ASSESSING COMMUNITY KNOWLEDGE AND PREVENTATIVE PRACTICES FOR MALARIA IN THE VAAL TRIANGLE, GAUTENG, SOUTH AFRICA

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DECLARATION

I, Fungai Maburutse, declare that this dissertation is my own, unaided work. It is being submitted for the degree of Master of Science in Medicine by Research (Clinical and Experimental Pharmacology) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.

Signature

Signed on the 31st day of October 2025

HREC Number: M221039

DEDICATION

I dedicate this dissertation

To my lovely children Kupakwashe John and Kuzivakwashe Justice Gwara, for being supportive, understanding and for excusing me for the times when I was not available for you and because I love you.

To my late father Kunda Maburutse
"Mudhara Durban" I made it.

CONFERENCES

CONFERENCE PRESENTATIONS

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ABSTRACT

Malaria remains a major public health concern in Southern Africa, necessitating robust vector control strategies and community awareness to prevent transmission. Insect repellents play a crucial role in reducing mosquito bites, but the increasing insecticide resistance and high operational costs of chemical spraying highlight the need for alternative, cost-effective repellents. In South Africa, particularly in rural communities, traditional phytomedicines derived from indigenous knowledge are widely used for mosquito repellence. However, despite general awareness of malaria, knowledge gaps and misconceptions persist, especially in non-endemic areas such as the Vaal Triangle, Gauteng. This study aimed to assess community knowledge, attitudes, and perceptions toward malaria prevention, treatment, and the use of traditional mosquito repellents. A semi-structured questionnaire was used in a descriptive cross-sectional study with 419 Vaal Triangle residents. Both in-person interviews with people (n=216) and focus group interviews with traditional healers (n=203) were used to gather data. The findings indicated a high level of malaria awareness (95%), yet significant misconceptions about transmission and treatment were prevalent. A majority (70.17%) incorrectly believed malaria could spread through contact with an infected person, while only 12.65% correctly identified the bite of an infected female *Anopheles* mosquito as the mode of transmission. Furthermore, 86.87% of participants believed malaria could be managed without medical treatment. Regarding prevention, 89.88% reported using mosquito repellents, though only 48.93% recognized the effectiveness of sleeping under mosquito nets. Logistic regression analysis revealed that males (adjusted OR: 0.25, p=0.001), individuals practicing Hinduism (adjusted OR: 0.20, p=0.004), and those with no formal schooling (adjusted OR: 0.18, p=0.015) were significantly less likely to be aware of malaria. Traditional medicine remained a prominent aspect of malaria prevention, with 49.40% of respondents referencing unspecified remedies, however plants species such as *Nepeta cataria, Lavandula, Lippia javanica*, *Artemisia afra*, *Hypoxis hemerocallidea* and *Helichrysum odoratissimum* amongst others were reported in the traditional profiles of malaria treatment and mosquito control. This study highlights the need for targeted, culturally sensitive educational interventions to correct misconceptions and improve malaria prevention practices. Integrating traditional knowledge with evidence-based malaria control strategies, in collaboration with community leaders and traditional healers, could enhance public health efforts. Future research should focus on scientifically validating traditional phytomedicines to assess their efficacy and potential inclusion in malaria prevention programs.

Keywords: Malaria, Mosquito repellents, Traditional medicine, Community perceptions

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LIST OF ABBREVIATIONS

CHCs:	Community Health Centres
WHO:	World Health Organization
NICD:	National Institute for Communicable Diseases
RDTs:	Rapid diagnostic tests
HRP2:	Histidine-rich protein 2
ACTs:	Artemisinin-based combination therapies
ITNs:	Insecticide-treated mosquito nets
IRS:	Indoor residual spraying
DDT:	Dichlorodiphenyl-trichloroethane
LSDI:	Lubombo Spatial Development Initiative
DEET:	N,N-diethyl-3-methyl-toluamide
IR3535:	Insect Repellent 3535
E8:	Elimination 8
LLINs:	Long-lasting insecticidal nets
ITNs:	Insecticide-treated nets
et al :	et alia (and others)

