria in pregnancy (IPTp) in South-Western Nigeria. *PLoS One,* 16**,** e0248412.

NYARKO, S. H. & COBBLAH, A. 2014. Sociodemographic determinants of malaria among under-five children in Ghana. *Malaria research and treatment,* 2014.

OBASOHAN, P. E., WALTERS, S. J., JACQUES, R. & KHATAB, K. 2021. A scoping review of selected studies on predictor variables associated with the malaria status among children under five years in sub-Saharan Africa. *International Journal of Environmental Research and Public Health,* 18**,** 2119.

OKOLI, C. I., HAJIZADEH, M., RAHMAN, M. M. & KHANAM, R. 2021. Decomposition of socioeconomic inequalities in the uptake of intermittent preventive treatment of malaria in pregnancy in Nigeria: evidence from Demographic Health Survey. *Malaria Journal,* 20**,** 300.

OWOEYE, D. O., AKINYEMI, J. O. & YUSUF, O. B. 2018. Decomposition of changes in malaria prevalence amongst under-five children in Nigeria. *MalariaWorld Journal,* 9.

PATOUILLARD, E., GRIFFIN, J., BHATT, S., GHANI, A. & CIBULSKIS, R. 2017. Global investment targets for malaria control and elimination between 2016 and 2030. *BMJ global health,* 2**,** e000176.

PHELAN, J. C., LINK, B. G. & TEHRANIFAR, P. 2010. Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *Journal of health and social behavior,* 51**,** S28-S40.

PHIRI, J. & ATAGUBA, J. E. 2014. Inequalities in public health care delivery in Zambia. *International journal for equity in health,* 13**,** 1-9.

PICKETT, K. E. & WILKINSON, R. G. 2007. Child wellbeing and income inequality in rich societies: ecological cross sectional study. *Bmj,* 335**,** 1080.

PMI, U. S. P. S. M. I. 2022. Ghana malaria profile. Available here: https://www.pmi.gov/?s=ghana+malaria+profile.

POND, B. S. 2013. Malaria indicator surveys demonstrate a markedly lower prevalence of malaria in large cities of sub-Saharan Africa. *Malaria journal,* 12**,** 1-12.

POPHAM, F., DIBBEN, C. & BAMBRA, C. 2013. Are health inequalities really not the smallest in the Nordic welfare states? A comparison of mortality inequality in 37 countries. *J Epidemiol Community Health,* 67**,** 412-418.

RAPHAEL, D. 2006. The social determinants of health: what are the three key roles for health promotion?-editorial. *Health promotion journal of Australia: official journal of Australian Association of Health Promotion Professionals,* 17.

REGIDOR, E. 2004a. Measures of health inequalities: part 1. *Journal of epidemiology and community health,* 58**,** 858.

REGIDOR, E. 2004b. Measures of health inequalities: part 2. *Journal of epidemiology and community health,* 58**,** 900.

SARFO, J. O., AMOADU, M., KORDORWU, P. Y., ADAMS, A. K., GYAN, T. B., OSMAN, A.-G., ASIEDU, I. & ANSAH, E. W. 2023. Malaria amongst children under five in sub-Saharan Africa: a scoping review of prevalence, risk factors and preventive interventions. *European Journal of Medical Research,* 28**,** 80.

SARKODIE, A. O. 2021. Factors influencing under-five mortality in rural-urban Ghana: An applied survival analysis. *Social Science & Medicine,* 284**,** 114185.
SEVERE MALARIA OBSERVATORY 2023. Ghana. Facts on Malaria. Available : https://www.severemalaria.org/countries/ghana#:~:text=Malaria%20is%20endemic%20and%20perennial,which%20there%20is%20little%20transmission.
SINGH, G. K. & SIAHPUSH, M. 2006. Widening socioeconomic inequalities in US life expectancy, 1980–2000. *International journal of epidemiology,* 35**,** 969-979.
SIRI, J. G. 2014. Independent associations of maternal education and household wealth with malaria risk in children. *Ecology and Society,* 19.
SITTHIYOT, T. & HOLASUT, K. 2020. A simple method for measuring inequality. *Palgrave Communications,* 6**,** 1-9.
SMITH, G. D., BARTLEY, M. & BLANE, D. 1990. The Black report on socioeconomic inequalities in health 10 years on. *BMJ: British Medical Journal,* 301**,** 373.
SOLAR, O. & IRWIN, A. 2010. A conceptual framework for action on the social determinants of health. WHO Document Production Services.
SONKO, S. T., JAITEH, M., JAFALI, J., JARJU, L., D'ALESSANDRO, U., CAMARA, A., KOMMA-BAH, M. & SAHO, A. 2014. Does socio-economic status explain the differentials in malaria parasite prevalence? Evidence from The Gambia. *Malaria Journal,* 13**,** 1-12.
STATA CORP, T., UNITED STATES 2023.
TAWIAH, T., ASANTE, K. P., DWOMMOH, R. A., KWARTENG, A., GYAASE, S., MAHAMA, E., ABOKYI, L., AMENGA-ETEGO, S., HANSEN, K. & AKWEONGO, P. 2016. Economic costs of fever to households in the middle belt of Ghana. *Malaria journal,* 15**,** 1-8.
TUSTING, L. S., IPPOLITO, M. M., WILLEY, B. A., KLEINSCHMIDT, I., DORSEY, G., GOSLING, R. D. & LINDSAY, S. W. 2015. The evidence for improving housing to reduce malaria: a systematic review and meta-analysis. *Malaria journal,* 14**,** 1-12.
TUSTING, L. S., REK, J. C., ARINAITWE, E., STAEDKE, S. G., KAMYA, M. R., BOTTOMLEY, C., JOHNSTON, D., LINES, J., DORSEY, G. & LINDSAY, S. W. 2016. Measuring socioeconomic inequalities in relation to malaria risk: a comparison of metrics in rural Uganda. *The American journal of tropical medicine and hygiene,* 94**,** 650.
TUSTING, L. S., WILLEY, B., LUCAS, H., THOMPSON, J., KAFY, H. T., SMITH, R. & LINDSAY, S. W. 2013. Socioeconomic development as an intervention against malaria: a systematic review and meta-analysis. *The Lancet,* 382**,** 963-972.
TUTEJA, R. 2007. Malaria− an overview. *The FEBS journal,* 274**,** 4670-4679.
UN 2018. Reduced Inequalities: Why it matters| Sustainable Development. Available here: file:///C:/Users/Marian%20Edusei/OneDrive/Documents/malaria%20proposal/ethics/10_Why-It-Matters-2020.pdf.
UN 2020. Rising inequality affecting more than two-thirds of the globe, but it's not inevitable: new UN report. Available here: https://news.un.org/en/story/2020/01/1055681#:~:text=Inequality%20is%20growing%20for%20more,by%20the%20UN%20on%20Tuesday.
UN 2023. Sustainable Development Goals | Reducing Inequalities| Goal 10. Available here: https://www.un.org/sustainabledevelopment/inequality/.
UNICEF 2023. Malaria in Africa. Available online :https://data.unicef.org/topic/child-health/malaria/
WAGSTAFF, A. 2005. The bounds of the concentration index when the variable of interest is binary, with an application to immunization inequality. *Health economics,* 14**,** 429-432.
WAGSTAFF, A., O'DONNELL, O., VAN DOORSLAER, E. & LINDELOW, M. 2007. *Analyzing health equity using household survey data: a guide to techniques and their implementation*, World Bank Publications.
WAGSTAFF, A., PACI, P. & VAN DOORSLAER, E. 1991. On the measurement of inequalities in health. *Social science & medicine,* 33**,** 545-557.

