University Of Zambia

School Of Veterinary Medicine

Prevalence and Factors Associated with Malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.

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"A dissertation submitted to the University of Zambia in partial fulfillment of the requirements for the award of the degree of Masters of Science degree in One Health Analytical Epidemiology"

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Declaration

I, Arthur Shaba Santu, do hereby declare that this dissertation being presented for the award of the Degree of Master of Science in One-Health Analytical Epidemiology has not been previously submitted either wholly or in part for the award of Degree at this or any other University nor is it being currently considered for the award of any other Degree.

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Arthur Shaba Santu

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Abstract

Malaria is one of the major public health problems in developing countries like Zambia. Under-five years of age children are the most vulnerable group affected by malaria, accounting for 61% of all malaria deaths worldwide. Despite efforts to reduce the mortality and morbidity, the disease is still a prominent health problem in Senga Hill District. The District is described as a high risk area for malaria in the country. Knowledge of malaria prevalence and associated risk factors among under-five children in the district is insufficient. This study, therefore, was undertaken to assess the prevalence of malaria and associated risk factors amongst Under-Five Children in Senga Hill District, Northern Province, Zambia.

Community-based cross-sectional study was conducted among under-five children in Senga Hill District from November 2022 to August, 2023. A structured questionnaire was used to collect data on hypothesised risk factors from the guardians or parents of children through face to face interview. A Care Start^{TM} Malaria Rapid diagnostic test which can detect histidine-rich protein 2 of *Plasmodium falciparum* and *Plasmodium* lactate dehydrogenase of *P. vivax* was used to diagnose malaria. Bivariate analysis was used to determine associations between categorical variables, while for multivariable, binary logistic regression analysis was used to identify predictors of malaria among under-five children in the district.

A total of 216 under-five children took part in the study. The overall prevalence of malaria was 31.9%. Correct use of ITNs (OR = 0.089, 95% CL = 0.034, 0.232, p = <0.001), those households that reported IRS had been done (OR = 0.375, 95% CL = 0.178, 0.789, p = 0.010) and those that reported having a single mosquito net (OR = 0.137, 95% CL = 0.141, 0.891, p = 0.003) had significantly reduced odds of under-five children being positive to malaria, than those that had not. Male children had significantly higher odds (OR = 3.035, 95%CL = 1.518, 6.068, p = 0.028) of being malaria positive than females.

The local authorities and other concerned bodies should focus on the regular and proper use of ITNs and changing attitudes towards ITNs as malaria prevention and control measures.

Certificate of Approval

This dissertation by Arthur Shaba Santu has been approved as fulfilling the partial requirements for the award of the Master of Science Degree in One Health Analytical Epidemiology by the University of Zambia.

The Supervisor

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Date: _____

The Chairperson of Board of Examiners

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Date: _____

Dedication

This work is dedicated to God for enabling me to go through this programme; my wife Nachimata Nambela, daughters Uma and Emy Santu for their patience and support during the process of the study.

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List of Abbreviations and Acronyms

AIDS: .....Acquired Immunodeficiency Syndrome

CHA: .....Community Health Asistants

CSO: .....Central Statistic Office

DDT:..... Dichlorodiphenyltrichloroethane

DHO: .....District Health Office

GRZ: .....Government of the Republic of Zambia

HH: ..... HouseHold

HIV: .....Human Immunodeficiency Virus

HRP2: .....Histidine-rich protein 2

IRS: .....Indoor Residual Spraying

ITN: .....Inserticide Treated Bed Net

MoH; .....Ministry of Health

NGO: .....Non-Governmental Organisation

pLDH: .....Plasmodium lactate Dehydrogenase

RDT:..... Rapid Diagnostic Test

U5:..... Under-Five Children

ZWK: ..... Zambian Kwacha

$\chi 2$: .....Chi-Square

Charter One

1.0. Introduction

1.1. Background

The protozoan parasites of the genus *Plasmodium* are the major cause of the disease malaria (Masaninga et al., 2013). Humans contract it through the bite of a female *Anopheles* mosquito carrying the infection. Ninety-eight percent (98%) of illnesses are caused by *Plasmodium falciparum*, with the remaining two percent (2%) caused by the three other malaria parasite species that are found in Zambia *(P. malariae, P. ovale, and P. vivax*) (Masaninga et al., 2013). Children under five years of age (U5) are the most susceptible to the disease and make up 61% of all malaria deaths globally (Ahmed et al., 2021). According to data from the World Health Organization and United Nations Children's Education Fund (World Health Organization, 2019) malaria claims the lives of over 3,000 children in Africa every day, with one child dying from the disease every thirty seconds (Nawa et al., 2019).

Children who survive malaria may experience long-term effects from the illness(Masaninga et al., 2013) . Frequent bouts of fever and sickness limit play, social engagement, and educational opportunities, suppress appetite, and ultimately hinder growth (Nawa et al., 2019). Poorer households are known to have higher rates of child mortality, with malaria accounting for a significant share of these deaths (Nawa et al., 2019).

In resource-poor environments, malaria is a significant contributor to poverty, especially in tropical regions of the world (Ayele et al., 2012). Some population groups are at considerably higher risk of contracting malaria and developing severe disease including infants, mobile populations and travellers (Nawa et al., 2019). Further, new-borns, children under five, pregnant women, and HIV/AIDS patients, are significantly more likely to get malaria and develop severe illness (Nawa et al., 2019).

Malaria has an impact not only on health status but also on homes and daily life. Severe episodes of the disease can cause modest developmental and cognitive abnormalities in children as well as long-term neurological sequelae. Families may also suffer significant financial implications (Nawa et al., 2019).

Malaria prevention and control in Zambia commenced in 1952. Since then great progress has been achieved, however, malaria still kills more children under the age of five than any other diseases. It affects more than four million Zambians annually(World Health Organization, 2015), causing 30% of outpatient visits resulting into about 8000 deaths each year (World Health Organization, 2015)

According to a ZDHS data (ZDHS, 2022) malaria is one of the leading causes of morbidity and mortality in Senga Hill District affecting both adults and children under five. Hence, knowing the current prevalence of malaria and its associated risk factors in the district has paramount importance to design and scale up appropriate intervention programs. Currently, there is scarcity of information as no previous similar study has been done in the study area.

1.2. Problem Statement.

Northern Province has twelve administrative districts, one of which is Senga Hill District. Numerous public health issues have beset the district since it was established in 2016. Malaria has been and continues to be the district's primary cause of illness and mortality (MoH, 2021). The district saw an extremely high incidence rate of malaria between 2018 and 2021. The incidence risk for all ages in the three years 2018–2019, 2020, and 2019 was 405, 478, and 439 cases / per 1000 population, respectively (MoH, 2021). The incidence risk for children under five rose over the same time period, from 823 cases per 1000 in 2018 to 860 cases per 1000 in 2019 and 853 cases per 1000 in 2020. (MoH, 2021). The malaria inpatient case fatality rate (CFR) (%) for 2018, 2019, and 2020 were 12.2, 15.2 and 15.2 respectively (MoH, 2021).

In view of the above challenges, it is imperative to assess the prevalence of malaria and its associated risk factors that contribute to sustained high incidence of cases amongst under-five children in Senga Hill District.

1.3. Justification of Study

To effectively implement targeted control and preventive measures that can lessen the burden that malaria places on the health care and economic systems, a thorough understanding of the determinants of the disease is necessary. Given that malaria is endemic in Sub-Saharan Africa, implementing successful health strategies requires having the requisite understanding about the disease. Implementation of foreign Control measures in impoverished nations and communities can be difficult to finance. Hence appropriate local control solutions are essential because they will be simpler to execute than those that call for the involvement of reputable international financiers. The Ministry of Health (MOH) does report on the extent of malaria infection, but little is known about the risk factors and prevalence of malaria in children under five years old in Senga Hill District. Closing this disparity and providing information for the planning and execution of focused interventions in the district would be made possible by determining the present prevalence of malaria and the risk factors associated with its occurrence.

1.4. Study Objectives

1.4.1. Main Objective

To determine the prevalence of malaria and its associated risk factors amongst under-five children in Senga Hill District.

1.4.2. Specific Objectives

a. To determine the prevalence of malaria cases amongst under-five children in Senga Hill District.

b. To determine risk factors associated with malaria cases amongst under-five children in Senga Hill District.

1.4.3. Research Question

What is the Prevalence and risk factors associated with malaria cases amongst under-five children in Senga Hill District?

1.5. Significance of study

By identifying potential risk factors for malaria infection among children under five, this study seeks to close the information gap and add to the body of knowledge regarding the prevalence of malaria in Senga Hill District. The results of this study may be utilized as empirical proof of the risk factors affecting the prevalence of malaria among children under five in Senga Hill District and the neighbouring districts in Northern Province. It also serve as a foundation for the creation of policies aimed at combating malaria.

1.6. Conceptual Framework

The conceptual framework shows the relationship among Demographic, Socio-Economic and Environmental Risk Factors for malaria. Eliminating malaria requires collaboration across different sectors, and disciplines. Malaria risk factors at different levels need to be identified in order to develop strategies for its prevention and control. This partnership model translates bold ideas into products and strategies, and leverages national /district capacities.

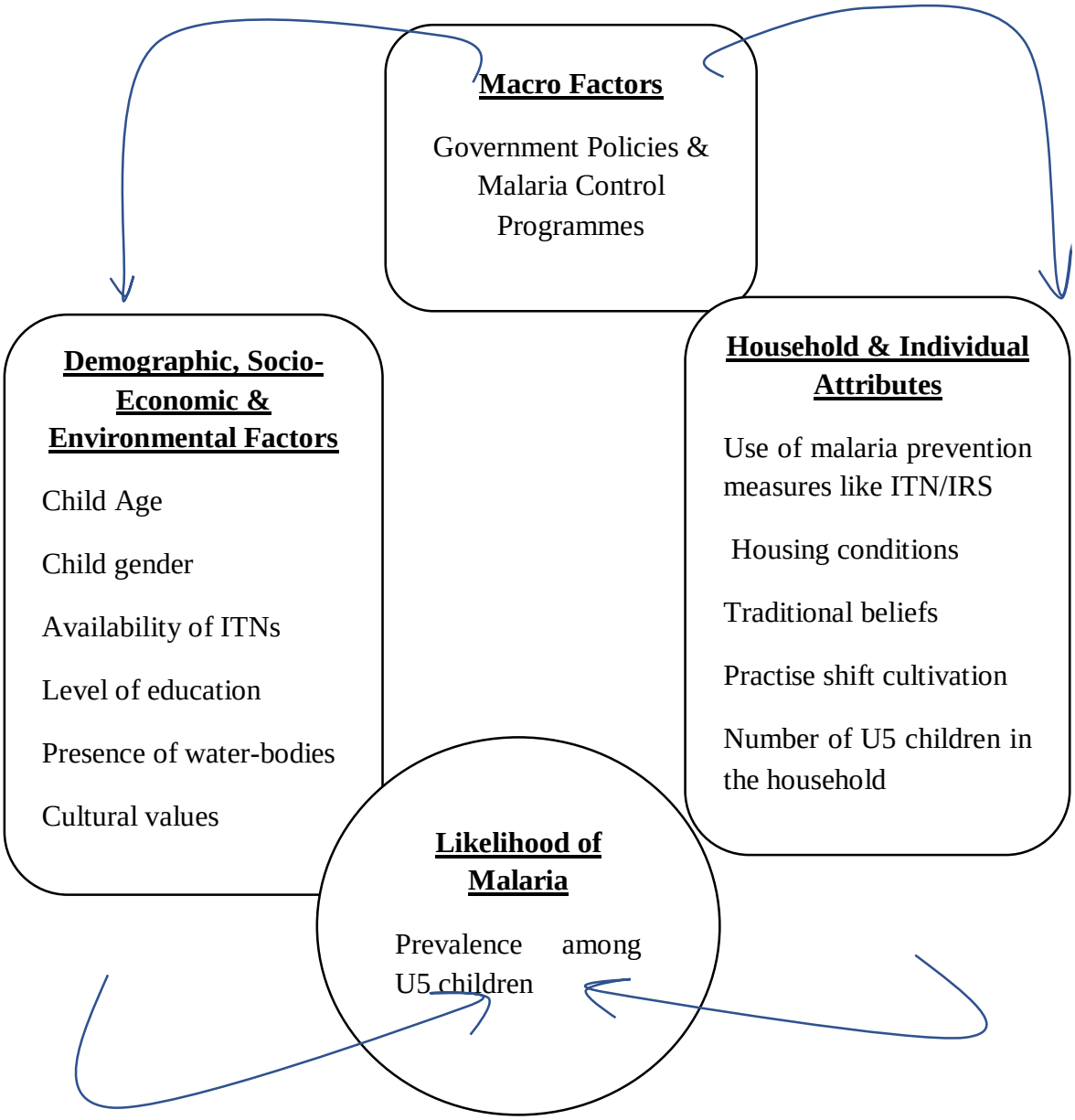

Figure 1; Conceptual Framework

Charter Two

2.0. Literature Review

2.1. Introduction.

Malaria still presents a major public health concern worldwide (Snow et al., 2017). The World Health Organization (WHO) World Malaria Report 2019, estimated 228 million cases of malaria globally, causing 405 000 deaths in the year 2018, mainly under the age of five children (World Health Organization, 2019).