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PREFACE

Malaria remains a significant public health challenge in Southern Africa, particularly in countries with tropical and subtropical climates where mosquitoes thrive (Balmith et al., 2024). Despite being preventable and treatable, the transmission and prevalence vary widely across the region, with high-risk zones in low-lying areas and along river valleys. High burden countries include Mozambique, Zimbabwe (particularly in lowland areas), Angola, Malawi and Zambia; whilst moderate to low transmission countries include Botswana, Namibia and Eswatini (WHO, 2024). Malaria transmission in South Africa occurs mainly in the Limpopo, Mpumalanga and Kwazulu-Natal provinces and significant efforts to reduce cases maps South Africa as a “near elimination country” (Maharaj et al., 2012).

Malaria elimination requires coordination amongst neighbouring countries, regions sharing poorly monitored land boarders have difficulty controlling importation risks in Southern Africa (Sikaala et al., 2024). Border screening is not always practical and desirable especially in areas with artificial administrative borders and frequent migration border crossing by a large proportion of the population on a daily basis at times facilitated by economic reasons (Moonen et al., 2010). Migration between high and low transmission areas increases the spread of malaria, such as travellers between Mozambique and South Africa, who have an increased risk of carry infections across the borders (Fernández Montoya et al., 2022).

Vector control is a major component of the global strategy for malaria control with programmes aimed at strengthening prevention of malaria parasite transmissions (Barreaux et al., 2017). These include wide distribution of insecticide-treated bed nets to vulnerable populations, indoor residual spraying, seasonal malaria chemoprevention during peak transmission seasons, larval source management targeting mosquito breeding sites and avoiding mosquito bites by using mosquito repellents (Hansen and Paintsil, 2016).

The Elimination 8 (E8) Initiative is a collaboration amongst eight Southern African countries to eliminate malaria by 2030, this includes cross-border initiatives, harmonized policies and resource sharing (Sikaala et al., 2024). The RTS,S/A01 (Mosquirix®) malaria vaccine has been introduced in some African countries, however not yet widely used in Southern Africa (Baral et al., 2021).

Even though many countries in Southern Africa have made progress in malaria control particularly South Africa, climate change is altering transmission patterns, potentially expanding malaria-prone areas (Ayanlade et al., 2022). Warm temperatures and seasonal rains create ideal conditions for mosquito breeding. Political instability and economic challenges in some African countries hinder sustained control efforts. In addition, antimalarial drug and insecticide resistance are emerging threats (Brooke et al., 2015).

Understanding the knowledge and awareness of malaria and its vectors help communities to fight to eliminate malaria across continents and globally (Killeen et al., 2013). While modern antimalarial medications and mosquito control programs have drastically reduced the incidence of malaria, traditional methods continue to play a vital role in communities, especially where conventional treatments access may be limited. Traditional medicines have long been used as cost effective natural mosquito repellents in various cultures (Govere et al., 2000). These methods are rooted in local knowledge, and the use of medicinal plant continue to be valuable for prevention and treatment in many parts of the world. As such, this study aimed to assess the knowledge of communities on mosquito repellents and malaria management and to assess the more commonly used plants and plant-derived formulations as mosquito repellents in the Vaal Triangle, Gauteng, South Africa.

CHAPTER ONE: LITERATURE REVIEW

1.0 Malaria

Malaria is an infectious mosquito-borne killer disease caused by a parasitic protozoon of the genus *Plasmodium* that affects many vertebrates (Gilson et al., 2019). This disease predominantly affects populations in tropical and subtropical regions, with *Plasmodium falciparum* being the most prevalent species in these areas. Out of the known 156 species of the *Plasmodium* genus, majority of malaria cases and associated morbidity in humans are as a result of only five species namely *P. falciparum*, *P. vivax*, *P. ovale*, *P. malariae* and *P. knowlesi* (Azmi et al., 2023). According to the World Health Organization (WHO), *P. falciparum* and *P. vivax* pose the most significant public health threats, responsible for the majority of global malaria-related infections and fatalities (WHO, 2024).