WERE, V., BUFF, A. M., DESAI, M., KARIUKI, S., SAMUELS, A., TER KUILE, F. O., PHILLIPS-HOWARD, P. A., PATRICK KACHUR, S. & NIESSEN, L. 2018. Socioeconomic health inequality in malaria indicators in rural western Kenya: evidence from a household malaria survey on burden and care-seeking behaviour. *Malaria journal,* 17**,** 1-10.
WHO 2022. world malaria report https://www.who.int/publications/i/item/9789240064898.
WHO 2023a. Social determinants of health. Available here: https://www.who.int/health-topics/social-determinants-of-health#tab=tab_3.
WHO, W. H. O. 2023b. Sustainable development goals, themes. Available here https://www.who.int/data/gho/data/themes/sustainable-development-goals.
WORLD BANK 2023. Facts and figures of malaria. available here https://data.worldbank.org/indicator/SH.MLR.INCD.P3.
WORLD MEDICAL ASSOCIATION 2013. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *Jama,* 310**,** 2191-2194.
ZERE, E., KIRIGIA, J. M., DUALE, S. & AKAZILI, J. 2012. Inequities in maternal and child health outcomes and interventions in Ghana. *BMC public health,* 12**,** 1-10.

PART D: Policy Brief

Socioeconomic inequalities in malaria prevalence in children under-five in Ghana: A policy brief.

Key messages

- Malaria is prevalent among under-five children with poorer backgrounds.
- The top three socioeconomic status related factors that contributed to inequality in malaria prevalence in 2019 are socioeconomic status (wealth) by 59%, region by 23% and maternal education by 7%.
- Eliminating wealth inequality and inequality in mother's education will reduce inequality in malaria prevalence by 7%.
- Vector control programmes that prioritized high risk areas can contribute to reducing inequalities in malaria prevalence.
- Overall reduction of inequalities in malaria prevalence can only be achieved through intersectoral collaboration between the health and other government institutions as well as civil societies and non-governmental organizations.

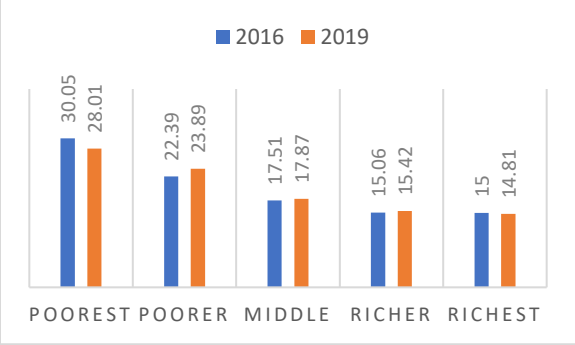
Existing socioeconomic inequalities in malaria prevalence

Globally, under-five children and pregnant women are the most vulnerable population that are affected by malaria. As of 2021, 95% of all malaria cases were centred in Africa and sub-Saharan African (SSA) countries with an alarming figure of 234 million people at risk, 80% of which are under-five children. In Ghana, under-five children are still severely impacted by malaria which is endemic across the country.

Environmental, climatic, and socio-economic factors (i.e., household wealth, education) influence the prevalence of malaria in endemic countries, and the effect of its burden is so devastating on the vulnerable and disadvantaged populations.

The detrimental effect of this disease affects individuals' economic productivity to work, child's cognitive development, morbidities, mortalities, and risk of pushing households into poverty due to catastrophic expenditure. Ghana has made a significant stride to eradicate malaria by the year 2030 as it saw a decline in malaria mortality from 3% in 2019 to 2% in 2021. This reduction was made possible through strategies like the implementation of the Ghana malaria strategic plan (2021-2025), National Malaria Elimination Programme (NMEP), child health policy, and the National Health Insurance Scheme (NHIS). However, the prevalence of malaria is varying with regards to its association with socio-economic status (SES) factors and related inequalities. Existing studies have shown positive associations and inequalities with regards to parental education and knowledge on malaria, household wealth, region, rural and urban locations with regards to malaria prevalence in children. While these studies provide information, an understanding of socioeconomic status (SES)-related inequalities in malaria prevalence in under-five children in Ghana is needed as well as factors contributing to these inequalities. ***Part D: Figure 1*** below indicates the distribution of under-five children from 2016 to 2019, according to socioeconomic status.

Part D: Figure 1: Distribution of under-five children according to socioeconomic status



Source; Author's compilation

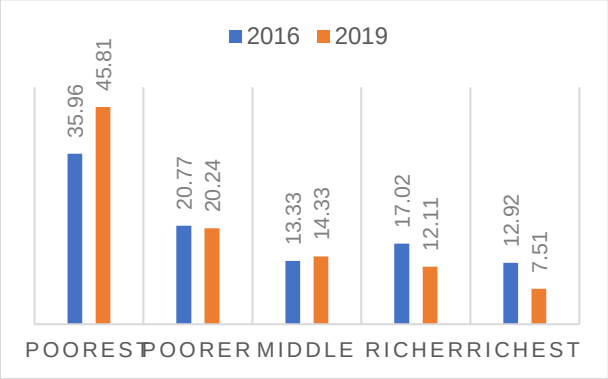
Objective of study and methodological approach

This study examined the SES-related inequalities as well as factors that contributed to the inequalities of malaria prevalence in under-five children in Ghana. The Ghana malaria indicator survey for 2016 and 2019 were utilised, as those were the current data available. Socioeconomic variables including maternal education, household wealth, place of residence, ownership of insecticide treated nets were the variables chosen for explaining inequality, given its context.

What is the evidence?

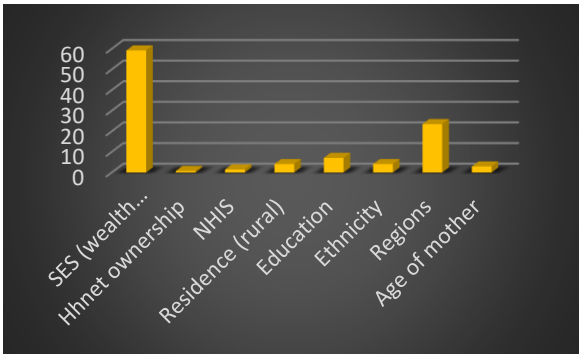
In 2016 there was no evidence of significant inequality in malaria prevalence. However, SES-related inequalities in malaria prevalence in under-five children in 2019 was concentrated in the poorer populations indicating a pro-poor inequality, meaning the poorer population bear a bigger share of the disease.

Part D: Figure 2: Malaria prevalence in under-five children according to socioeconomic status in 2016 and 2019.



Source: Author's compilation

Part D: Figure 3: Socioeconomic factors contributing to malaria prevalence inequalities in under-five children, 2019



Source: Author's compilation

SES (wealth), region, maternal education, and ethnicity were the most important contributing factors to the established socioeconomic inequalities in malaria prevalence in under-five children.

What does the evidence say?

While these findings are consistent with other studies in different countries, malaria infection inequality under-five children is likely to be influenced by maternal knowledge on the disease and the care seeking behaviour of the parents. Likewise, regional developments and resources also influence the prevalence of the disease. From the study, the rate of malaria prevalence in Greater Accra and Ashanti region were 5 times less than rates in Upper East and West region. This could be attributed to, the former regions being developed, households are exposed to clean water, good roads infrastructure, proximity to health facilities and climatic differences. Socioeconomic status is also a crucial indicator for malaria prevalence to persist, high income households are likely to invest in their health and seek healthcare early compared to low-income households.

Recommendations

Socioeconomic inequalities affect our health and development. Therefore, as Ghana's health reforms are implemented towards the achievement of the Universal Health Coverage (UHC), and other social development strategies are rolled out, there should be.

- Targeted health interventions for populations which are at higher risk of malaria. This could be in the form of distributing malaria prevention interventions in the rural and deprived regions.
- Formal education should be prioritised among women especially in regions with high illiteracy rates. Again, there should be more education and awareness of malaria control programmes and interventions among mothers and how to effectively use them in the households.
- Malaria elimination programmes should target regions that are overly affected by climatic conditions like heavy rainfalls and high temperatures when rolling out interventions.

4 PART E: APPENDICES

Part E: Appendix 1: Plagiarism Declaration

Plagiarism Declaration

1) I know that plagiarism is wrong. Plagiarism is to use another's work and pretend it is one's own.

2) I have used the Havard style for referencing in the research protocol, literature review and journal manuscript. Each quotation in this thesis from the work(s) of other people has been attributed and has been cited and referenced.

3) This dissertation is my own work. I have not allowed and will not allow anyone to copy my work with the intention of passing it off as his/her own work.