An estimated 219 million cases of malaria and 660 000 malaria fatalities globally were reported in 2010 in the sub-Saharan African countries (World Health Organization, 2019) and an estimated 627,000 people losing their lives to the disease in 2020. In 2021, the global tally reached 247 million cases of malaria (World Health Organization, 2019). According to the 2012 World Malaria Report, Approximately 80% of malaria episodes and 90% of the deaths were reported from the African continent. (World Health Organization, 2019). Endemic malaria results in tremendous economic losses annually and is a central element to the vicious cycle of poverty in many developing nations (Snow et al., 2017).

The WHO African Region continues to shoulder the heaviest burden of malaria. Globally in 2020, the Region accounted for 95% of all malaria cases (228 million), 96% of all malaria deaths (602 000) and 80% of all malaria deaths in the Region are among children under the age of 5 (World Health Organization, 2021). Between 2000 and 2019, the Region made good progress in reducing its malaria burden by case incidence (cases per 1000 population at risk) fell from 368 to 222.9 (World Health Organization, 2019). The mortality rate (deaths per 100 000 population at risk) fell from 149.6 to 56 (World Health Organization, 2019). However, in countries with moderate and high malaria transmission, the rate of progress has levelled off since

2015 and, in 2020, disruptions to malaria services during the COVID-19 pandemic, had an added impact on the malaria burden in the Region. Between 2019 and 2020 the total malaria cases increased from 213 million to 228 million, case incidence increased from 222.9 to 232.8 cases per 1000 population at risk and total malaria deaths increased from 534 000 to 602 000 (World Health Organization, 2019). The mortality rate increased from 56 to 61.5 deaths per 100 000 population at risk including children under five years of age.

Malaria prevention and control in Zambia commenced in 1952. Since then great progress has been achieved, however, malaria still kills more children under the age of five than any other diseases. It affects more than 4 million Zambians annually (World Health Organization, 2008), causing 30% of outpatient visits resulting into about 8000 deaths each year (world malaria report, 2023). Malaria incidence in Zambia increased from 230 / 1000 cases in 2010 to 335 / 1000 cases in 2015 (Central Statistical Office (CSO) [Zambia], 2018).

According to (ZDHS-2020) data, malaria is one of the leading causes of morbidity and mortality in the District affecting both adults and children under five.

2.2. Malaria Distribution.

Malaria occurs primarily in tropical and some subtropical regions of Africa, Central and South America, Asia, and Oceania (Knudsen and Slooff, 1992).

Distribution of these parasites varies geographically, and not all species of malaria are transmitted in all malarious areas. *P. falciparum*, the species most commonly associated with fatal malaria, is transmitted at some level in nearly all areas where malaria occurs (Milner, 2018). The current distribution of human-pathogenic *Plasmodium* species shows preponderance of *P. falciparum* in tropical Africa, while P. vivax is the most widely distributed species outside Africa (Gething et al., 2012) and in a few African countries, such as Ethiopia (Geleta, 2016) and Uganda (Asua et al., 2019). *P. vivax* prevails over *P. falciparum* in South America (Milner, 2018). Both *P. falciparum* and *P. vivax* are prevalent in south-eastern Asia and western Pacific. Although *P. malariae* may occur in all malarious areas, its prevalence is generally low. In tropical Africa, *P. falciparum* and *P. malariae* co-infection is sometimes encountered. *P. ovale* is widespread principally in tropical Africa whereas *P. knowlesi* infection occurs only in certain forested areas of South-East Asia (Milner, 2018).

In Zambia, majority of malaria episodes are caused by *Plasmodium falciparum* (Kamuliwo et al., 2013) and the major malaria vectors are *Anopheles gambiae, Anopheles arabiensis* and *Anopheles funestus* (Mharakurwa, 2012) it has been reported that 98% of malaria is caused by *P. falciparum*, 2% is caused by *P. malariae* and *P. vivax* is a rare infection (Zambia Satisitics agency, 2014) . A cross-sectional study conducted in high transmission areas in Eastern and Luapula Provinces revealed approximately 10.6% of all *P. falciparum* infections were co-infections with one or more other *Plasmodium* species (Kamuliwo et al., 2013).

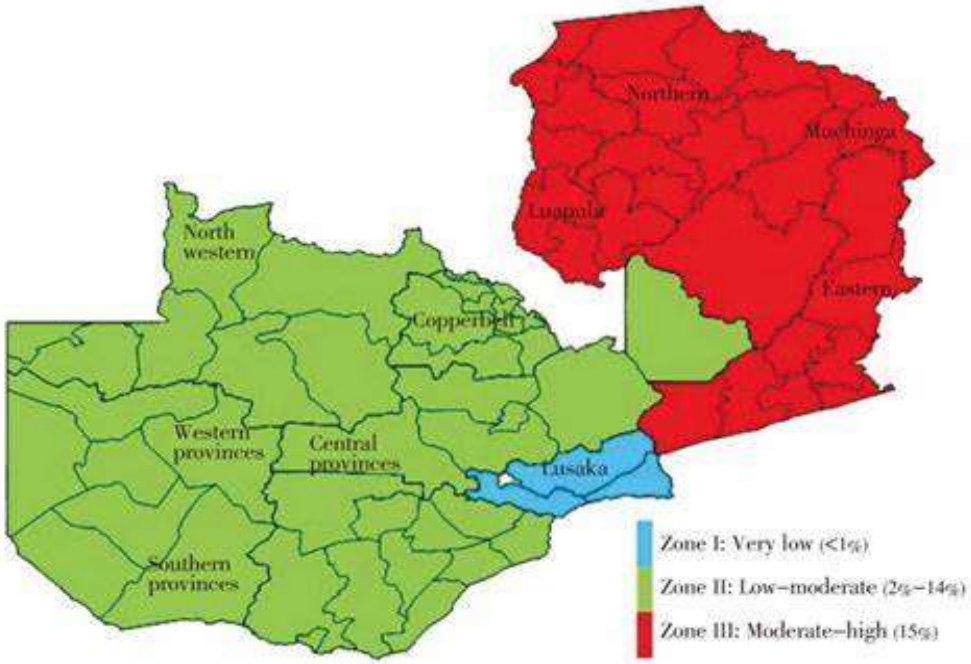

Figure 2; Malaria Stratification by Region in Zambia

2.3. Aetiology of Malaria

2.3.1. Origin of Malaria.

Plasmodium falciparum is a unicellular protozoan parasite and the deadliest species of *Plasmodium* that causes malaria in humans (Rich et al., 2009). It belongs to the domain - *Eukaryote*, Phylum- *Apicomlexa*, Class- *Aconoidasida*, Order- *Haemospororida*, Family- *Plasdiidae* and Genus *Plasmodium* (Rich et al., 2009). The species originated from the malarial parasite *Laverania* found in gorillas, around 10,000 years ago (Loy et al., 2017). Alphonse Laveran identified the parasite in 1880, and named it *Oscillaria* malariae. Ronald Ross discovered its transmission by mosquito in 1897. Giovanni Battista Grassi elucidated the complete transmission by a female *anopheline* mosquito to humans in 1898. In 1897, William H. Welch created the name *Plasmodium falciparum*, which International Commission on Zoological Nomenclature (ICZN) formally adopted in 1954 (Rich et al., 2009).

2.3.2. Classification of *Plasmodium Falciparum.*

Plasmodium falciparum belongs to subgenus *Laverania,* whereas all the others species belong to subgenus *Plasmodium. P. knowlesi* that causes zoonotic malaria in humans also belongs to the subgenus *Plasmodium.* Generally, *P. falciparum* only infects humans in natural conditions (Liu et al., 2016), though it's possible to adapt the species to infect chimpanzees in the laboratory (Bradley-Moore et al., 1985). Isolation of P. *falciparum* from bonobos (*Pan paniscus)* kept at the Lola ya Bonobo Sanctuary in the Democratic Republic of the Congo (DRC) had been reported, though mitochondrial haplotype isolates from bonobos were genetically distant from *P. falciparum* parasites infecting humans (Krief et al., 2010) The non-*Plasmodium falciparum Laverania* species that is phylogenetically closest to *P. falciparum* is *P. praefalciparum,* which infects gorillas and not humans or chimpanzees (Liu, 2016). As with these two species, all *Plasmodium* species of subgenus *Laverania* so far described show strong host specificity in their natural transmission (Liu, 2016).

2.4. Malaria Vector

Human malaria is transmitted by the bite of female mosquitoes belonging to the genus *Anopheles.* Of the 400 species of *Anopheles* in the world, approximately 60 are important vectors of malaria (Abeku et al., 2003). Malaria infection is caused by interactions between humans, mosquitoes, and the pathogen. Female mosquitoes change during the egg-laying period when they experience a deficiency in protein and plant sucrose necessary for egg maturation. Consequently, they blood-feed on humans and can infect them after effective biting where infectious protozoans (of the genus *Plasmodium*) are injected into the human bloodstream (Arifin et al., 2014; Harrington et al., 2001).

Female mosquitoes most found in West Africa belong to the *Anopheles* Giles genus (Li et al., 2005). *Anopheles gambiae* (*sensu stricto*) prefers to use human blood (anthropophilic) to complete its gonotrophic cycle, bites primarily indoors (endophagic), and rests indoors (endophilic). As far as its feeding habits are concerned, *An. gambiae* is the major malaria vector in West Africa (Tuno et al., 2010). In addition, there are other vectors, such as *An. arabiensis*, *An. funestus* and *An. melas* able to carry *P. falciparum*. Similar to *An. gambiae*, *An. funestus* is anthropophilic, endophagic, and endophilic (Asare and Amekudzi, 2017; Sinka et al., 2010). On the other hand, *An. arabiensis* is zoophilic (prefers blood-feeding animals), exophilic (bites outdoors), and exophagic (rests outdoors) (Li et al., 2005). *An. melas* is also anthropophagic, exophagic, and exophilic (Tuno et al., 2010). Therefore, *P. falciparum* adapts well to Anopheles species, increasing malarial vulnerability in the host. The wide range of vector conditions, feeding habits, and geographical heterogeneity in malaria transmission make malaria modeling even more challenging (Childs et al., 2015).

A mosquito's ability to adapt to environmental conditions such as humidity and temperature, is influenced by its sensitivity to those conditions. This adaptation can take the form of a change in the life cycle length, or the biting efficiency (Adu-Prah and Kofi Tetteh, 2015; Eikenberry and Gumel, 2018; White, 2018). As a long-term study carried out in Kenya (1999–2010) has shown, vectors' feeding habits and effectiveness can change over time (Mwangangi et al., 2013).

The transmission intensity may differ significantly across host populations because vectors' attraction to the host varies(Busula et al., 2017). This variation is elicited by the difference in human bodies' microflora and their reaction to mosquito bites

(Verhulst et al., 2011). For instance, an infected host is more attractive to other mosquitoes than a non-infected one (Lacroix et al., 2005). Likewise, mosquitoes prefer the scent of children to that of the adults (Busula et al., 2017).