Malaria is transmitted through the bite of infected female *Anopheles* mosquitoes, which act as vectors for the *Plasmodium* parasites (Manana et al., 2018). A vector is defined as an organism, often an arthropod, that transmits a pathogen from one host to another. In the case of malaria, the female *Anopheles* mosquito serves as the vector, carrying the malaria-causing *Plasmodium* parasites and facilitating their transmission to humans through its bites (Gilson et al., 2019). Malaria remains a serious health threat globally and can be a medical emergency.

1.1 Epidemiology of malaria

Malaria is one of the deadliest infections globally and poses one of the greatest public health challenges, particularly as it remains the leading cause of death among children (WHO, 2024). According to the WHO, there were an estimated 263 million malaria cases and 597,000 malaria-related deaths globally in 2023. This reflects 4% increase of approximately 11 million cases compared to 2022, while the number of deaths remained nearly unchanged (WHO, 2024). The WHO African Region continues to bear a disproportionately high share of the global malaria burden, accounting for 94% of all cases and 95% of deaths in 2023. Malaria during pregnancy poses significant health risks to both the mother and the foetus, including maternal anaemia, low birth weight, and increased infant mortality. Children under five years of age are particularly vulnerable to malaria accounting for approximately 73.7% of all malaria deaths in 2023 from this preventable, treatable disease. The WHO further emphasizes the severity of the situation, reporting that the disease claims the life of an African child approximately every minute (WHO, 2024). The general increase may have been aggravated by disruptions of the malaria-related campaigns and activities as a result of the Covid-19 pandemic (Hessou-Djossou et al., 2023). The African region carries an extremely high share of the global malaria burden. According to the WHO World Malaria Report of 2024, sub-Saharan Africa continues to bear the highest burden of malaria globally (WHO, 2024). In 2023, the region accounted for approximately 94% of all malaria cases and 95% of malaria-related deaths. Factors contributing to the rise in malaria cases include resistance to drugs and insecticides, climate-related events, and humanitarian crises. In 2023, there was an estimated 35.96 million pregnancies in Sub-Saharan Africa, of whom 4 million (34%) were exposed to malaria infection during pregnancy. While malaria cases have generally decreased from 2009 to 2019 with a reported 40% decline in mortality in Africa (WHO, 2018), the control measures used worldwide seem not to be sufficient in some parts of Africa especially in Sub-Saharan Africa. Notably, about two-thirds (47,000) of the increase in deaths between 2019 to 2021 were associated with interruptions in malaria services and decreased funding for prevention, diagnosis, and treatment during the pandemic (Hessou-Djossou et al., 2023). About 90% of new malaria cases were documented in Africa, where financing was deficient by over 42% of the necessary funds required to manage an efficient disease management (WHO, 2021; 2024). Nevertheless, the adverse effects of interruptions were less severe than anticipated, as the pandemic did not result in a doubling of worldwide malaria mortality. Following the outbreak, most malaria infections and fatalities were concentrated in select nations in Sub-Saharan Africa. Nigeria accounted 25.9% of global malaria cases and 30.9% of malaria fatalities, whereas the Democratic Republic of the Congo supplied 12.6% of cases and 11.3% of deaths world (WHO, 2024).

In 2023, Sub-Saharan Africa recorded approximately 45 million refugees and internally displaced persons, as reported by the Internal Displacement Monitoring Centre and United Nations High Commissioner for Refugees. These forcibly displaced populations are at a heightened risk for malaria (Alhassan et al., 2024). Despite these alarming statistics, there is optimism, as malaria is both preventable and treatable. These statistics underscore the critical need for intensified malaria control and prevention efforts in Sub-Saharan Africa and globally, with a focus on protecting vulnerable populations, particularly young children.