Signature:

Name: Marian Yaa Abrafi Edusei

Student number: EDSMAR003

Date: 10th February,2024

Part E: Appendix 2: Ethical clearance and Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee
Room 45 E-52-E-Floor- Old Main Building
Groote Schuur
Hospital
Observatory
7925
Telephone [021] 406 6492
Email: hrec-submissions@uct.ac.za
Website: www.health.uct.ac.za/home/human-research-ethics

04 December 2023

HREC REF: 770/2023

Dr A Obse
Health Economics Unit
Public Health & Family Medicine
Email: ag.obse@uct.ac.za
Student:Edsmar003@myuct.ac.za

Dear Dr Obse

PROJECT TITLE: SOCIO-ECONOMIC INEQUALITIES IN MALARIA PREVALENCE AMONG UNDER-FIVE CHILDREN IN GHANA BETWEEN 2016 AND 2019-(MASTERS' CANDIDATE-MISS MARIAN YAA ABRAFI EDUSEI)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

We apologise for the very long delay.

It is a pleasure to inform you that the HREC has formally approved the above-mentioned study.

Approval is granted for one year until the 30 December 2024.

Please submit a progress form, using the standardised Annual Report Form (FHS016) or FHS017 if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za fhs research human ethics/forms)

The HREC acknowledge that the student: Miss Marian Yaa Abrafi Edusei will also be involved in this study.

Please quote HREC REF 770/2023 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator must obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely,

PROFESSOR M
CHAIRPERSON
RESEARCH

BLO '(MAN
FACULTY OF HEALTH SCIENCES HUMAN
ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637. Institutional Review Board (IRB) number: IRB00001938 NHREC-registration number: REC-210208-007HREC/ref 770.2023

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisatjon of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DOH 2020), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/1CH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC/ref 770.2023

Part E: Appendix 3: International Journal for Health Equity (proposed guidelines for authors)

Guidelines for submission

The information below details the section headings that you should include in your manuscript and what information should be within each section.

Please note that your manuscript must include a 'Declarations' section including all of the subheadings (please see below for more information).

1. **Title page**

The title page should:

- present a title that includes, if appropriate, the study design e.g.:
    - "A versus B in the treatment of C: a randomized controlled trial", "X is a risk factor for Y: a case control study", "What is the impact of factor X on subject Y: A systematic review"
    - or for non-clinical or non-research studies a description of what the article reports
- list the full names and institutional addresses for all authors
    - if a collaboration group should be listed as an author, please list the Group name as an author. If you would like the names of the individual members of the Group to be searchable through their individual PubMed records, please include this information in the “Acknowledgements” section in accordance with the instructions below
    - Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Notably an attribution of authorship carries with it accountability for the work, which cannot be effectively applied to LLMs. Use of an LLM should be properly documented in the Methods section (and if a Methods section is not available, in a suitable alternative part) of the manuscript.
- indicate the corresponding author.

2. **Abstract**

The Abstract should not exceed 350 words. Please minimize the use of abbreviations and do not cite references in the abstract. Reports of randomized controlled trials should follow the CONSORT extension for abstracts. The abstract must include the following separate sections:

- Background: the context and purpose of the study
- Methods: how the study was performed and statistical tests used
- Results: the main findings
- Conclusions: brief summary and potential implications

- Trial registration: If your article reports the results of a health care intervention on human participants, it must be registered in an appropriate registry and the registration number and date of registration should be stated in this section. If it was not registered prospectively (before enrollment of the first participant), you should include the words 'retrospectively registered'. See our editorial policies for more information on trial registration

3. Keywords

Three to ten keywords representing the main content of the article.

4. Background

The Background section should explain the background to the study, its aims, a summary of the existing literature and why this study was necessary or its contribution to the field.

Methods

The methods section should include:

- the aim, design and setting of the study
- the characteristics of participants or description of materials
- a clear description of all processes, interventions and comparisons. Generic drug names should generally be used. When proprietary brands are used in research, include the brand names in parentheses
- the type of statistical analysis used, including a power calculation if appropriate

5. Results

This should include the findings of the study including, if appropriate, results of statistical analysis which must be included either in the text or as tables and figures.

6. Discussion

This section should discuss the implications of the findings in context of existing research and highlight limitations of the study.

7. Conclusions

This should state clearly the main conclusions and provide an explanation of the importance and relevance of the study reported.

List of abbreviations

If abbreviations are used in the text they should be defined in the text at first use, and a list of abbreviations should be provided.

8. Declarations

All manuscripts must contain the following sections under the heading 'Declarations':

- Ethics approval and consent to participate

- Consent for publication
- Availability of data and materials
- Competing interests
- Funding
- Authors' contributions
- Acknowledgements
- Authors' information (optional)

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All manuscripts must include an ‘Availability of data and materials’ statement. Data availability statements should include information on where data supporting the results reported in the article can be found including, where applicable, hyperlinks to publicly archived datasets analysed or generated during the study. By data we mean the minimal dataset that would be necessary to interpret, replicate and build upon the findings reported in the article. We recognise it is not always possible to share research data publicly, for instance when individual privacy could be compromised, and in such instances data availability should still be stated in the manuscript along with any conditions for access.

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- The datasets generated and/or analysed during the current study are not publicly available due [REASON WHY DATA ARE NOT PUBLIC] but are available from the corresponding author on reasonable request.
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Hao Z, AghaKouchak A, Nakhjiri N, Farahmand A. Global integrated drought monitoring and prediction system (GIDMaPS) data sets. figshare. 2014. http://dx.doi.org/10.6084/m9.figshare.853801

With the corresponding text in the Availability of data and materials statement:

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Always use footnotes instead of endnotes.

Part E: Appendix 4: Demographic and health survey questionnaires for 2016 and 2019

FORMATTING DATE: 14 Mar 2016

ENGLISH LANGUAGE:

23 Oct 2014 MALARIA INDICATOR SURVEY

MODEL BIOMARKER QUESTIONNAIRE

[NAME OF COUNTRY]

[NAME OF ORGANIZATION]

IDENTIFICATION (1)				
PLACE NAME NAME OF HOUSEHOLD HEAD **Part E: Appendix 4; Demographic and health survey questionnaires for 2016 and 2019** CLUSTER NUMBER. . . . . . HOUSEHOLD NUMBER.				
FIELDWORKER VISITS				
	1	2	3	FINAL VISIT
DATE FIELDWORKER'S NAME				DAY MONTH YEAR
NEXT VISIT: DATE TIME				TOTAL NUMBER OF VISITS

NOTES:

TOTAL ELIGIBLE CHILDREN

LANGUAGE QUESTIONNAIRE**(YES = 1, NO = 2) **0 1**

LANGUAGE OF INTERVIEW**

NATIVE LANGUAGE OF RESPONDENT**

OFTRANSLATOR

LANGUAGE OF QUESTIONNAIRE** **ENGLISH**

**LANGUAGE CODES:

01 ENGLISH 03 LANGUAGE 3 05 LANGUAGE 5
02 LANGUAGE 2 04 LANGUAGE 4 06 LANGUAGE 6

SUPERVISOR	FIELD EDITOR	OFFICE EDITOR	KEYED BY
NAME NUMBER	NAME NUMBER	NUMBER	NUMBER

Note: Brackets [ ] indicate items that should be adapted on a country-specific basis.