In Zambia major malaria vectors are *Anopheles gambiae, Anopheles arabiensis* and *Anopheles funestus* (Mharakurwa et al., 2012). Zambia has stable transmission throughout the year (Mharakurwa et al., 2012). The burden of the disease follows a seasonal pattern that is dictated by environmental factors including rainfall, vegetation and temperature among others (Mharakurwa et al., 2012). It is lowest during the cold and dry season around June to August and highest during the warm and rainy season from November to April (Mharakurwa et al., 2012). The northern parts of Zambia namely Luapula, Northern, North-western and Muchinga provinces receive the highest rainfall of up to 1200 mm annually and similarly have the highest malaria prevalence of above 20% in children aged below 5 years at the peak of the transmission season (Mharakurwa et al., 2012). The middle parts of Zambia from Eastern, Central, Copper-belt and Western provinces which receive between 800 and 1000 mm of rainfall annually also have low to moderate burden of malaria with prevalence from 10 to 20% whilst the southernmost parts of the country including Lusaka, Southern and the southern parts of Western provinces receive less than 800 mm of rainfall annually similarly have malaria prevalence rates of less than 10% malaria in under five children (Mharakurwa et al., 2012).

2.5. Malaria Pathogenesis and Clinical Signs.

The rupture of the first liver schizont and the release of motile merozoites into peripheral circulation to invade red blood cells marks the start of a possible symptomatic infection (White, 2018). The first rupture and invasion are usually silent in most infected patients, but as the asexual cycle repeats itself in the next 24 to 48 hours, parasitaemia rises, and immune response increases (White, 2018). Higher parasitaemia are generally associated with a more severe clinical picture, but the relationship is very variable (White, 2018).

The most important virulence determinant in *P. falciparum* infection is the parasite´s ability to modify the surface of the infected red blood cell, thus creating an adhesive phenotype. The cytoadhesion is mediated through the *P. falciparum* erythrocyte membrane protein 1(PfEMP1) family, which is the product of var-gene transcription. The cytoadherence of mature-staged infected RBC to the endothelium, platelets, and uninfected red blood cells causes sequestration in the microvasculature of various organs, resulting in microcirculation obstruction, impaired tissues perfusion, lactic acidosis and consequently, end-organ damage (Plewes, 2019). Prominent sequestration occurs in the placenta during pregnancy, causing low birth weight, anemia, miscarriage, and congenital malaria (Milner, 2018).

Malaria can be separated into two disease presentations: uncomplicated and severe (Ashley et al., 2018). The WHO defines the presence of symptoms without clinical or laboratory signs to indicate severity or vital organ dysfunction as uncomplicated malaria (Milner, 2018) Symptoms are generally non-specific, including fever, chills, myalgia, headache, anorexia, and cough, making clinical diagnosis unreliable (Ashley, 2018). Patients occasionally present with gastrointestinal symptoms, respiratory symptoms, and jaundice (Fletcher and Beeching, 2013) The classical malarial

paroxysms with spiking fever, chills, and rigors occurring at specific intervals are relatively uncommon, but if present, indicate an infection with *P. ovale or P. vivax* (Breman, 2009). Progression to severe or ultimately fatal disease is largely confined to *P. falciparum* infections, although only a small percentage, approximately 1% to 2% of infections, lead to severe malaria (Bhatt et al., 2015).

The patient presenting with at least one of the clinical or laboratory features of asexual *P. falciparum* parasitaemia (either detected in the peripheral blood smear or confirmed with rapid diagnostic test) and no other cause of symptoms is being classified as severe malaria (Bhatt et al., 2015).

A shortened list of danger signs is used for rapid clinical assessment, which includes prostration, respiratory distress (acidotic breathing), and impaired consciousness (Ashley, 2018). Other clinical manifestations of severe malaria include multiple convulsions, radiologically confirmed pulmonary edema (respiratory failure due to acute lung injury progressing to acute respiratory distress syndrome), abnormal bleeding (disseminated intravascular coagulation), acute kidney injury, jaundice, shock, and coma (Ashley, 2018).

Children are more likely to present with non-specific and gastrointestinal symptoms such as fever, lethargy, malaise, nausea, vomiting, abdominal cramps, and somnolence (Fletcher, 2013). They are more likely to develop hepatomegaly, splenomegaly, and severe anemia without major organ dysfunction than adults. In a case of severe malaria, they present with more frequent seizures (in 60% to 80%), hypoglycemia, and concomitant sepsis but are less likely to develop pulmonary edema and renal failure than adults (Breman, 2009).

2.6. Malaria Diagnosis.

Once malaria is suspected, it is important to facilitate immediate laboratory testing (Ashley, 2018). It is essential to distinguish between non-falciparum and falciparum malaria(Lalloo et al., 2016). As per the Centers for Disease Control and Prevention (CDC) guidelines, malaria should be routinely suspected in any febrile patient that has a recent history of travel to the endemic areas. The clinical features of either uncomplicated or severe malaria are non-specific, therefore requiring diagnosis by microscopy or rapid diagnostic test (RDT) (Plewes et al., 2019).

A full blood count, urea, creatinine and electrolytes, blood glucose level, and liver function tests should be routinely performed. Thrombocytopenia suggests both non-falciparum and falciparum malaria infections in non-immune adults and children. In severely ill patients, additional studies such as blood gases, blood culture, lactate, and clotting studies are appropriate. In patients with fever and impaired consciousness, one should consider a lumbar puncture to exclude meningitis (Lalloo et al., 2016).

2.6.1. Microscopy.

The golden standard for diagnosis is a microscopic analysis of thick and thin blood smears. Thick smears allow for a sensitive parasitaemia quantification, as parasitaemia as low as 30-50 parasites/microL can be detected, while thin smears enable a determination of the Plasmodium species, prognostic assessment based on the staging of parasite development and estimation of the proportion of neutrophils containing malaria pigment (Plewes, 2019). Three sets of thick and thin blood films spaced 12 to 24 hours apart should be performed by experienced laboratory personnel before a clinician can confidently rule out malaria (Mitchell et al., 2024)

2.6.2. Rapid Diagnostic Tests (RDT).

Rapid diagnostic tests (RDTs) are commonly used in addition to blood slides and are useful alternatives in settings where a microscopic diagnosis is non-reliable or infeasible (Lalloo et al., 2016). They are immune-chromatographic tests that most commonly identify either malaria antigens (e.g., P. falciparum histidine-rich-protein 2 (PfHRP2)) or enzyme called *Plasmodium* lactate dehydrogenase (pLDH). It is recommended that all the RDTs should be followed by microscopy for confirmation and, if positive, quantification of parasitaemia (Gerstenlauer, 2019) Tests have several downfalls as they cannot provide quantitative results, if testing for pLDH, positive only with living parasites in the blood. These tests can stay positive months after infection with *P. falciparum* (Lalloo et al., 2016) .

2.6.3. Polymerase chain reaction (PCR).

Polymerase chain reaction (PCR), PCR-based techniques are a recent development in the molecular diagnosis of malaria, and have proven to be one of the most specific and sensitive diagnostic methods, particularly for malaria cases with low parasitemia or mixed infection (Magnaval et al., 2002) The PCR technique continues to be used extensively to confirm malaria infection, follow-up therapeutic response, and identify drug resistance (Kim et al., 2006). It was found to be more sensitive than QBC and some RDTs (Makler et al., 1998), Although PCR appears to have overcome the two major problems of malaria diagnosis-sensitivity and specificity- the utility of PCR is limited by complex methodologies, high cost, and the need for specially trained technicians. PCR, therefore, is not routinely implemented in developing countries because of the complexity of the testing and the lack of resources to perform these tests adequately and routinely(Kim et al., 2006). Quality control and equipment

maintenance are also essential for the PCR technique, so it may not be suitable for malaria diagnosis in remote rural areas or even in routine clinical diagnostic settings (Utzinger et al., 2002).

2.6.4. Automated blood cell counters (ACC).

Automated blood cell counters (ACC) is a practical tool for malaria diagnosis (De Langen et al., 2006) with 3 reported approaches. The first used a Cell-Dyn-3500 apparatus to detect malaria pigment (hemozoin) in monocytes, and showed a sensitivity of 95% and specificity of 88%, compared with the gold-standard blood smear (Hänscheid, 2003). The second method also used a Cell-Dyn-3500, and analysed depolarized laser light (DLL) to detect malaria infection, with an overall sensitivity of 72% and specificity of 96% (Mendelow et al., 1999) (Mendelow, 1999). The third technique used a Beckman Coulter ACC to detect increases in activated monocytes by volume, conductivity, and scatter (VCS), with 98% sensitivity and 94% specificity (Briggs et al., 2006). Although promising, none of the 3 techniques is routinely available in the clinical laboratory; further studies are required to improve and validate the instrument and its software (Briggs et al., 2006). The accuracy of these methods are promise for detecting malaria parasites, meaning ACC could become a valuable and routine malaria-diagnostic laboratory method (Briggs et al., 2006).

2.7. Malaria Risk Factors.

2.7.1. Social Economic Factors.

Socio-economic factors for malaria risk and burden at regional level include the availability of financial support, availability of insecticide chemicals, availability of antimalarial drugs, availability of diagnostic supplies, human and programme-based resources of individual states to the fight against malaria (Chipoya and Shimaponda-Mataa, 2020). On the other hand, eco-environmental factors such as climate and topographic factors contribute to malaria transmission by affecting the vector and parasite development regardless of the region while other factors like housing structure, proximity of households to vector breeding sites, contribute by facilitating exposure of community members to vectors (Chipoya and Shimaponda-Mataa, 2020).

2.7.2. Rainfall and temperature.

Rainfall mainly contributes to the availability of breeding habitat for mosquito vectors (Kibret et al., 2019). On the other hand, temperature determines the length of development of larval mosquitoes and malaria parasites, as well as the lifespan and the rate of blood feeding of adult vectors (Kibret et al., 2019).

2.7.3. Mosquito Resistance to Insecticides.

Increasing malaria incidence in several areas are mosquito resistance to dichloro diphenyl trichloroethane (DDT) used in indoor residual spraying (IRS), chemical pyrethroids in long-lasting insecticide nets (LLIN) (Lubinda et al., 2021) population movement and environmental factors driven by climate change (Lubinda *et al.*, 2021.

2.7.4. Age and Gender.

Age and gender are the other important factors that are also associated with malaria illness with the majority of malaria illness and deaths occurring in children under the age of five. Studies carried out in Gabon and Tanzania showed that children under the age of five were most at risk in the transmission of malaria (Eisele et al., 2012). In the Tanzania study, males were more at risk of malaria illness compared to females, (Kim, 2012).

2.7.5. Absence of Acquired Immunity.

In Sub Saharan Africa, the burden of malaria amongst under five years of age children varies across various countries. For example, Malaria contributes to more than 30% of under five deaths in Nigeria, and more than 10% in Tanzania (Sarfo et al., 2023). Perhaps, during this period under five are most vulnerable as they have lost maternal immunity and they have not yet developed specific immunity to infection. Besides, children under five years are at highest risk for malaria infection and its related complication. Also that malaria is traditionally more prevalent in rural areas amongst under five years children (Sarfo et al., 2023). In Zambia it has been shown that children under five carry the heaviest burden of malaria, this is because their immune system is not yet fully developed (Chizema-Kawesha et al., 2010).

2.8. Malaria treatment

Malaria therapy is administered using antimalarial drugs that have evolved from quinine. According to its primary effect, antimalarial are divided into pre-erythrocytic (sporozoite and liver-stage), blood-stage, and transmission-blocking drugs (Ummukulsum Mustapha et al., 2023) . Most medications used in the treatment are active against parasitic forms in the blood (the type that causes disease) (Shingadia, 2014). The two crucial antimalarial medications currently used are derived from plants whose medical importance has been known for centuries: artemisinin from the plant Qinghao *(Artemisia annua* L, China, 4th century) and quinine from *Cinchona* (South America, 17th century). Side-by-side with artemisinin, quinine is one of the most effective antimalarial drugs available today (Cowman et al., 2016).