1.2 Malaria in South Africa

Focusing specifically on South Africa, the first case of malaria which was documented is assumed to be that of the Louis Trichardt trek to Maputo between 1837 to 1838 which claimed 20 of the 53 members of the party (Coetzee & Koekemoer, 2013a). By the end of 1905, intensive antimalarial measures were implemented with financial backing from Central South African Railways. Comprehensive efforts in Komatipoort, including mosquito-proofing all transport hubs, led to an impressive 87.5% reduction in malaria cases. Approximately 10% of the South African population is at risk of malaria (Health.gov.za.; 2022).

According to the latest data from the National Institute for Communicable Diseases (NICD), South Africa has made significant progress in malaria control over the past decade, resulting in a notable decline in both malaria cases and related deaths. The burden of malaria in South Africa varies significantly by province, with transmission being seasonal and predominantly occurring along border areas. Most malaria cases are found in the north-eastern provinces, especially in Limpopo, Mpumalanga, and KwaZulu-Natal, which are known as endemic areas. In South Africa, as in other parts of Africa, *P. falciparum* is the most common species. It is especially common in the north-eastern provinces of Limpopo, Mpumalanga, and KwaZulu-Natal (Figure 1.1). The transmission season typically spans from September to May, with a peak observed between January and April (Munzhedzi et al., 2021a).

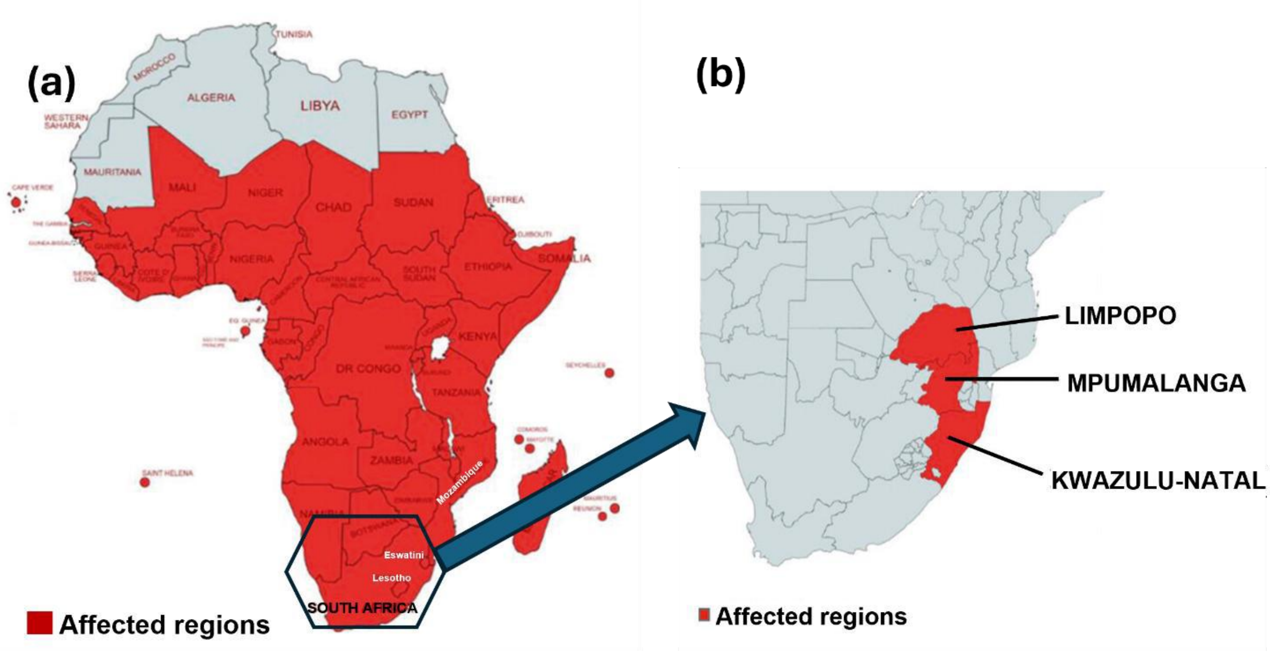

Figure 1.1: (a) Malaria distribution in sub-Saharan Africa and (b) the malaria endemic regions in South Africa (Balmith et al., 2024)