BIO-1

101	CHECK COLUMN 9 IN HOUSEHOLD QUESTIONNAIRE. RECORD THE LINE NUMBER AND NAME FOR ALL ELIGIBLE CHILDREN 0-5 YEARS IN QUESTION 102; IF MORE THAN SIX CHILDREN, USE ADDITIONAL QUESTIONNAIRE(S).			
		CHILD 1	CHILD 2	CHILD 3

102	CHECK HOUSEHOLD QUESTIONNAIRE: LINE NUMBER FROM COLUMN 9.	LINE NUMBER . . . . . NAME _____	LINE NUMBER . . . . . NAME _____	LINE NUMBER . . . . . NAME _____
103	IF MOTHER INTERVIEWED: COPY CHILD'S DATE OF BIRTH (DAY, MONTH, AND YEAR) FROM BIRTH HISTORY. IF MOTHER NOT INTERVIEWED ASK: What is (NAME)'s date of birth?	DAY . . . . . MONTH . . . . . YEAR . . .	DAY . . . . . MONTH . . . . . YEAR . . .	DAY . . . . . MONTH . . . . . YEAR . . .
104 (2)	CHECK 103: CHILD BORN IN 20102015?	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)
105	CHECK 103: CHILD AGE 0-5 MONTHS, I.E., WAS CHILD BORN IN MONTH OF INTERVIEW OR 5 PREVIOUS MONTHS?	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2
106	LINE NUMBER OF PARENT/OTHER ADULT RESPONSIBLE FOR THE CHILD FROM COLUMN 1 OF HOUSEHOLD SCHEDULE.	LINE NUMBER . . . . . (RECORD '00' IF NOT LISTED)	LINE NUMBER . . . . . (RECORD '00' IF NOT LISTED)	LINE NUMBER . . . . . (RECORD '00' IF NOT LISTED)
107 (2)	ASK CONSENT FOR ANEMIA TEST FROM PARENT/OTHER ADULT.	As part of this survey, we are asking children all over the country to take an anemia test. Anemia is a serious health problem that usually results from poor nutrition, infection, or chronic disease. This survey will assist the government to develop programs to prevent and treat anemia. We ask that all children born in 2010 or later take part in anemia testing in this survey and give a few drops of blood from a finger or heel. The equipment used to take the blood is clean and completely safe. It has never been used before and will be thrown away after each test. The blood will be tested for anemia immediately, and the result will be told to you right away. The result will be kept strictly confidential and will not be shared with anyone other than members of our survey team. Do you have any questions? You can say yes or no. It is up to you to decide. Will you allow (NAME OF CHILD) to participate in the anemia test?		
108	CIRCLE THE CODE AND SIGN YOUR NAME.	GRANTED . . . . . 1 (SIGN) _____ REFUSED . . . . . 2 NOT PRESENT/OTHER . 3	GRANTED . . . . . 1 (SIGN) _____ REFUSED . . . . . 2 NOT PRESENT/OTHER . 3	GRANTED . . . . . 1 (SIGN) _____ REFUSED . . . . . 2 NOT PRESENT/OTHER . 3

109 (2)	ASK CONSENT FOR MALARIA TEST FROM PARENT/OTHER ADULT.	As part of this survey, we are asking children all over the country to take a test to see if they have malaria. Malaria is a serious illness caused by a parasite transmitted by a mosquito bite. This survey will assist the government to develop programs to prevent malaria. We ask that all children born in 2010 or later take part in malaria testing in this survey and give a few drops of blood from a finger or heel. One blood drop will be tested for malaria immediately, and the result will be told to you right away. A few blood drops will be collected on slide(s) and taken to a laboratory for testing. You will not be told the results of the laboratory testing. All results will be kept strictly confidential and will not be shared with anyone other than members of our survey team. Do you have any questions? You can say yes or no. It is up to you to decide. Will you allow (NAME OF CHILD) to participate in the malaria test?		
110	CIRCLE THE CODE, SIGN YOUR NAME, AND ENTER YOUR FIELDWORKER NUMBER.	GRANTED . . . . 1 REFUSED . . . . 2 ____________ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) [ ][ ][ ][ ] NOT PRESENT/OTHER . 3	GRANTED . . . . 1 REFUSED . . . . 2 ____________ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) [ ][ ][ ][ ] NOT PRESENT/OTHER . 3	GRANTED . . . . 1 REFUSED . . . . 2 ____________ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) [ ][ ][ ][ ] NOT PRESENT/OTHER . 3
111	PREPARE EQUIPMENT AND SUPPLIES ONLY FOR THE TEST(S) FOR WHICH CONSENT HAS BEEN OBTAINED AND PROCEED WITH THE TEST(S).			
112 (3)	PLACE BAR CODE LABEL FOR MALARIA LAB TEST.	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT . . . 99994 REFUSED . . . . 99995 OTHER . . . . 99996 PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT . . . 99994 REFUSED . . . . 99995 OTHER . . . . 99996 PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT . . . 99994 REFUSED . . . . 99995 OTHER . . . . 99996 PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.
113	RECORD HEMOGLOBIN LEVEL HERE AND IN THE ANEMIA AND MALARIA PAMPHLET.	G/DL . . . . [ ][ ] . [ ] NOT PRESENT . . . . 994 REFUSED . . . . 995 OTHER 996	G/DL . . . . [ ][ ] . [ ] NOT PRESENT . . . . 994 REFUSED . . . . 995 OTHER 996	G/DL . . . . [ ][ ] . [ ] NOT PRESENT . . . . 994 REFUSED . . . . 995 OTHER 996

114	CIRCLE THE CODE FOR THE MALARIA RDT.	TESTED . . . . . 1 NOT PRESENT . . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)	TESTED . . . . . 1 NOT PRESENT . . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)	TESTED . . . . . 1 NOT PRESENT . . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)
115	RECORD THE RESULT OF THE MALARIA RDT HERE AND IN THE ANEMIA AND MALARIA PAMPHLET.	POSITIVE 1 (SKIP TO 118) NEGATIVE . . . . . 2 OTHER 6	POSITIVE 1 (SKIP TO 118) NEGATIVE . . . . . 2 OTHER 6	POSITIVE 1 (SKIP TO 118) NEGATIVE . . . . . 2 OTHER 6

116	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)
117	**SEVERE ANEMIA REFERRAL** RECORD THE RESULT OF THE ANEMIA TEST ON THE REFERRAL FORM.	The anemia test shows that (NAME OF CHILD) has severe anemia. Your child is very ill and must be taken to a health facility immediately. (SKIP TO 130)		
118 (4)	Does (NAME) suffer from any of the following illnesses or symptoms: a) Extreme weakness? b) Heart problems? c) Loss of consciousness? d) Rapid or difficult breathing? e) Seizures? f) Abnormal bleeding? g) Jaundice or yellow skin? h) Dark urine?	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2
119	CHECK 118: ANY 'YES' CIRCLED?	NO YES (SKIP TO 122)	NO YES (SKIP TO 122)	NO YES (SKIP TO 122)
120	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6
121 (5)	In the past two weeks has (NAME) taken or is taking [FIRST LINE MEDICATION] given by a doctor or health center to treat the malaria? VERIFY BY ASKING TO SEE TREATMENT	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)

122	**SEVERE MALARIA REFERRAL** RECORD THE RESULT OF THE MALARIA RDT ON THE REFERRAL FORM.	The malaria test shows that (NAME OF CHILD) has malaria. Your child also has symptoms of severe malaria. The malaria treatment I have will not help your child, and I cannot give you the medication. Your child is very ill and must be taked to a health facility right away. (SKIP TO 128)

123 (5)	ALREADY TAKING [FIRST LINE MEDICATION] REFERRAL STATEMENT	You have told me that (NAME OF CHILD) had already received [FIRST LINE OF MEDICATION] for malaria. Therefore, I cannot give you additional [FIRST LINE OF MEDICATION]. However, the test shows that he/she has malaria. If your child has a fever for two days after the last dose of [FIRST LINE MEDICATION], you should take the child to the nearest health facility for further examination. (SKIP TO 130)		
124 (2)	READ INFORMATION FOR MALARIA TREATMENT AND CONSENT STATEMENT TO PARENT/OTHER	The malaria test shows that your child has malaria. We can give you free medicine. The medicine is called [FIRST LINE OF MEDICATION]. [FIRST LINE OF MEDICATION] is very effective and in a few days it should get rid of the fever and other symptoms. You do not have to give the child the medicine. This is up to you. Please tell me whether you accept the medicine or not.		
125	CIRCLE THE APPROPRIATE CODE AND SIGN YOUR NAME.	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6
126	CHECK 125: MEDICATION ACCEPTED	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)
127 (5)	READ INFORMATION FOR MALARIA TREATMENT AND CONSENT STATEMENT TO PARENT/OTHER ADULT.	[INSERT DOSAGE INSTRUCTI ONS] , is ALSO TELL THE PARENT/OTH ER ADULT: If [NAME] has a ets high f ever, fast or difficult breathing not able to drink or breastfeed, g sicker or does not get bet or er in two days, you should take him/her to a health professional f treatment right away. (SKIP TO 130)		
128	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6 (SKIP TO 130)
129	**SEVERE ANEMIA REFERRAL** RECORD THE RESULT OF THE ANEMIA TEST ON THE REFERRAL FORM.	The anemia test shows that (NAME OF CHILD) has severe anemia. Your child is very ill and must be taken to a health facility immediately.		
130	GO BACK TO 103 IN NEXT COLUMN OF THIS QUESTIONNAIRE OR IN THE FIRST COLUMN OF THE NEXT PAGE; IF NO MORE CHILDREN, END INTERVIEW.			