Chloroquine phosphate is the preferred agent if the infection is considered uncomplicated and is caused by chloroquine-sensitive *P. falciparum* and works by inhibiting parasite growth by concentrating within the parasite acid vesicles, thereby raising internal pH. Hydroxychloroquine is also an acceptable first-line treatment of chloroquine-sensitive P. falciparum and has a similar mechanism of action as chloroquine phosphate. (Naß and Efferth, 2018).

Primaquine phosphate is utilized as an add-on agent to either chloroquine phosphate or hydroxychloroquine when infections are caused by *P. vivax* or *P. ovale* with chloroquine sensitivity. This medication works by eliminating the hypnozoites that remain dormant in the patient's liver, which reduces the risk of patient relapse.(Karunajeewa and Berman, 2020).

Atovaquone-proguanil is utilized in infections caused by *P. falciparum* with chloroquine resistance. This combination product acts as an antimalarial as atovaquone selectively inhibits parasite mitochondrial electron transport, and proguanil inhibits dihydrofolate reductase disrupting deoxythymidylate synthesis (Karunajeewa, 2020).

Artemether-lumefantrine is an alternative first-line option for the treatment of malaria caused by chloroquine-resistant *P. falciparum*. The proposed mechanism of action for both agents is to inhibit nucleic acid and protein synthesis. (Hamaluba, 2021).

Quinine sulfate plus doxycycline, tetracycline, or clindamycin is a second-line option for treating malaria caused by chloroquine-resistant *P. falciparum*. Quinine intercalates into DNA, disrupting the parasites' replication and transcription to exert its antimalarial effects (Hamaluba, 2021).

Quinidine gluconate is the drug of choice for suspected severe malaria because it is the only parenterally available antimalarial drug (Kapulu et al., 2021). Severe malaria is characterized by the presence of parasites in the blood and any of the following conditions: altered mental status, seizures, respiratory distress, circulatory collapse, renal failure, anemia, thrombocytopenia, liver failure, and acidosis (Kapulu et al., 2021). The most common causative agent of severe malaria is P. falciparum. Quinidine gluconate acts primarily as an intraerythrocytic schizonticide, with little effect upon sporozoites or upon pre-erythrocytic parasites. Quinidine is gametocidal to *P. vivax* and *P. malariae*, but not *to P. falciparum*. Clindamycin, doxycycline, or tetracycline should be added to quinidine therapy when treating severe malaria in either IV or oral form, depending on the patient's clinical condition (Kapulu et al., 2021).

Doxycycline is indicated for malaria chemoprophylaxis for travel in endemic areas. It is also used in combination with the quinine or artesunate for malaria treatment when Artemisine Combination therapy (ACT) is unavailable or when the treatment of severe malaria with artesunate fails. The disadvantage of doxycycline is that children and pregnant women cannot use it(Kapulu et al., 2021). Due to the global resistance of *P. falciparum* to chloroquine, ACTs are recommended for the treatment of malaria, except in the first trimester of pregnancy. ACTs consist of a combination of an artemisinin derivative that fast decreases parasitaemia and a partner drug that eliminates remaining parasites over a more extended period. The most common ACTs in use are artemether-lumefantrine, artesunate-amodiaquine, dihydroartemisinin-piperaquine, artesunate-mefloquine, and artesunate with sulfadoxine-pyrimethamine (Nabudere et al., 2010) (Nabudere., 2010). The ACTs were very efficient against all *P. falciparum* until recently when numbers of treatment failures raised in parts of Southeast Asia. Atovaquone-proguanil is an option non-artemisinin-based treatment that is helpful for individual cases which have failed therapy with usual ACTs (Price et al., 2009). Although, it is not approved for comprehensive implementation in endemic countries because of the ability for the rapid development of atovaquone resistance, Quinine remains efficient, although it needs a long course of treatment and it is poorly tolerated especially by children. As such, it has to be combined with another drug, such as doxycycline or clindamycin. Uncomplicated *vivax, malariae*, and *ovale* malaria are handled with chloroquine except in case of chloroquine-resistant *P. vivax* when an ACT is used (Ashley., 2018).

2.9. Malaria Prevention and Control

The importance of understanding vector biology and behavior prior to initiating control measures is evident when one considers the key questions that must be answered to determine which type of control measure is best for a given situation (Killeen et al., 2018). Identification of the mosquito species responsible for most malaria transmission involves surveillance, collection, and species identification from various parts of the affected area. Control activities aimed at one important vector species may not be effective against another vector species. For example, insecticide-treated nets may be useful for reducing exposure to mosquitoes biting inside houses but may have no effect on mosquitoes biting primarily outside (Killeen et al., 2018).

Information about the breeding places of vectors is required in determining appropriated control measures. Mosquitoes have diverse breeding habits, some of which may be targeted for control purposes as is the case with larval source management and environmental manipulation.

Differences in the behaviour patterns of adult mosquitoes have a marked effect on their capacity to transmit malaria as well as the choice of control methods used. Preferred time of biting, for example, can vary from daytime to late evening (Killeen et al., 2018). The efficacy of many control measures varies, depending on the mosquito activity cycle. Insecticide-treated bed nets or other control measures that are used indoors, such as space spraying with insecticides, would obviously have little effect on malaria transmission occurring at times when people are not indoors. For example, malaria transmission in much of Southeast Asia is associated with exposure to mosquitoes during activities conducted in the forest (Killeen et al., 2018).

2.9.1. Indoor Residual Spraying.

Indoor residual spraying is the application of long-acting chemical insecticides on the interior walls and roofs of houses to kill adult mosquito resting on these surfaces (World Health Organization, 2008). Studies have shown that IRS is effective in reducing new malaria infections and mortality from malaria (World Health Organization, 2008), and has been implemented as one of the major vector control measure. The use of indoor residual spraying with DDT had played a central role in the success of the 1950s and 1960s WHO-led malaria eradication campaign, and remains the mainstay in the global coordinated effort to control and eliminate malaria (World Health Organization, 2008).

2.9.2. Long Lasting Insecticide Treated Nets

Studies have equally shown that the use of Long Lasting Insecticide Treated Nets (LLIN) is an effective tool in preventing malaria transmission, and has been implemented as one of the main vector control intervention in malaria endemic countries (Giardina, 2014). High coverage and utilization of LLINs is recommended to achieve malaria elimination goals (MoH, 2017). In Ethiopia, vector resistance to the insecticide chemicals on the LLINs, misuse and high bed net loss are the serious challenges of LLINs (Giardina et al., 2014) .

2.9.3. Physical Barrier-House Screening

Poor housing conditions, such as the presence of open eaves or holes allowing mosquito entrance is risk factors for malaria infection (Woyessa et al., 2013). Meanwhile, mosquito-proofed housing can limit the entrance of mosquito into the house and reduce the risk of indoor malaria transmission that occurs before sleeping time (Animut et al., 2013). Among others, screening and a general housing

improvement had been used as supplementary component in the malaria elimination strategy in the developed world (Giardina, 2014).

2.9.4. Ivermectin (IVM)

This is an effective medicine against a variety of parasites and vectors, and is used to treat lymphatic flariasis and onchocerciasis (World Health Organization, 2017). Studies have shown that IVM can kill Anopheles mosquitoes feeding on human blood, and simultaneously it can kill Plasmodium parasites (World Health Organization, 2016). An experimental study on human volunteers showed higher mosquito mortality in the IVM group compared to the control (Chaccour et al., 2013)

2.9.5. Aerosols

Synthetic odour blend consisting of mosquito attractants can attract more mosquitoes than humans, and can be used as means of trapping and killing mosquitoes (Okumu, 2009). This system can attack both male and female mosquitoes, and result in reduction of malaria vector density (Killeen et al., 2017). Studies have shown that an odour-baited station can be used as a trap and the contamination kills mosquitoes escaping the trap shortly afterwards (Okumu, 2010). Male mosquitoes aggregate in swarms, where they compete for the attention of female mosquitoes visiting them in search of a mate. Swarms usually happen at sunset and at locations that can be mapped (Zahar, 1984). A review on space spraying targeting these aggregations with hand-held insecticide aerosol spray was found to be effective (Zahar, 1984). The WHO recommends space spraying in buses, trains and airplanes at their departure from malaria endemic countries as a strategy to prevent re-introduction of malaria into countries where malaria is eliminated (Zahar, 1984).

2.9.6. Larvicides

Chemical larvicides Temephos (Abate) is the most common larvicidal chemical in use in Ethiopia. It is effective and safe for use in water (Karunamoorthi, 2011) (Karunamoorthi, 2011), and a potential complementary tool to control malaria in areas where breeding sites are findable places, such as urban areas, dams, irrigation canals and there developmental areas.

Larval control measure is the use of environmental manipulation to reduce vector breeding sites or use of chemical or biological larvicidal methods to eliminate the larval stage of mosquitoes (World Health Organization, 2014). This could be an important tool to reduce risk of vector biting in low malaria transmission settings, especially those planning to eliminate malaria (World Health Organization, 2014). The WHO recommends larval control measures as complementary to LLINs or IRS in areas where mosquito breeding sites are few, fixed and findable (World Health Organization, 2014). Larval control could use chemical larvicides, biological or environmental methods.

2.9.7. Repellents

Repellent lotions may provide personal protection against outdoor biting mosquitoes, in situations where LLINs or IRS cannot be used. A cluster randomized trial from Ethiopia showed that mosquito repellents are potentially effective to reduce malaria infection (Woyessa et al., 2014). However, a cluster randomized controlled trial in the Greater Mekong Sub-region has shown that mass distribution of repellents did not contribute to reduction of malaria (Sluydts et al., 2016).

Charter Three

3.0. Materials and methods

3.1. Study Area

The study was conducted in Senga Hill District, one of the twelve administrative districts of Northern Province. The district is approximately 175 kilometres from Kasama, the provincial headquarters and 68 Kilometres from the nearest Mbala district. It borders the Republic of Tanzania, and Mbala districts to the north, Mungwi to the south, and Nakonde to the east, Kasama to the south west and Mpulungu to the North West. It has a population of 126,308 according to the population census of 2022, (ZDHS, 2022) with a population growth of 2.8 per annum. The district is divided into 31 Catchment areas with Mambwe Mission being the central catchment area. The district has an estimated number of 27470 under five children,(ZDHS, 2022).

The study was conducted in four catchment areas (community level) of Senga Hill District. These were Senga and Nondo (pri-urban catchment areas), Mambwe and Mpande (rural catchment areas). The four targeted catchment areas were selected using simple random sampling.

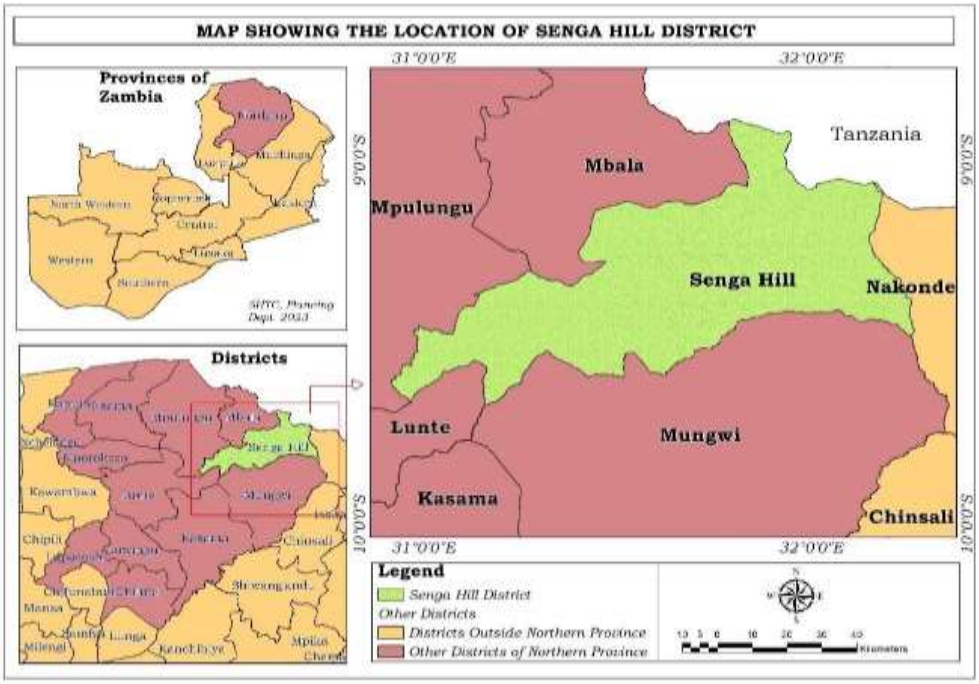

Figure 3; Location of Senga Hill District

3.1.2. Research Design

A cross-sectional study-design was conducted in Sanga hill district between November 2022 and August 2023.

3.1.3. Study Population and Eligibility Criteria

The population consisted of under-five (5) children who were residence of Senga Hill district and have lived or stayed in the area for more than 6 months. Only children whose guardians or parents signed a written consent form (appendices III) were included in the study. Since the parasite is believed to be eliminated from the blood after 42 days of treatment and re-infection is possible beyond that. Children who had received antimalarial chemotherapy 42 days prior to data collection were not included in the analysis (World Health Organization, 2009).

3.1.4. Sample Size

The sample size was determined using single population proportion formula of Dobson formula (Charan and Biswas, 2013). The sample size was estimated assuming the 85% malaria prevalence for Senga Hill (MoH, 2021), 95% confidence level, 5% margin of error, and 10% non-response rate. The sample size was calculated as follows:

$n= Z^2 \times p (1-p) /d^2$

Where n = the sample size, $Z_1-\alpha/2$ = the Z-value at a given confidence level, P = estimated prevalence of malaria in the study population, d = margin of error or sample error. Therefore, sample size was calculated as

$n = (1.96)^2 \times (0.85) \times (0.15) / (0.05)^2$ n = 196.

A sample size of 216 children was calculated as the sample required with the malaria prevalence at 85%. The absolute precision used is 0.05 and a 95% confidence level (1.96). A minimum sample size of 196 was adjusted for none response at 10% giving 216 children to be sampled.

Based on the number of under-five children in each catchment area, the sample was proportionally allocated to each catchment area. Then, under-five children were sampled by using simple random sampling from each catchment.

Table 1; Sample Size Allocation

Catchment Area	U5 Catchment Population	Sample size Proportion by catchment	Sample size Allocation
Senga	3022	(7432/3022) 2.46	87
Mambwe	1511	(7432/1511) 4.91	44
Nondo	1496	(7432/1496) 4.96	44
Mpande	1401	(7432/1401) 5.31	41

Total	***7432***	***216***

3.1.5. Data Collection

Data was gathered at community level in the respective catchment areas. Simple random sample techique was employed to select the study participants to be interveiwed.

Following consent and enrolment of the child into the study, data was collected from the guardian or caregivers of the under-five children by face-to-face interview using a questionnaire (appendices II). Information on socio-demographic characteristics, ITN condition and availability, ITN utilization, IRS, presence of stagnant water within 500m of HH, child outdoor stay beyond 19 hours, housing condition, and health information about malaria was collected using a questionnaire. The questionnaire was pre-tested to determine the quality of data to be collected. The pre-test was done at Chikunta Catchment area (not part of the study sites) that has similar population characteristics to the target catchment areas in this study.

Data on ITN utilization was measured by asking the caregivers whether the under-five children slept under ITN during the night preceding the survey or not. The conditions of the ITN were assessed by asking for presence of any holes and age of the ITN currently used. Caregivers were also asked whether their houses got IRS service in the last six months or not.

Data on travel history was obtained by asking specifically when they had last travelled out of their district or crossed borders.

A malaria test was subsequently done by a prick on the finger or big toe aseptically. This was performed using sterile lancets, and 5 ml of whole blood sample was

collected using a capillary tube from each child regardless of whether they had signs and symptoms of malaria. The blood sample test was done by medical laboratory professional (laboratory technologists).

The blood sample were tested immediately using Care Start^{TM} Malaria RDT which detect histidine-rich protein 2 (HRP2) of *Plasmodium falciparum* and *plasmodium* lactate dehydrogenase (pLDH) of *Plasmodium vivax* (Gerstenlauer, 2019). According to th manufacturer, the sensitivity and specificity of the RDT is 98% and 97.5% respectively (Lalloo, 2016).

3.1.6. Data quality assurance

Several strategies were used to maintain the quality of the data. Initially, field assistants (data collectors) received training to ensure that they shared a consistent knowledge of how to gather the necessary demographic data. Secondly, the laboratory technologists collected blood samples and performed RDTs. A discussion was held regarding the application of standard operating diagnostic procedures. The team members cross-checked each filled questionnaire to ensure that they were accurate, consistent, and comprehensive. Where necessary, corrective action was performed. Additionally, basic codes were used to organize / marked all of the sampled houses.

3.1.7. Data Analysis

Data was initially entered into MS Excel spreadsheets then transferred to SPSS-V20 software for analysis. Frequencies and proportions were then generated for each independent variable. Chi-Square ($\chi 2$) test was used in the bivariate analysis to determine association between categorical variables. All variables that had p-values

less than or equal to 0.250 in the bivariate analysis were included in the binary logistic regression model using a backward Stepwise (Likelihood Ratio) method. The omnibus test for model coefficients and the Hosmer and Lemeshow test was used to assess that the model-fitted the data. All statistics were considered significant at $p \leq 0.050$.

3.1.8. Ethical approval

The study was ethically approved by ERES Converge Ethics Committee (Ref. No. 2023 -Oct-006) (Appendices-V), National Health Research Authority (Ref. No. NHRAR-R-2002/30/09/2023) (appendices-VIII) and Operational ethical approval was sought from the Senga Hill DHO (appendices-VI). Verbal assent from the children and written consent from the caregivers or families were taken before data collection. In addition to these, a simple oral explanation of the study was offered to the guardian / caretaker of the child before performing study-related procedures. Children with tests that returned a positive malaria result were referred to the health centre in the catchment area for appropriate treatment. The confidentiality of study subjects' identity of the participants were not used.

Charter Four

4.0. Results

4.1. Socio-demographic characteristics

A total of 216 study participants were included in the study. Among the study participants, 55% were female with a mean age of 2.38 months. Among these, 27% were less than one year old. Majority of them 40% were from Senga catchment area (Community). About 41% of the households reported having only one (1) under five child. Regarding mother or caregiver related socio-demographic characteristics, majority of them 85% were married, 40% had no formal education and 45% reported having no monthly income, Table 2.

Insecticide-treated bed net was the most commonly mentioned malaria prevention measures reported by 52% of the respondents. Eighty of the households reported using an ITN with an average of 1.87 mosquito nets per household. Households who reported having ITN, 59%, 17% and 0.1% of them possessed one, two and three ITNs respectively. One Hundred fifty seven (48%) of them reported that their ITN was torn / or damaged, Table 2.

In this study, 18.5% of the parents/caregivers had not attained any formal education, whereas a total of 81.0% parents/caregivers had knowledge that mosquitoes were the vector for malaria transmission, the remaining (19.0%) had misconceptions about the mode of transmission. Furthermore, a majority (73.0%) of the guardians reported seeking treatment at least within 24 hours after the onset of fever (Table 2).

Table 2; Socio-Demographic Characteristics of Under-Five Children in Senga Hill District, Northern Province Zambia.

Variables	**Categories**	**n**	**(%) (95% CI)**
Childs Location	Senga	87	40.0(34.0, 47.0)
	Mambwe	44	20.0(15.0, 26.0)
	Nondo	44	20.0(15.0, 26.0)
	Mpande	41	19.0(14.0, 25.0)
Gender of the Child	Male	98	45.0 (39.0, 52.0)
	Female	119	55.0 (48.0, 61.0)
Age of Child (months)	<12	59	27.0 (22.0, 33.0)
	’12-23	59	27.0 (22.0, 33.0)
	24-35	55	26.0 (20.0, 32.0)
	36-47	43	20.0 (15.0, 25.0)
U5-Population/HH	one	88	41.0 (34.0, 47.0)
	Two	77	35.0 (29.0, 42.0)
	Three & above	51	24.0 (19.0, 30.0)
Number of Sleeping Spaces per Household	One	14	6.4 (4.0, 11.0)
	Two	104	48.0 (42.0, 55.0)
	Three & above	98	45.0 (39.0, 52.0)
Travel History	Two weeks ago	7	3.2 (2.0, 7.0)
	Three weeks ago	14	6.5 (4.0, 11.0)
	A month ago & more	103	48.0 (41.0, 54.0)
	Not travelled	92	43.0 (39.0, 49.0)
Educational Status of caregiver	College & above	9	4.2 (2.0, 8.0)
	Secondary	39	18.0 (14.0, 24.0)

	Primary	128	59.0 (52.0, 65.0)
	No formal education	40	19.0 (14.0, 24.0)
Marital status of caregiver	Married	183	85.0 (79.0, 89.0)
	Not married	30	14.0 (10.0, 19.0)
	Widow	2	0.9 (0.0, 2.0)
	Divorced	1	0.6 (0.0, 3.0)
Income Status of caregiver-Monthly (ZWK)	No Formal income	45	21.0 (16.0, 27.0)
	<K200	103	48.0 (41.0, 54.0)
	Between K200-K500	36	17.0 (13.0, 23.0)
	K500 & above	32	15.0 (11.0, 20.0)
Number of ITN per Household	One	137	63.0 (57.0, 69.0)
	Two	36	17.0 (13.0, 23.0)
	Three & Above	10	4.6 (3.0, 8.0)
	No ITN	33	15.0 (11.0, 21.0)
Sources of ITNs	Self-Procured	14	6.5 (3.0, 10.0)
	GRZ Mass Distribution	142	65.0 (59.0, 71.0)
	NGO Supplied	27	13.0 (9.0, 18.0)
	No ITN	33	15.0 (11.0, 21.0)

Caregiver Knowledgeable on malaria transmission & Prevention	Yes	175	81.0 (75.0, 86.0)
	No	41	19.0 (14.0, 25.0)
Caregiver Health Seeking Behaviour	Yes	158	73.0 (67.0, 79.0)
	No	58	27.0 (21.0, 33.0)

4.2. Malaria prevalence and risk factors associated with it

The overall prevalence of malaria among under-five children in Senga Hill District was 31.9%. Children in the age group 12-23 months had the highest prevalence of malaria (27.6%) followed by the age groups <12 months (27.2%) while those aged between 24-35 were third highest (25.3%) and the least were older children aged 36-47 months (19.8%)(Table 3).

Table 3: Bivariate analysis of factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.