101	CHECK COLUMN 9 IN HOUSEHOLD QUESTIONNAIRE. RECORD THE LINE NUMBER AND NAME FOR ALL ELIGIBLE CHILDREN 0-5 YEARS IN QUESTION 102; IF MORE THAN SIX CHILDREN, USE ADDITIONAL QUESTIONNAIRE(S).			
		CHILD 4	CHILD 5	CHILD 6

102	CHECK HOUSEHOLD QUESTIONNAIRE: LINE NUMBER FROM COLUMN 9.	LINE NUMBER . . . . . ☐☐ . NAME _____	LINE NUMBER . . . . . ☐☐ . NAME _____	LINE NUMBER . . . . . ☐☐ . NAME _____
103	IF MOTHER INTERVIEWED: COPY CHILD'S DATE OF BIRTH (DAY, MONTH, AND YEAR) FROM BIRTH HISTORY. IF MOTHER NOT INTERVIEWED ASK: What is (NAME)'s date of birth?	DAY . . . . . ☐☐ . . . . . ☐☐ MONTH ☐☐ YEAR . . .	DAY . . . . . ☐☐ . . . . . ☐☐ MONTH ☐☐ YEAR . . .	DAY . . . . . ☐☐ . . . . . ☐☐ MONTH ☐☐ YEAR . . .
104 (2)	CHECK 103: CHILD BORN IN 20102015?	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)	YES . . . . . 1 NO . . . . . 2 (SKIP TO 130)
105	CHECK 103: CHILD AGE 0-5 MONTHS, I.E., WAS CHILD BORN IN MONTH OF INTERVIEW OR 5 PREVIOUS MONTHS?	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2	0-5 MONTHS . . . . . 1 (SKIP TO 130) OLDER 2
106	LINE NUMBER OF PARENT/OTHER ADULT RESPONSIBLE FOR THE CHILD FROM COLUMN 1 OF HOUSEHOLD SCHEDULE.	LINE NUMBER . . . . . ☐☐ . (RECORD '00' IF NOT LISTED)	LINE NUMBER . . . . . ☐☐ . (RECORD '00' IF NOT LISTED)	LINE NUMBER . . . . . ☐☐ . (RECORD '00' IF NOT LISTED)
107 (2)	ASK CONSENT FOR ANEMIA TEST FROM PARENT/OTHER ADULT.	As part of this survey, we are asking children all over the country to take an anemia test. Anemia is a serious health problem that usually results from poor nutrition, infection, or chronic disease. This survey will assist the government to develop programs to prevent and treat anemia. We ask that all children born in 2010 or later take part in anemia testing in this survey and give a few drops of blood from a finger or heel. The equipment used to take the blood is clean and completely safe. It has never been used before and will be thrown away after each test. The blood will be tested for anemia immediately, and the result will be told to you right away. The result will be kept strictly confidential and will not be shared with anyone other than members of our survey team. Do you have any questions?		

		You can say yes or no. It is up to you to decide. Will you allow (NAME OF CHILD) to participate in the anemia test?		
108	CIRCLE THE CODE AND SIGN YOUR NAME.	GRANTED. . . . . 1 (SIGN) REFUSED. . . . . 2 NOT PRESENT/OTHER . 3	GRANTED. . . . . 1 (SIGN) REFUSED. . . . . 2 NOT PRESENT/OTHER . 3	GRANTED. . . . . 1 (SIGN) REFUSED. . . . . 2 NOT PRESENT/OTHER . 3

109 (2)	ASK CONSENT FOR MALARIA TEST FROM PARENT/OTHER ADULT.	As part of this survey, we are asking children all over the country to take a test to see if they have malaria. Malaria is a serious illness caused by a parasite transmitted by a mosquito bite. This survey will assist the government to develop programs to prevent malaria. We ask that all children born in 2010 or later take part in malaria testing in this survey and give a few drops of blood from a finger or heel. One blood drop will be tested for malaria immediately, and the result will be told to you right away. A few blood drops will be collected on slide(s) and taken to a laboratory for testing. You will not be told the results of the laboratory testing. All results will be kept strictly confidential and will not be shared with anyone other than members of our survey team. Do you have any questions? You can say yes or no. It is up to you to decide. Will you allow (NAME OF CHILD) to participate in the malaria test?		
110	CIRCLE THE CODE, SIGN YOUR NAME, AND ENTER YOUR FIELDWORKER NUMBER.	GRANTED. . . . . 1 REFUSED . . . . . 2 _____ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) ☐☐☐☐ NOT PRESENT/OTHER . 3	GRANTED . . . . . 1 REFUSED . . . . . 2 _____ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) ☐☐☐☐ NOT PRESENT/OTHER . 3	GRANTED . . . . . 1 REFUSED . . . . . 2 _____ (SIGN AND ENTER YOUR FIELDWORKER NUMBER) ☐☐☐☐ NOT PRESENT/OTHER . 3
111	PREPARE EQUIPMENT AND SUPPLIES ONLY FOR THE TEST(S) FOR WHICH CONSENT HAS BEEN OBTAINED AND PROCEED WITH THE TEST(S).			
112 (3)	PLACE BAR CODE LABEL FOR MALARIA LAB TEST.	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT. . . 99994 REFUSED . . . . . 99995 OTHER 99996	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT. . . 99994 REFUSED . . . . . 99995 OTHER 99996	PUT THE 1ST BAR CODE LABEL HERE. NOT PRESENT. . . 99994 REFUSED . . . . . 99995 OTHER 99996

		PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.	PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.	PUT THE 2ND BAR CODE LABEL ON THE SLIDE AND THE 3RD ON THE TRANSMITTAL FORM.
113	RECORD HEMOGLOBIN LEVEL HERE AND IN THE ANEMIA AND MALARIA PAMPHLET.	G/DL . . . . |__|__|.__| NOT PRESENT. . . . . 994 REFUSED . . . . . 995 OTHER 996	G/DL . . . . . |__|__|.__| NOT PRESENT. . . . . 994 REFUSED . . . . . 995 OTHER 996	G/DL . . . . . |__|__|.__| NOT PRESENT. . . . . 994 REFUSED . . . . . 995 OTHER 996
114	CIRCLE THE CODE FOR THE MALARIA RDT.	TESTED. . . . . 1 NOT PRESENT. . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)	TESTED. . . . . 1 NOT PRESENT . . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)	TESTED. . . . . 1 NOT PRESENT . . . . . 2 REFUSED . . . . . 3 OTHER . . . . . 6 (SKIP TO 116)
115	RECORD THE RESULT OF THE MALARIA RDT HERE AND IN THE ANEMIA AND MALARIA PAMPHLET.	POSITIVE 1 (SKIP TO 118) NEGATIVE. . . . . 2 OTHER 6	POSITIVE 1 (SKIP TO 118) NEGATIVE. . . . . 2 OTHER 6	POSITIVE 1 (SKIP TO 118) NEGATIVE. . . . . 2 OTHER 6