Variable	Category	n	% (95CI)	P-Value
Childs Location	Senga	87	14.8 (10.36, 20.27)	
	Mambwe	44	5.6 (2.90, 9.50)	0.599
	Nondo	44	6.5 (3.59, 10.64)	
	Mpande	41	5.1 (2.57, 8.93)	
Gender of the child	Male	98	20.8 (15.62, 26.87)	<0,001
	Female	118	11.1 (7.26, 16.08)	
Age of the Child (months)	<12	59	7.4 (4.29, 11.75)	
	13-23	59	8.8 (5.38, 13.40)	0.615
	24-35	55	7.9 (4.65, 12.30)	
	36-47	43	7.9 (4.65, 12.30)	
U5-Population / HH	One	88	10.6 (6.87, 15.55)	0.313
	Two	77	13.0 (8.79, 18.19)	
	Three & above	51	8.3 (5.01, 12.85)	
Number of sleeping spaces / HH	One	14	1.4 (0.29, 4.01)	0.654
	Two	104	15.3 (10.76, 20.78)	
	Three & above	98	15.3 (10.76, 20.78)	
Educational status of caregiver	College & above	9	2.3 (0.76, 5.32)	
	Secondary	39	6.0 (3.24, 10.07)	0.449
	Primary	128	17.6 (12.76, 23.34)	
	No formal Education	40	6.0 (3.24, 10.07)	

Income status caregiver monthly (ZWK)	No formal income	45	6.0 (3.24, 10.07)	
	< K200	103	13.9 (9.57, 19.23)	0.610
	Between K200-K500	36	6.5 (3.59, 10.64)	
	K501 & above	32	5.6 (2.90, 9.50)	
Number of ITNs / HH	One	137	16.7 (11.29, 22.32)	
	Two	36	8.3 (5.01, 12.85)	0.030
	Three & above	10	0.9 (0.11, 3.30)	
	No ITN	33	6.0 (3.24, 10.07)	
ITNs used last night	Yes	115	15.3 (10.76, 20.78)	0.275
	No	101	16.7 (11.95, 22.32)	
Daily use of ITN	Yes	146	17.6 (12.76, 23.34)	0.007
	No	70	14.4 (9.96, 19.75)	
Correct ITN use	Yes	148	14.8 (10.36, 20.27)	<0.001
	No	68	17.1 (12.36, 22.82)	
Tear on ITN	Yes	157	25.9 (20.22, 32.27)	0.055
	No	59	6.0 (3.24, 10.07)	
IRS done last spray-season	Yes	81	8.3 (5.01, 12.85)	0.018
	No	135	23.6 (18.11, 29.85)	
Overgrown grass within 500m of HH	Yes	80	11.1 (7.25, 16.08)	0.638
	No	136	20.8 (15.62, 26.87)	
waterbodies within 500m of HH	Yes	83	13.0 (8.79, 18.19)	0.656
	No	133	19.0 (19.98, 24.86)	

Materials of structure for HH	Cement Blocks	9	3.7 (1.61, 7.17)	<0.001
	Burnt Bricks	182	24.5 (18.95, 30.88)	
	Mud & Sticks	25	3.7 (1.61, 7.17)	
Child outdoor stay after 19 hours	Yes	86	15.7 (11.15, 21.30)	0.052
	No	130	16.2 (11.55, 21.81)	
Caregiver Knowledgeable on malaria prevention & treatment	Yes	175	24.1 (18.53, 30.34)	0.146
	No	41	7.9 (4.65, 12.30)	
Cultural / beliefs attributed to poor health seeking behaviours	Yes	109	16.2 (11.55, 21.81)	0.958
	No	107	15.7 (11.15, 21.30)	
Community Factors attributed to poor health seeking behaviour	Yes	133	21.8 (16.45, 27.86)	0.176
	No	83	10.2 (6.49, 15.01)	
Caregiver health seeking behaviour	Yes	158	25.0 (19.37, 31.33)	0.245
	No	58	6.9 (3.94, 11.20)	

Chi Square Test of Association

The results in Table 3 shows that the gender was significantly associated with positive malaria RDT test result (^{p} = < 0.001). Further, correct use of ITN and households that reported IRS services the previous season had significant low malaria prevalence on RDT test than those that did not (p = < 0.001) and (p = 0.018) respectively. Daily ITN use equally showed a significant reduced malaria prevalence, than those that did not use nets daily (p = 0.007). However, the age of the child, number of sleeping spaces

per household and educational status of the caregiver were not significantly associated with positive malaria prevalence. Similarly, Child outdoor stay after 19 hours and tear on ITN showed no association with malaria prevalence. Overgrown grass within 500m of the household also showed no association with malaria prevalence.

Caregiver/guardian knowledge status on malaria transmission & prevention, cultural/beliefs attributed to poor health seeking behaviour and community factors attributed to poor health seeking behaviour were not significantly associated with associated with malaria prevalence in the under-five children in Senga Hill District.

4.3. **Predictors of under-five children being positive for malaria**.

The Omnibus test of model coefficient was significant ($P < 0.001$) and the Hosmer and Lemeshow test was not significant ($p=0.853$), indicating that the model fitted the data. The maximum likelihood estimates obtained from the logistics regression analysis are shown in Table 3.

Four variables were found to be significant predicators of malaria in under-five children in Senga Hill District. The odds of being positive for malaria were 0.089 times less in those who used ITNs correctly than those who that did not. Those who reported having IRS service for mosquitoes previous season were 0.375 times less likely to be positive for malaria than those that did not. Being a boy increased the odds of being positive for malaria than being a girl. Children from households that reported to have a single ITN (OR = 0.354) had less odds of malaria than those that had none. While households with three or more ITNs were found to have increased odds of positive for malaria than those that reported to have no ITN. The other variables were not significant predictors of under-five children being positive to malaria in under-five children in Senga Hill District.

Table 4; Maximum-likelihood estimates of factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.

Variables	Categories	n	odds Ratios	95% CI for OR	p-value
Gender of Child	Male	98	3.035	1.518, 6.068	0.002
	Female	118			
Correct ITN use	Yes	148	0.089	0.034, 0.232	<0.001
	No	68			
IRS done last Spray-season	Yes	81	0.375	0.178, 0.789	0.01
	No	135			
Number of ITNs / HH	One	137	0.354	0.141, 0.891	0.028
	Two	36	0.797	0.147, 4.325	0.792
	Three & above	10	7.366	2.299, 23.598	0.001
	No ITN	33			

Charter Five
5.0. Discussion

Malaria is a serious public health issue that affects the health status of many people in tropical and subtropical regions of the world, including Zambia. It is important that the drivers of the burden of the disease at local level are understood so that preventive and control measures are planned and implemented. This study therefore aimed at estimating the prevalence and determination of risk factors that are associated with the malaria amongst under five children in Senga Hill District Northern Province of Zambia. The study found that malaria prevalence was lower compared the previous study findings of 48.1% and 61.3% in Chiengi and Puta Districts, respectively, of Luapula Province, Zambia (Chisompola et al., 2024). One possible explanation for the high prevalence in this study could be the different study period. Different local malaria parasite epidemiology and variations in the way malaria intervention efforts are implemented could also be a reason (Central Statistical Office (CSO) [Zambia], 2018). The prevalence estimate from this study was however, more than that reported from another study in Choma District, Southern Province, Zambia, that ranged from 2.1 percent to 3.9 percent (Ippolito et al., 2022).

Long Lasting Insecticide Treated Nets.

The risk of contracting malaria infection was higher among children who reported to be from households that did not use ITNs. This result is consistent with earlier research conducted in Zimbabwe (Mugwagwa et al., 2015), that showed children from households without ITNs had a higher risk of contracting malaria infection. ITN usage is largely dependent on access (Koenker et al., 2018).

Households that reported having a single ITNs had reduced odds of malaria in under-five children compared to those whose households reported not having ITN. Results

are consistent with studies including a cohort study from Kenya in which ITN use was associated with a 44% relative reduction in malaria risk among under-five children (Fegan et al., 2007) and a study from Tanzania in which the estimated protective efficacy of ITN use was 27% among children under five years old (Schellenberg et al., 2001). Nevertheless, the percentage of children using ITNs in this study was still below the World Health Assembly (Korenromp et al., 2003) and Ministry of Health target of 80% for an acceptable level of protection. Low rates of bed net usage reported by communities in the tropics are attributed primarily to lack of sufficient nets to cover all household members (Tchinda et al., 2012) but also to heat discomfort associated with poor airflow caused by bed nets (Von Seidlein et al., 2012).

Households that reported incorrect use and/or use of worn out ITNs had an increased odds of being positive for malaria amongst under-five children compared to households reported correct use of ITN. These results are consistent to recent findings from a study in western Kenya that reported that lack of protective effect by ITN that was attributed to the state and conditions of the ITNs (Githinji et al., 2010). This is in line with earlier research conducted in the East Shewa zone of the Oromiya regional state and Southern Ethiopia (Haji et al., 2016) which showed that households that reported incorrect use and/or use of worn out ITNs had an increased odds of having malaria positive under-five children. Additionally, this is consistent with existing literature on ITNs reducing malaria transmission, a recent systematic review and meta-analysis of 11 studies in Ethiopia found that the use of ITNs was associated with lower odds of malaria (Biset et al., 2022). ITN use is protective against malaria for individuals using them, especially in Africa where the primary vectors are endophagic and anthropophilic mosquitoes (Takken et al., 2024).

Gender was significantly associated with increased risk of malaria. Male children had a high odds of being positive for malaria compared to female children. This findings is in agreement with reports from the Ministry of Health in Zambia which show that the annual incidence of malaria for males was 447 cases per 1000 population, while for females this was 413 cases per 1000 population in the year 2020 (MoH, 2021). Furthermore, data from the same Ministry indicates that the malaria inpatient case fatality rate (CFR) reported among children were at 7.2/1000 population and 6.0 / 1000 population for male and female children respectively (MoH, 2021).This result is also consistent with earlier study conducted in Nsanje District in Malawi, which also showed that there were more malaria cases in males (51.4%) than in females (48.6%) (Gondwe et al., 2021). The lack of predominance of males (45%) in the study population compared to female children may suggest potential gender-related health disparities or differences in healthcare-seeking behaviour. However, another study in Zambia specifically on health-seeking behaviour did not find any significant differences between boys and girls for common childhood illnesses (Apuleni et al., 2021). The sex of the child was not statistically associated with the risk of malaria similar to other studies on malaria in other countries such as Nigeria, a country with the highest malaria burden in sub-Saharan Africa (Isiko et al., 2024). Potential explanation could be the difference in population proportions between males and females and also households tasks which differentially expose male and females to malaria (Isiko et al., 2024).

Households that reported not having been sprayed in the last 12 months had increased odds of under-five children for being positive malaria compared to those whose households reported receiving the service within the same period. This finding is in

line with the previous studies done in Nchelenge district of Northern Zambia (Nambozi et al., 2014) and a secondary analysis of Zambia Malaria Indicator Survey 2018 (Central Statistical Office (CSO) [Zambia], 2018), (Tembo et al., 2024). Children who sleep in rooms that have been sprayed in the last six months were about 68% less likely to be infected with malaria than children who did not (Mabaso *el al.*, 2004), all else being equal. This finding supports similar evidence (Mabaso *et al.*, 2004) that IRS significantly reduces the incidence of falciparum malaria.

It is important to note that Senga Hill District borders the Republic of Tanzania, with substantial population movements across the borders, and is difficult to reach due to poor terrain, possibly explaining the low coverage of control interventions.

.**Limitations of the study**

Restricted logistics (financial resources) and absence of electricity in three of the four catchment areas, the gold standard test (microscopy) for diagnosing malaria in the laboratory was challenge. Quality controls (10% of 216 tests) of all the tests were performed at Senga District Hospital adding to the high cost of Transport and time for implementation of study.

Charter Six

6.0. Conclusion and Recommendations

6.1. Conclusion.

This study revealed a high prevalence of malaria among under-five children of 31.9%. In this study, the risk factors associated with malaria cases amongst under-

five children in Senga Hill District were non availability of ITNs at household level and incorrect use of ITN. Others risk factors were low coverage of IRS services and (Gender) male under-five children.

6.2. Recommendations

1. Ministry of Health should strengthen a community Neighbourhood Health Committees for health education purposes on correct ITN use and the importance and benefits of IRS as of the key health concerns.
2. Ministry of Local Government and Housing to focus on community lead indoor Residual House Spraying (Community level). This is to ensure 100% coverage of all eligible structures.

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Charter Seven

7.0 Appendices

Appendices I; Information Sheet

PREVALENCE AND FACTORS ASSOCIATED WITH MALARIA AMONGST UNDER-FIVE CHILDREN IN SENGA HILL DISTRICT, NORTHERN PROVINCE ZAMBIA.

Information Sheet

The information sheet is for mothers/caregivers with children under five years of age that have been invited to participate in a study entitled "Prevalence and Factors Associated with Malaria Amongst Under-Five Children in Senga Hill District, Northern Province Zambia".

Introduction:

My names are **Arthur Shaba Santu**, a student of MSc in One health Analytical Epidemiology (MSc OHAE), sponsored by African Centre on Infectious Diseases for Humans and Animals (ACEIDHA), at the School of Veterinary Medicine, The University of Zambia (UNZA), studying the Prevalence and factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.

Main objective and purpose:

The objective of the cross section study is to determine the Prevalence and factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.

Senga Hill is one of the 12 districts of Northern Province that has a high malaria burden of above 80% in children aged below 5 years. Determinants of malaria range from biological, socio-economic and eco-environmental and they vary over space and time.

For this reason, this questionnaire will capture the factors which can contribute to the transmission of the disease in addition to the determination of disease prevalence.

Type of Research Intervention

The study will require your participation in an interview/ Malaria testing of the U5 child using the laboratory confirmation–Malaria RDTs through finger pick-blood sample technique that may take about 30 minutes only.

Procedure and methods:

The study will involve asking questions about you and your family especially the U5 child on malaria illness experiences. The locally based-translated information sheet and consent form will be read for those have challenges understanding the English vision-documents. Those with vision impairment and the deaf, consent will sort from abled caregivers only. Additionally, In order to ascertain the child status, a finger pick-blood sample will be taken from the child and have an on spot (laboratory confirmatory technique) Malaria test using Care Start^{TM} Malaria RDT (which detect histidine-rich protein 2 (HRP2) of Plasmodium falciparum and plasmodium lactate dehydrogenase (pLDH) of Plasmodium vivax). All study related injuries will be managed by qualified staff members (Nurse) of the research team.

Voluntary participation

Your participation in this study is entirely voluntary. Therefore, you are free to either take part or not take part.

Confidentiality:

Be advised that anything you tell us is going to be treated as confidential and will not be

Personally attributed to you in any reports that result from this interview. All of our reports will be written in a manner that no individual comment can be attributed to a particular person.

Sharing of results

The information to be collected will not be shared with or given to anyone except among the

Research team and university of Zambia. The information will also be shared with you through the Ministry of Health.

Right to refuse or withdraw

You have the right to refuse to participate or to withdraw from the study at any time of the

Interview.

Ethical approval:

The study protocol will be approved by the University of Zambia, ERES Converge IRB and Zambia Health research Authority NHRA. Confidentiality, anonymity shall be ensured. Consent will be sought from parents or guardians of the children.

Risks

There are not risks in this study. But in case you feel some information is personal or confidential, you are free to tell us. Finger prick Blood samples will be collected by professional health workers in sterile environment and we do not expect you to have any problems (this shall be explained to the guardian prior to the test conducted) The finger prick for malaria tests will be done on the 4^{th} finger on the child's hand, clean the finger with the alcohol swab, allowed to dry before pricking with a sterile lancet. An alcohol swab will then be placed firmly on the finger to stop any blood flow. The child's participation in this study is in line with normal malaria diagnostic procedure of the MoH and will not affect the child daily routine activities in any way.

Benefits:

Although the findings of this study may not immediately benefit you, it is anticipated that it will help regulatory institutions such as Ministry of Health, (MoH) and cooperating partners in decision making with regards to public health policy on malaria disease in children under- five years of age (to scale up and design appropriate intervention for Malaria control programs and ultimately Malaria elimination in the district). The other benefit is that those with malaria positive test results will be given referral forms and directed to immediately to the nearest Health care facility. Above all, caregivers whether they have participated or not in the study will be advised on the malaria preventive package - measures available for you and your family

Incentives:

You will not be provided with any incentives to take part in this assessment except above benefits.

Who to contact

If you have any questions, you may ask me now or later. If you wish to ask questions later, you may contact the Principal Investigator on the following address:

Santu Shaba Arthur
The University of Zambia
Department of Disease Control
School of Veterinary Medicine
P. O. Box 32379
LUSAKA.
Cell 0950982205/0973026029.
E-mail: santu.tulani@yahoo.com
Or

The Assistant Dean

UNZA School of Vet

Disease Control Department

P.O Box 50110

LUSAKA.

You may also contact

The Chairperson

ERES Converge IRB

Plot No. 272, Cnr Olive Tree Meanwood Road,

Cell: 0955 155 633/ 0955 155 634

Email: eresconverge@yahoo.co.uk

Or

The Director

National Health Research Authority

Lot No. 18961/M in Chalala, off Kasama Road

Email: www.nhra.org.zm

Appendices II; Informed Consent Form

I confirm that I have read/have been explained to me the information sheet above concerning the study and have had the opportunity to ask questions and have had these answered satisfactorily. I understand that my participation is voluntary and I am free to withdraw consent at any time, without giving a reason, without my legal rights being affected. I give permission for these individuals to have access to relevant information and I agree to participate in the survey.

Name of Participant……Date:…….Time:

Signature:……..……Or thumb print of the participant:

Name of Data collector:……Time:……..

Person to contact for problems and queries;

Santu Shaba Arthur
The University of Zambia
Department of Disease Control
School of Veterinary Medicine
P. O. Box 32379
LUSAKA.

Cell 0950982205/0973026029
E-mail: santu.tulani@yahoo.com

You may also contact;

ERES Converge for more information on the purpose of the study in-relation to your rights and privileges for participating in the study.

ERES Converge IRB
Plot No. 272, Cnr Olive Tree Meanwood Road,
Cell: 0955 155 633/ 0955 155 634
Email: eresconverge@yahoo.co.uk

Or

The Director

National Health Research Authority

Lot No. 18961/M in Chalala, off Kasama Road

Email: www.nhra.org.zm

Appendices III; Questionnaire for Malaria Respondents.

QUESTIONNAIRE

Questionnaire #: _____ Date: _____

RHC/Catchment Area: _____ Household No: _____

Interviewer: _____ Respondent code: _____

Instructions

1. This research questionnaire is targeted at U5 children through Care—takers/guardians
2. Place respondents answer or code in the box / space alongside each question.
3. If the space is not adequate for other specified answers use the back of the page and number the response accordingly.
4. Fill in all the spaces provided for in this questionnaire.
5. Where there respondent is not sure in put the code 99.

Table 5; QUESTIONNAIRE

S/N	Questions	Respondent Category	code

Section A. Socio-demographic characteristic			
Now I am going to ask you some general questions about the child			
A1	Sex of child	(1)Male (2) Female	
A2	Age (Months) of child	(1) <12, (2) 12-23 (3) 24-35 (4) 36-47 (5) 48-59	
A3	Total number of Household members at Childs home?	(1)One (2)Two (3) Three And Above	
A4	Total number of U5 children at child's home?	(1) One (2) Two (3) Three And Above	
A5	Number of sleeping spaces available?	(1) One (2) Two (3) Three And Above	
A6.	When last did you travelled out of the district or crossed borders with the child?	(1) Two weeks ago (2) Three weeks ago (3) A month ago (4) None of the above	
A7.	Education status of caregiver	(1) (1)College & Above (2) Secondary (3) Primary (4) No Formal education	
A9.	Marital status of care-giver	(1) Married (2) Not married (3) Divorced	

		(4) widowed	
A10.	Income status of caregiver Monthly	(1)No income (2) ≤ K200 (3) ≤ K500 (4) K500 and above (5) Not sure	
Section B. Practice of the respondent on ITN and IRS **(ITN availability and use age)**			
Am now going to ask you some question on the availability and use age of mosquito nets			
B1	How many ITN do have at this household?	(1)One (2)Two (3) Three And Above (4) non	
B2	How many ITNs are currently hanged?	(1)One (2)Two (3) Three And Above (4) No ITN	
B3	What is the source of the ITNs?	(1)Self-procured (2)GRZ (3)NGO (4) No ITN	
B4	Did the child sleep under the Insecticide Treated Net last night?	(1) (1)Yes (2) (2) No	
B5	Who else is current using the ITNs in the household?	(1)Parents	

		(2)Children (3)Visitors (4) No ITN	
B6	How frequent is the child sleeping under the Insecticide Treated Net?	(1) Every Night (2) Seasonally (3) When Mosquitoes Are Seen In The House (4) No ITN	
B7	Is the Insecticide Treated Nets used Correctly?	(1) **Yes**- Hang and draw (2) **No**- Use as blanket and or Use as curtains in doors, windows.	
B8	Does sleeping under an Insecticide Treated Net cause you any problem?	(1) (1)Yes (2) (2) No	
B9	If YES, what is the major problem?	(1)Causes-heat (2)Suffocation If other,(specify)____	
B10	Is there any holes or tear on the ITN used by the child	(1) Yes (2) No	
B11	Was the house Sprayed during the previous indoor residual spraying program	(1)Yes (2) No	
Section C. (Home Environment) Am now going to ask you question on the environmental conditions of your home			
C1.	Are there any Water practices creating potential breeding sites within 500m of the household?	(1)Yes (2) No	
C2	What type of water practices creates potential breeding sites near your home?	(1) Dump Site (2) Fish Ponds (3) Construction sites (4) Irrigation sites	

		(5) None of the above	
C3.	What is the main source of water for the household?	(1) River (2) Well (3) Borehole (4) Tap	
C4.	Is there any permanent stagnant water body near the house (Within 500 m)?	(1)Yes (2) No	
C5.	Is there any over-grown vegetation near the house?	(1)Yes (2) No	
C6.	What materials is the main house contracted of?	(1) Cement blocks (2) Burnt bricks (3) Stick and mud	
C7.	Is there any Presence of hole in the walls of the house?	(1)Yes (2) No	
C7.	Doses the child stay out-door in the evening beyond 19 hours?	(1) Yes (2) No	
Section D. (Knowledge level)			
Am now going to ask you question on the disease malaria			
D1	Caregiver/guardian knowledgeable on malaria transmission & prevention	(1) **Yes** -(Mosquito bite), Not using ITN, Not having house sprayed) (2) **No** - (Drinking un boiled water, bad season, Getting soaked by rains and No sure)	

D2.	How soon do you seek treatment when your child has fever?	(1) **Yes**- One day (within 24 h) (2) **No**- 2 – 3 days, 4 – 6 days, 7 days or more	
D3.	When last did the child have fever?	(1) A week ago (2) Two weeks ago (3) A month ago and more (4) Don't remember	
D4.	How frequent should one use the Insecticides Treated Nets?	(1)Every night (2)Seasonally (3)When mosquitoes are seen in the house If other, (specify)_____	
Section E. **(Institutional level)**			
Am now to ask some questions on health service provision			
E1	Do Community factors seek as Distance to facility, long waiting time and Negative attitude of health providers attributed to poor health seeking behavior?	(1) Yes (2) No	
E2.	Do Cultural factors such as Misconceptions on Malaria, Value attached to Malaria (Community norm) or Cultural beliefs attributed to poor health seeking behavior	(1) Yes (2) No	

I would like to sincerely thank you for your time and honest Reponses to this research questionnaire.

THANK YOU.

Appendices IV; IBULA - LYAKWISHIBILAPO

IBULA - LYAKWISHIBILAPO

Ukuilondolola

Ishina lyandi nine Arthur Shabasantu umusambi ya MSC mwisukulu ya One Health Analytical Epidemiology (MSC-OHAE), ukutungililwa naba Africa Centre patya infectious diseases mu bantu namu nama (ACEIDHA) pesukulu lya lyafitekwa, pa isukulu likalamba mu calo cesu (UNZA), epo ndesambilila ifisa amalwele no netilenga ubulwele bwa mpepo (malaria) kuli bana aba shilafika paamuushiku ya myaka isa-no.

Icikomo ne ubukankala

Icinkakala bwa icicipututulwa kushiba ifyo ukulwele bali ne filenga ubulwele bwa mpepo ku bana mushinku ya myaka ishila fika isano mu Senga hill district an mu northern province ya mu calo cesu Zambia.

Senga Hill District yaba mu pa ma District e ikuni lino na fibili mu northern province. Iya tebelelwa no bulwele bwa mpepo ukucila 80% ku abana aba shilafika pashinku ya myaka isano. Ubu bulwele bwa mpepo bwisa ukulingana ifyo mwafyalwa, ubikashi ne mikalile panshita imo.

Pamulandu waici, amepusho yala tutwala nangula ukuwishiba icilenga ubulwele ukusalangana no kushiba ifyo bwenda.