116	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER . . . . 6 (SKIP TO 130)
117	**SEVERE ANEMIA REFERRAL** RECORD THE RESULT OF THE ANEMIA TEST ON THE REFERRAL FORM.	The anemia test shows that (NAME OF CHILD) has severe anemia. Your child is very ill and must be taken to a health facility immediately. (SKIP TO 130)		
118 (4)	Does (NAME) suffer from any of the following illnesses or symptoms: a) Extreme weakness? b) Heart problems? c) Loss of consciousness? d) Rapid or difficult breathing? e) Seizures? f) Abnormal bleeding? g) Jaundice or yellow skin? h) Dark urine?	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2	YES NO a) EXTREME WEAKNESS 1 2 b) HEART PROBLEMS 1 2 c) LOSS OF CONSCIOUS. 1 2 d) RAPID BREATHING 1 2 e) SEIZURES 1 2 f) BLEEDING 1 2 g) JAUNDICE 1 2 h) DARK URINE 1 2
119	CHECK 118: ANY 'YES' CIRCLED?	NO YES (SKIP TO 122)	NO YES (SKIP TO 122)	NO YES (SKIP TO 122)
120	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA . . . 1 (SKIP TO 122) 8.0 G/DL OR ABOVE . . . 2 NOT PRESENT . . . . . . 3 REFUSED . . . . 4 OTHER 6
121 (5)	In the past two weeks has (NAME) taken or is taking [FIRST LINE MEDICATION] given by a doctor or health center to treat the malaria? VERIFY BY ASKING TO SEE TREATMENT	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)	YES . . . . 1 (SKIP TO 123) NO . . . . 2 (SKIP TO 124)

122	**SEVERE MALARIA REFERRAL** RECORD THE RESULT OF THE MALARIA RDT ON THE REFERRAL FORM.	The malaria test shows that (NAME OF CHILD) has malaria. Your child also has symptoms of severe malaria. The malaria treatment I have will not help your child, and I cannot give you the medication. Your child is very ill and must be taked to a health facility right away. (SKIP TO 128)

123 (5)	ALREADY TAKING [FIRST LINE MEDICATION] REFERRAL STATEMENT	You have told me that (NAME OF CHILD) had already received [FIRST LINE OF MEDICATION] for malaria. Therefore, I cannot give you additional [FIRST LINE OF MEDICATION]. However, the test shows that he/she has malaria. If your child has a fever for two days after the last dose of [FIRST LINE MEDICATION], you should take the child to the nearest health facility for further examination. (SKIP TO 130)		
124 (2)	READ INFORMATION FOR MALARIA TREATMENT AND CONSENT STATEMENT TO PARENT/OTHER	The malaria test shows that your child has malaria. We can give you free medicine. The medicine is called [FIRST LINE OF MEDICATION]. [FIRST LINE OF MEDICATION] is very effective and in a few days it should get rid of the fever and other symptoms. You do not have to give the child the medicine. This is up to you. Please tell me whether you accept the medicine or not.		
125	CIRCLE THE APPROPRIATE CODE AND SIGN YOUR NAME.	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6	ACCEPTED MEDICINE . 1 (SIGN) REFUSED . . . . . 2 OTHER 6
126	CHECK 125: MEDICATION ACCEPTED	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)	ACCEPTED MEDICINE . 1 REFUSED . . . . . 2 OTHER . . . . . 6 (SKIP TO 130)
127 (5)	READ INFORMATION FOR MALARIA TREATMENT AND CONSENT STATEMENT TO PARENT/OTHER ADULT.	[INSERT DOSAGE ONS] INSTRUCTI ER ADULT: If [NAME] ALSO TELL THE as a h ets sicker or PARENT/OTH not able to oes not get bett drink or breastfeed, g nent right away. to a health professional for treat (SKIP TO 130)	igh e er n t ver, fast or difficult breathing, wo days, you should take him/	is her
128	CHECK 113: HEMOGLOBIN RESULT	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6	BELOW 8.0 G/DL, SEVERE ANEMIA 1 8.0 G/DL OR ABOVE 2 NOT PRESENT 3 REFUSED 4 OTHER 6

		OTHER (SKIP TO 130)	(SKIP TO 130)	(SKIP TO 130)
129	**SEVERE ANEMIA REFERRAL** RECORD THE RESULT OF THE ANEMIA TEST ON THE REFERRAL FORM.	The anemia test shows that (NAME OF CHILD) has severe anemia. Your child is very ill and must be taken to a health facility immediately.		
130	GO BACK TO 103 IN NEXT COLUMN OF THIS QUESTIONNAIRE OR IN THE FIRST COLUMN OF THE NEXT PAGE; IF NO MORE CHILDREN, END INTERVIEW.			

FIELDWORKER'S OBSERVATIONS

TO BE FILLED IN AFTER COMPLETING BIOMARKERS

SUPERVISOR'S OBSERVATIONS

EDITOR'S OBSERVATIONS

BIOMARKER: FOOTNOTES

(1) This section should be adapted for country-specific survey design.

(2) Year of fieldwork is assumed to be 2015. For fieldwork beginning in 2016, all references to calendar years should be increased by one; for example, 2010 should be changed to 2011, 2011 should be changed to 2012, and similarly for all years throughout the questionnaire.

(3) This question should be deleted in surveys that do not collect blood smears.

(4) This is a list of generic symptoms indicative of severe malaria. Symptoms should be revised according to the country's national malaria treatment guidelines.

(5) The referral statement should be revised to reflect the country's national malaria treatment guidelines in reference to antimalarial treatment failure.

Part E: Appendix 5 Part A: Table 1: Variables description

Variable	Description
Malaria Prevalence (Binary variable)	Results of malaria blood tests and fever occurrence in the past two weeks. It will be coded 0 as negative 1 as positive
Socioeconomic status (wealth index) (Categorical Variable)	Proxy for household wealth Recoded into quintiles.0 as poorest, 1 as poor, 2 as middle, 3 as richer and 4 as richest.
Ethnicity (Categorical Variable)	To which ethnic group do you belong? Recoded as Akan (1), Ga/Dangme (2), Ewe (3), Guan (4), Mole-Dagbani (5), Grusi (6), Gurma (7), Mande (8), Other (9)
Age of child (Categorical Variable)	How old is your child in months? Recoded 0-12 months=0, 13-24 months=1, 25-36 months=2, 36-48 months=3, 49-59 months=4
Health Insurance coverage for child (NHIS) (Categorical variable)	Is the child registered on the NHIS Recoded yes= 1 no=0
Under-five sleeping in treated net. (Categorical variable)	Did the child sleep under an insecticide net. Recode as 0 as No and 1 as yes
Ownership of household net (Categorical Variable)	Does household own an insecticide net Recode as 0 as No and 1 as yes
Maternal education (Categorical Variable)	The level of the mother's education. The highest level of education attended by the mother. Recoded as 0 no formal education 1 primary 2 as secondary and 3 as tertiary.
Age of mother (Categorical Variable)	What is mother's current age? 15_24yrs=0, 25_34yrs=1, 35_44yrs=2, 45_49yrs=3
Place of residence	Rural =0 urban =1

(Categorical Variable)	
Regions (Categorical Variable)	Recoded 0 = Ashanti, 1= Western, 2= Volta, 3= Central, 4= Greater Accra, 5= Brong -Ahafo, 6=Northern, 7=Upper East, 8= Upper West, 9=Eastern region