Ukufwalisha uku kuka leta ubunonshi, tepa mulandu waka cingilila, lelo ukwafwa icalo kuntashi mu cende yesu nabena mupala mano besu. Mucitunga cesu ca ku bana abshila fika pa mushinka wa myaka isano. Abelkala calo bakalamipusha amepusho pa bulwele bwa mpepo. Kabili bakula pima no bulwele bwa mpepo ukubutya icipimo ca mpepo (RDTs) ku bana abashilafika pa mushiuku wa myaka isano.

Inkana

Amasuko yonse ba kalapela taya ka kubantu awe, yakaya kubale fwalisha epela.

Ukulambilila

Ukulambilila uku ka suminishiwa ne sukulu likalamba mu calo casu (UNZA) kubalolesha pa tya ku fwailisha .inkama ikasungwa kabili bakalapoka insambu.

Kuba fyashi babana (insambu yakukana no ku bwesha).

Abaka ba mumulimo yo, nabakwata insambi yakukana nangula ukwisa bwesa ifyo balanda. Aba kalambomba umu kuti ba totela sana cakatila umulimo webo wafika kumpela nangu ukupwa.

Takuli ubwafiya ubwingesa pa kusambilila awe. Nga caku musamona ati insebo tabafwile abantu ukufwako namukwata insambu yaku fweta.

Ukupima umulopa abakala pima bantu basambilila aba bomba ku chipatala, ico tatulecetelela umwe ukusakamena nangula cimo. Kabili nangula umwana bamupima ukubofwaya aka shindano. Tetuti umwana teti afilwe ukubomba icito ili yonse.

Amalipilo.

Takwa nangula kano ukupelwa ukucila pafyo ukukubomba ubunonshi bukaleta.

Aba kutumina

Ngana mukwata amepusho ayali yonse, kuti mwanjipusha apapene nangula inshit imbi. Elo kabili ngamulefwaya ukujipusha insita iyimbi kuti mwantumina lamya panambala angula pali icenda ya ;

Santu Shaba Arthur

The University of Zambia

Department of Disease Control

School of Veterinary Medicine

P. O. Box 32379

LUSAKA.

Cell 0950982205/0973026029.

E-mail: santu.tulani@yahoo.com

Nagula

The Assistant Dean

UNZA School of Vet

Disease Control Department

P.O Box 50110

LUSAKA.

Nagula

ERES Converge IRB

33 Joseph Mwila Road, Roads Park,

Cell: 0955 155 633/ 0955 155 634

Email: eresconverge@yahoo.co.uk

Nagula

The Director

National Health Research Authority

Lot No. 18961/M in Chalala, off Kasama Road

Email: www.nhra.org.zm

Appendices V; Clearance Letter by ERES

Plot No. 272, Cnr Olive Tree Mazzwood Road,
Mazzwood Park
Lusaka - Zambia
Tel: +260 955 155 633
+260 955 155 634
Cell: +260 977 493 220
Email: eresconverge@yahoo.co.uk
I.R.B. No. 00005948
F.W.A. No. 00011697

23 November 2023

Ref. No. 2023-Oct-006
The Prinicpal Investigator
Mr. Shabasantu, Arthur N/A

Dear Mr. Shabasantu, Arthur N/A,
RE: Univesity of Zambia
Reference is made to your protocol. The IRB has resolved to approve "Univesity of Zambia" and your participation as Principal Investigator for a period of one year.

Review Type	**Approval No. 2023-Oct-006**
Approval Date: 2023-11-23	Expiry Date:
Protocol Version	Version- Nil
Information Sheet, Conscent Forn and Dates	-English
Other Study Documents	Questionnaire

Number of Participants Approved for the Study-
Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.
Conditions of Approval
• No participant may be involved in any study procedure prior to the study approval or after the expiration date.
• All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
• All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
• All protocol deviations must be reported to the IRB within 5 working days.
• All recruitment materials must be approved by the IRB prior to being used.

• Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.

• Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us.

• A reprint of this letter shall be done at a fee.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of ERES Converge IRB, we would like to wish you all the success as you carry out your study.

Yours faithfully,

ERES CONVERGE IRB

Dr. Jason Mwanza

Dip. Clin. Med. Sc., BA., M.Soc., PhD

CHAIRPERSON

Appendices VI; Institutional-clearance Senga Hill - DHO

All correspondences to be addressed
The District Health Director

In reply please quote
Ref. Senga-hill district health office

REPUBLIC OF ZAMBIA
MINISTRY OF HEALTH
SENGA DISTRICT HEALTH OFFICE
P. O. BOX 420075

14th AUGUST, 2023

ARTHUR SHABASANTU

THE UNIVERSITY OF ZAMBIA

DEPARTMENT OF DISEASE CONTROL

SCHOOL OF VETERINARY MEDICINE

P. O. Box 32379

LUSAKA

Dear Sir/Madam,

REF; REQUEST; RESEARCH STUDY IN SENGA HILL DISTRICT

Reference is here by being made to the above captioned matter.

I write in receipt of your request to conduct research study "**Prevalence and factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia.**

I am pleased to inform you, this office has no objection in respect of your request. We are equally interested in the study findings of in relation with the study topic. Fill free to visit the office for any help as regards your study.

REPUBLIC OF ZAMBIA MINISTRY OF HEALTH SENGA HILL DISTRICT HEALTH OFFICE 14 AUG 2023 DISTRICT HEALTH DIRECTOR P.O. BOX 420075 SENGA HILL

We wise you all the best

Dr. Wilfred Namataa

DISTRICT HEALTH DIRECTOR

SENGA HILL DISTRICT HEALTH OFFICE

Appendices VII; Clearance Letter by NHRA.

NATIONAL HEALTH RESEARCH AUTHORITY
Lot No. 18961/M, off Kasama Road, Chalala, P.O. Box 30075, LUSAKA
Tell: +260211 250309 | Email: znhrasec@nhra.org.zm | www.nhra.org.zm

NHRA-1643/17/10/2024 **26th November 2024**

The Principal Investigator,
Mr. Arthur Santu,
University of Zambia Lusaka,

Dear Mr. Arthur Santu,

Re: Request for Authority to Conduct Research

The National Health Research Authority Is in Receipt of Your Request for Authority to Conduct Research Titled **"Prevalence and factors associated with malaria amongst Under-Five Children in Senga Hill District, Northern Province Zambia."**

I wish to inform you that following submission of your request to the Authority, our review of the same and in view of the ethical clearance, this study has been **approved** on condition that:

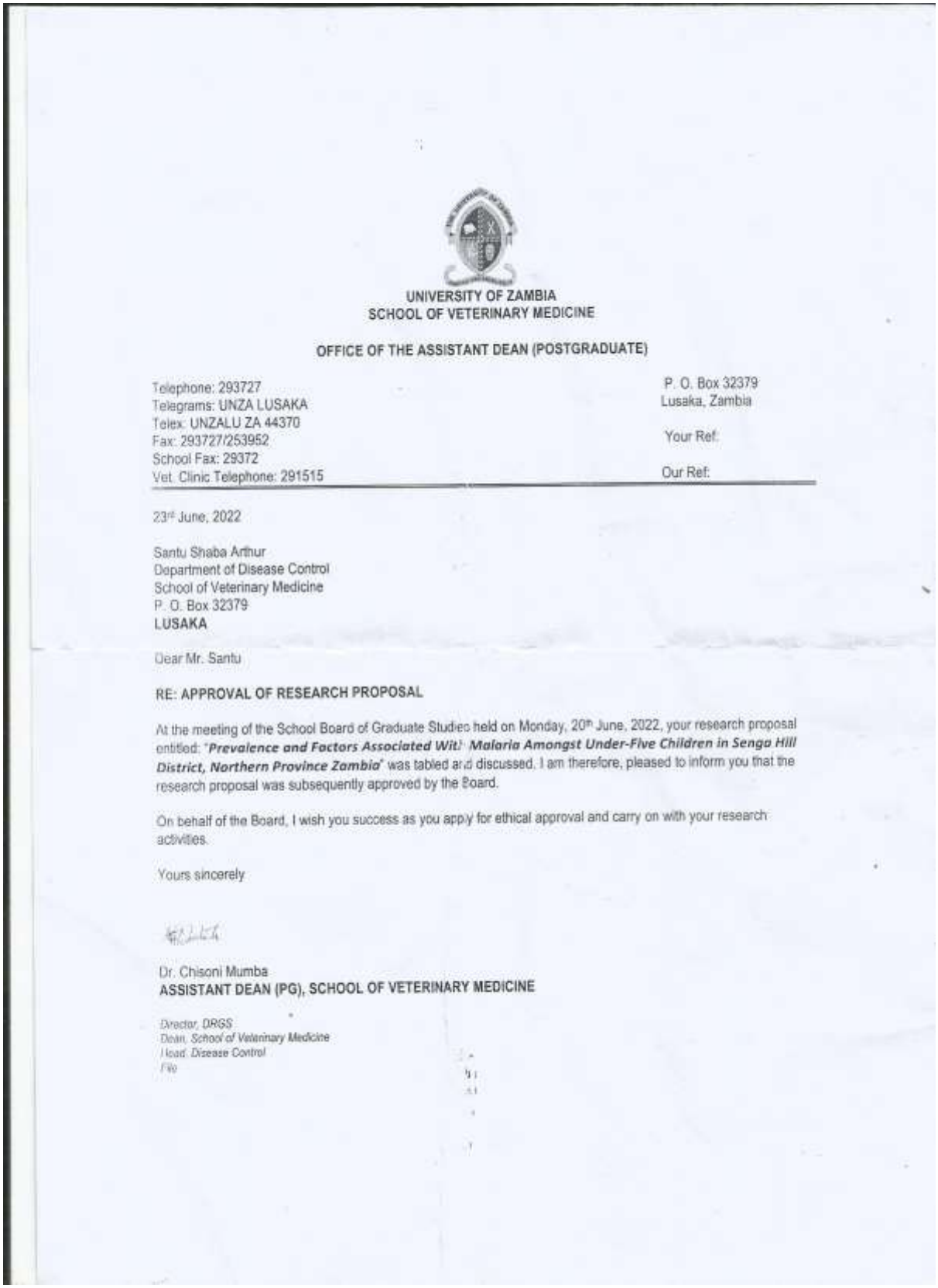
1. The relevant Provincial and District Medical Officers where the study is being conducted are fully appraised.
2. Progress updates are provided to NHRA bi-annually from the date of commencement of the study.
3. The final study report is cleared by the NHRA before any publication or dissemination within or outside the country.
4. After clearance for publication or dissemination by the NHRA, the final study report is shared with all relevant Provincial and District Directors of Health where the study was being conducted, University leadership, and all key respondents.

Yours sincerely,

National Health Research Authority

Prof Victor Chalwe,
Acting Director/Chief Executive Officer

Appendices VIII; Clearance Letter by UNZA



UNIVERSITY OF ZAMBIA
SCHOOL OF VETERINARY MEDICINE

OFFICE OF THE ASSISTANT DEAN (POSTGRADUATE)

Telephone: 293727
Telegrams: UNZA LUSAKA
Telex: UNZALU ZA 44370
Fax: 293727/253952
School Fax: 29372
Vet. Clinic Telephone: 291515

P. O. Box 32379
Lusaka, Zambia

Your Ref:

Our Ref:

23rd June, 2022

Santu Shaba Arthur
Department of Disease Control
School of Veterinary Medicine
P. O. Box 32379
LUSAKA

Dear Mr. Santu

RE: APPROVAL OF RESEARCH PROPOSAL

At the meeting of the School Board of Graduate Studies held on Monday, 20th June, 2022, your research proposal entitled: "***Prevalence and Factors Associated With Malaria Amongst Under-Five Children in Senga Hill District, Northern Province Zambia***" was tabled and discussed. I am therefore, pleased to inform you that the research proposal was subsequently approved by the Board.

On behalf of the Board, I wish you success as you apply for ethical approval and carry on with your research activities.

Yours sincerely

Dr. Chisoni Mumba
ASSISTANT DEAN (PG), SCHOOL OF VETERINARY MEDICINE

Director, DRGS
Dean, School of Veterinary Medicine
Head, Disease Control
File