Part E : Appendix 6 Part B: Table 2: Empirical Review of socioeconomic inequalities in malaria prevalence in endemic regions				
Author and year	Objective of study	Country of the study	Methodology/ key variables in the study	Results
Abdul Gafar et.al,2012	To measure changes in socioeconomic inequality in access to malaria control in Nigeria.	Nigeria	**Methodology -** Cross-Sectional study Concentration Index **Dataset** -Nigeria Demographic and Health Surveys 2003 and 2008 **Variables of interest**- Ownership of bed nets, socioeconomic status (wealth), under-five children who received non-Artemisinin-Combination Therapy	Results revealed in 2008, the concentration of treated net use was among the rich (pro-rich inequality) which was more pronounced in the northwest and southeast regions. It was less pronounced in the south. There was pro-rich inequality in the prompt and effective treatment of malaria using non-Artemisinin-Combination Therapy (ACT), ACT combination and use of intermittent preventive treatment by pregnant women. In the case geographical settings, access to some interventions were more pronounced in the northern regions. Again, from 2003 compared to 2008, there was an increased access to ownership of bed nets. Under-five utilisation of bed nets increased from 11,8% inn 2003 to 16.9% in 2008. Use of non-Artemisinin-combination therapies (ACT) in under-five also increased from 9.6% to 27.5% in 2003 and 2008 respectively. Although, there was an increase in coverage, utilisation was pro-rich.
Njau et.al,2014	1.To outline the vital factors of maternal education	Angola, Tanzania, and Uganda	**Methodology-**	From the results, a total of 1,390 2,997 and 5,975 women in Angola. Uganda, and Tanzania were interviewed in the survey. Children developing

	and childhood malaria infection. 2. To determine the statistical relationships between maternal education and childhood malaria infections		Cross-sectional study Descriptive Analysis Multivariate logistic regression Decomposition Analysis (Blinder-Oaxaca decomposition) **Datasets**- malaria indicator surveys (MIS) **Variables of interest**- Childhood malaria infection, maternal education, child health knowledge, household wealth	malaria infection were higher among women without any formal education. Comparatively malaria infection was about 12% high between women with no formal education and with primary education. Education was used as an indicator for SES. The decomposition analysis of the studies indicated an 8% gap of inequalities between educated mothers and uneducated mothers of which 60% of such inequalities were explained by household wealth (26%), place of stay (21%), malaria transmission intensities (14%), media exposure (12%) and, 27 % by regional differences.
Tusting et.al.,2013	To determine whether socioeconomic development can control childhood malaria infection in	Sub-Saharan African Countries	**Methodology-** Meta-analysis, systematic review Regression analysis	In the study, children within 0-15 years were chosen for the study. The likelihood of developing malaria infection was higher in the poorest children compared to the least poor children. The unadjusted and adjusted odds ration were 1.66 and 2.06 respectively. Results also indicated that poorer households were likely to develop high

	children aged 0-15 years		**Datasets-** Medline, Web of science, Embase, health systems evidence, Cochrane. **Variables of interest**- Socioeconomic status- measured by wealth index, asset ownership, parents occupation, children aged 0-15 years, malaria prevalence (by rapid diagnostic tests or microscopy)	Out-of-pocket expenditure of malaria treatments compared to wealthier households.
Barros et.al,2010	To determine the effect of social inequities of health and nutrition on under-five children	Low- and middle-income countries	**Methodology-** Concentration index Descriptive analysis **Datasets-** Demographic health survey and UNICEF multiple	From the results, prevalence of fever was associated with malaria infection in all the SSA countries chosen for the analysis. The results found that, inequalities of fever prevalence were pro-poor. This means they were more concentrated in the poorer populations.

			indicator cluster surveys **Variable interest-** SES-measured by wealth.	
Abeles &Conway,2020)	To explore the inequality in malaria at various population levels, local, sub-national, regional and global.	Globally	**Methodology-** Gini Index **Datasets-** country specific malaria indicator surveys **Variable interest-** Wealth Geographical regions, under-five malaria infections	The results from the study, revealed that across the six WHO regions, malaria burden recorded the most extreme case of inequality. The GINI coefficient for malaria burden was 0.77, which is centred in the socially disadvantaged. Also from the analysis, removing the European region did not change the Gini index compared to the Africa region. The Gini index reduced to 0.40 when the African region was removed. However, Asia or the western pacific Accounted for the remaining 40% of the index. Again, the analysis was broken down sub-nationally in the WHO regions, four countries in the African region precisely, Nigeria, Burkina Faso, Ghana, and Sierra Leone were the most contributing countries of inequalities in the African region.
Edwin *et.al.,*.,2021	1. To assess the prevalence of childhood malaria infection in Nigeria	Nigeria	**Methodology-** Decomposition Analysis Regression Analysis	Overall, a total of 28,634 under-five children were used for the analysis. Overall prevalence was found to be 12.7%. childhood malaria infection was found to be statistically significant associated with maternal education. An odds ratio of (0.26,95% CI: 0.05-0.48) was reported. Under-five children whose mothers had a higher level of education and in the richest quintile were less likely to report childhood malaria infection

	2. To determine the factors that significantly contributes to childhood malaria infection in Nigeria		**Datasets-** 2013 Nigeria Demographic and Health Survey **Variable interest-** Occurrence of fever in under-five children the past two weeks, maternal education, child health knowledge, age of child, place of residence, mother's age, ownership of insecticide treated nets and utilization, sex of child	compared to mothers with no formal education and in the poorest population. The results also found regional differences childhood malaria infection. In the decomposition analysis, there was a 34% gap between non-educated mothers and educated mothers. This gap was explained by differences in age of child (1.03%), region (0.06%) and household wealth (68%).
Okolie *et.al.,*., 2021	1.To assess the socioeconomic inequality in the uptake of Intermittent preventive treatment (IPTp) in Nigeria 2.To identify factors that contribute to	Nigeria (Edwin *et.al.,*., 2021)	**Methodology-** Concentration Index and curve Decomposition Analysis **Datasets-** 2018 Nigeria Demographic Health survey	Using the Nigeria Demographic Health Survey (DHS), uptake in intermittent preventive treatment (IPTp) was pro-rich in total. In the urban areas, uptake among pregnant women is pro-rich, however in the rural areas, uptake is pro-poor. In the decomposition analysis, there was 66.7% gap between pregnant women in the urban and rural areas. This inequality was jointly explained by geopolitical zone (67.4%), education (20.01%), more than 4 antenatal care visits (26.9%) and distance to health facilities (6.2%).

	socioeconomic inequalities in IPTp in Nigeria		**Variable interest-** Socioeconomic Status- measured by wealth, level education, place of residence, distance to health facility, uptake of adequate intermittent preventive treatment (IPTp)	
Hailu *et.al.,*.,2016	To examine the socioeconomic inequalities in malaria prevention interventions.	Ethiopia	**Methodology-** Regression Analysis Concentration Index and curves Decomposition Analysis **Datasets-** Household survey 2014 **Variable interest-** Socioeconomic status (Wealth index), Household long lasting insecticide net ownership,	From the analysis, household wealth, household size, availability of toilet facility, and ownership of radio were significantly positively with insecticide nets ownership. Moreover, level of education of household head was significantly associated with having indoor residual spraying. With respect to inequalities, ownership of long-lasting insecticide nets was found to be concentrated in the wealthy population. However, inequalities in indoor residual spraying were not that pronounced.

			indoor residual spraying	
Carrasco-Escobar *et.al.,*., 2021	To assess spatial trends in socioeconomic inequalities in malaria prevalence.	Sub-Saharan African Countries	**Methodology-** Slope index Inequality Relative index of Inequality **Datasets-** Malaria indicator survey (MIS) from 2015 to 2018 **Variable interest-** SES (mother's highest educational level and wealth index), malaria tests by rapid diagnostic test (RDT).	The Malaria Indicator Survey (MIS) were used for the analysis. From the results, a weighted prevalence of 36.44% was recorded for all the SSA countries. With respect to SES inequalities in malaria prevalence, the slope index of inequality and relative index of inequality were used for the analysis. Tanzania, Malawi, and Mozambique were the countries with the highest level of wealth index inequality in malaria prevalence in relative and absolute terms. The study also assessed spatial differences across countries. There were high absolute differences of malaria prevalence in the Eastern part of Africa in relation to wealth index. This was different in the Western part of Africa. Low relative malaria prevalence in relation to wealth index and mother's highest level of education was observed in Burkina Faso. The study also revealed that, this relative difference was concentrated in the poorer population.
Galactionova *et.al.,*.,2017	To assess the state of inequality in malaria intervention coverage in sub-Sharan Africa countries from 2005 to 2015.	SSA countries	**Methodology-** Concentration index **Datasets-** Demographic and health surveys (DHS)/ malaria	From the study results, the presence of disparities was showed in all the countries and among the countries. ITN use compared to access to formal care was found to be distributed equally in almost all the countries. However, there were some differences in some countries. Access to formal care in Congo, Togo, Uganda, and Democratic Republic of Congo favoured the highest SES households whilst ITN use favoured the poorest. Between the period of analysis, it was noticed

			indicator survey (MIS) **Variable interest-** Malaria parasitaemia in under-five children, SES (wealth index), malaria intervention coverage,	intervention coverage in the countries of study improved. Access to formal care and ITN use were distributed pro-poorly and equally across the SES gradient. Although, expansions of these malaria interventions were pro-poor, malaria prevalence was still concentrated in the poorest population in Ghana. From the analysis, it is important find the factors that are still causing such disparities of malaria intervention among the SES gradient.
Were *et.al.*,,2018	To determine the relationship between household socioeconomic status and inequality in malaria health indicators.	Kenya	**Methodology-** Cross-sectional study Regression Analysis **Datasets-** The 2012 health and demographic surveillance system data (HDSS) **Variable interest-** Malaria infection tested by microscopy, insecticide treated nets utilisation,	This study investigation found that, overall, 37.6% of persons from the poorest household developed malaria infection compared to the least poor at 29.2% when age, gender, geographical area and ITN use were adjusted. The difference of ITN usage was not very pronounced between the poorest and least-poor populations. To add to it, persons from the poorest households spent more of malaria medications than the least poor. Some limitations of this were that not all under-five children were included in the study.

			care seeking, SES (wealth), sex and age groups (<5, 5-14 and ≥ 15 years)	
Siri, J.G,2014	To measure independent associations of maternal education and household Wealth with Malaria Risk in Children	Multi- African countries	**Methodology-** Cross-sectional study Regression Analysis **Datasets-** Malaria indicator surveys (MIS) from 2008 and 2011 **Variable interest-** Malaria prevalence in under-five children, place of residence, household size, mother's age, sex of household, child slept under insecticide-treated bed net. Maternal education, Wealth index	In all the countries chosen for the study, wealth, maternal education, and type of housing were significantly associated with malaria parasitaemia with children. There was a negative relationship reported. An expected increase in wealth and maternal education reduces the odds of child malaria infection. Likewise living in urban areas also reduced the odds of malaria infection in children. It was also observed that malaria parasitaemia increased in child's age. In terms of assessing prevalence of malaria within population strata, countries like Uganda reported some disparities. Among children with low education, high wealth was associated with high prevalence of malaria. In Liberia, high education and wealth were also associated with high malaria prevalence. But it is also worthy to note, these were some few exceptions in the analysis. Out of nine countries analysed, seven countries revealed that, malaria reduction in children is likely to increase when household wealth and maternal education are increased. A decomposition analysis in the study could have explain such differences between malaria parasitaemia, wealth and maternal education.
Clouston *et.al.*,,2015	To establish social inequalities in	Madagascar	**Methodology-**	This study assessed inequalities using the Malaria Indicator survey (MIS). Mothers with secondary

	malaria knowledge, prevention, and prevalence among children under-five years old and women aged 15-49 in Madagascar		Descriptive statistics Regression Analysis **Datasets-** Malaria indicators survey for 2011 and 2013 **Variable interest-** Malaria knowledge, prevalence of malaria in under-five children tested by microscopy, Socioeconomic status (maternal education and household wealth), mother's age, child's age, place of residence and sex.	education or higher and wealth were significantly associated with malaria prevalence. It decreased the likelihood of child malaria infection. In addition, child's age, sex of child, rural/urban residence were all significantly associated with malaria prevalence. With regards to interventions, mothers' education and wealth were associated with antimalaria prevention in pregnancy. However, SES was not associated with child sleeping under a treated mosquito net or receiving antimalarial treatments for fevers. Regional disparities of malaria prevalence were also revealed in the study. The study could have further conducted decomposition and concentration index analysis to know the nature and distribution of malaria parasitaemia.
Novignon &Novignon, 2012	To establish the relationship between socioeconomic status and the prevalence of fever in children under	Ghana, Nigeria, Kenya, and Sierra Leone	**Methodology-** Regression analysis **Datasets-**	Fever in children were likely to be found in low SES households from all four countries. Only in Ghana, Nigeria and Kenya showed a statistically significant association of household wealth and fever. The association of wealth and fever was not significant in Sierra Leone. With regards to use of bed nets, children who slept under bed

	age five in sub-Saharan Africa (SSA) Lower-Middle Income Countries (LMICs).		2008 Demographic and health survey **Variable interest-** Prevalence of fever in under-five children in the past two weeks, socioeconomic status (wealth index), age of child, sex, utilisation of bed nets, health insurance coverage, availability of drinking water and toilet facilities.	nets in Ghana were more likely to report fever. In contrast, children who slept under bed nets in Nigeria were less likely to report fever. In all four countries sleeping under bed nets significantly decrease the chance of developing fever. Aside other epidemiological factors, socioeconomic status plays a vital role in fever prevalence in under-five children in SSA countries and LMICs. The nature and distribution should be emphasised more in under-resourced settings so that equity policies would be addressed towards it.
Krefis *et.al.*,, 2010	To assess the association of socioeconomic status and childhood malaria infection.	Ghana	**Methodology-** Logistic regression analysis **Datasets-** 2008 demographic health survey (DHS) **Variable interest-** Socioeconomic status- wealth	This study was analysed from one setting area in Ghana. From indication, children's age had a significant association with malaria prevalence. Children between the ages of 1 and 5 years were the most affected. Place of residence was notably associated with malaria prevalence. Household socioeconomic status was negatively and significantly associated with childhood malaria infection. The odds of a child developing malaria in an average socioeconomic household was 0.88 as compared to richer households, which decreased to 0.56.

			Maternal and paternal education, place of residence, National health insurance scheme (NHIS)	
Sonko *et.al.*,,2014	To assess the relationship between socioeconomic status, housing quality and malaria infection.	Gambia	**Methodology-** Logistic regression analysis **Datasets-** Gambia malaria indicator survey (MIS) 2010/11 **Variable interest-** Socioeconomic status (SES)(wealth), housing quality, prevalence of malaria in under-children tested by microscopy, regions, child's age	From the study, there were heterogeneity of malaria prevalence in the regions. Additionally, under-five children from poorest quintile in the SES gradient were 8.2 times more likely to have malaria than children from average to richest quintile. Housing materials and housing type were strongly associated with malaria prevalence in under-five children. The odds ratio was reported as 1.6, 95% CI (1.1-2.3, P = 0.01).
Nawa *et.al.*,,2019	To investigate factors contributing to the upsurge of malaria prevalence in Zambia between 2010 and 2015.	Zambia	**Methodology-** Logistic regression Analysis, Decomposition Analysis	This study was assessed between 2010 and 2015. Malaria prevalence increased between that period, whilst ITN and IRS utilization increased as well. Child's age, rural residency increase was significant associated with increase in malaria prevalence. In contrast, urban residency, IRS,

			Datasets- Malaria indicator surveys 2010/12 and 2015 **Variable interest-** Malaria prevalence in under-five children tested by microscopy, age, location of residence, gender, wealth, housing type, rainfall, temperature and altitude, indoor residual spraying (IRS), ownership of insecticide treated nets (ITN).	standard housing, and altitude were reduced the risk pf malaria infection significantly.
Owoeye *et.al.*,,2018	To decompose changes in malaria prevalence in children under-five between 2003 and 2013.	Nigeria	**Methodology-** Descriptive statistics, logistic regression decomposition analysis **Datasets-** Nigeria Demographic and	From the study, childhood malaria infection was high in 2003 (31.8%) than in 2013 (13.1). However, with regards to child's age there were variations between age groups. Children between 48-59 months had a low malaria prevalence rate at 11.6% in 2003 and 13.2% in 2013 compared to children within 12-23 months whose rates increased from 25.5% in 2003 to 28.4% in 2013. Maternal education was statistically significant with childhood malaria infection. Mothers with no formal education were likely to report high

			health survey 2003 and 2013 **Variable interest-** Occurrence of fever in the past two weeks in under-five children, child's age, sex of child, location of residence, maternal education, wealth index, under-five slept under net, insecticide treated ownership and use	infection rate in children compared to mothers with secondary/ tertiary education. Rural areas recorded a high prevalence rate of malaria in under-five children compared to urban areas. The decomposition analysis found ownership of ITN and use of ITN to be the largest driving factor of reduction in malaria prevalence between the period respectively, 95% and 13.3%. other variables wealth index, maternal education, place of residence contributed -10.7%, 19.5% and 4% respectively.