From 2000 to 2015, worldwide donor support and initiatives reduced malaria fatalities in children under five from 723,000 to 306,000 (NICD, 2023). The COVID-19 pandemic disrupted malaria campaigns and services, causing a rise in mortality from 2016 to 2022. There was only a 10% increase in malaria-related deaths in 2019 to 2020 and remained constant in 2021 (Matjane, 2023). In 2023, the NICD reported a notable rise in malaria cases in endemic provinces and Gauteng. The rise in cases is mainly due to delayed presentation and detection of the disease, underscoring the essential role of early diagnosis and prompt treatment, alongside the necessity for effective methods and enhanced educational campaigns to mitigate the increase in malaria (Matjane, 2023).

Malaria control programs in South Africa have displayed a degree of resilience, despite these advancements, challenges persist, including the emergence of insecticide-resistant mosquito vectors and drug-resistant *P. falciparum* strains (Balmith et al., 2024; Coetzee & Koekemoer, 2013b).

Malaria continues to pose a considerable health challenge in South Africa, especially in provinces adjacent to Mozambique, Eswatini, and Zimbabwe. Although there has been significant progress in decreasing cases and fatalities since 2000, various factors persistently hinder malaria control initiatives. A significant percentage of malaria cases in South Africa are imported from neighbouring countries, and cross-border movement with nations such as Mozambique and Zimbabwe further complicate eradication efforts, exacerbating the overall disease burden (Munzhedzi et al., 2021a).

Although Gauteng is not a primary malaria-endemic region, imported cases have been documented, particularly in places such as Doornpoort (Moonasar et al., 2012). Rapid and uncontrolled urbanization, migrants moving rapidly to non-receptive areas, overcrowding, inadequate sanitation, climatic conditions change in nearby regions, changes in land use with inconsistent enforcement of control measures can influence malaria transmission patterns which further heighten transmission risks influencing the distribution of the disease. (Maharaj et al., 2019). The substantial occurrence of imported cases exacerbates malaria transmission, especially in rural and semi-urban areas. The possible introduction of new malaria parasite strains exacerbates drug resistance, imposing a burden on financial systems, human resources, and healthcare infrastructure (Balmith et al., 2024; Moonasar et al., 2012). Poverty, lack of awareness of illness interventions, and limited medical infrastructure play roles in the spread and severity of the disease which further impedes effective disease control (Balmith et al., 2024).

These challenges underscore the need for sustained and adaptive strategies to effectively control and eventually eliminate malaria in South Africa (Moonasar et al., 2016a). Reducing the effect of malaria on impacted populations mostly depends on raising public knowledge of its causes and symptoms as well as supporting preventative actions. Moreover, better healthcare access and training for healthcare professionals help to enable early identification, therefore lowering the morbidity and death related with malaria (Balmith et al., 2024; Moonasar et al., 2016a).

1.3 Malaria vectors in Africa

Anopheles mosquitoes are a genus of mosquito known primarily for their role as vectors in the transmission of malaria, a serious and sometimes fatal disease caused by parasites of the genus *Plasmodium*. There are over 400 species of *Anopheles*, but only about 30–40 species are known to be effective in transmitting malaria to humans (Coetzee & Koekemoer, 2013b). The survival of *Plasmodium* within a mosquito at various stages of its lifecycle presents a potential avenue for eradicating malaria. Educating individuals, particularly in rural areas where mosquito breeding is most prevalent during humid and summer months, is essential. It is also crucial to develop a comprehensive understanding of the types of vectors involved in malaria transmission and their ecological habits, as this knowledge can inform strategies to curtail their spread. *Plasmodium* parasite has two hosts in its lifecycle: humans and female adult *Anopheles* mosquitoes. The principal malaria vectors in Africa include *Anopheles arabiensis, An. funestus, An. gambiae,* and *An. coluzzii* (Coetzee & Koekemoer, 2013b). Some researchers have reported that these species can inadvertently become infected with malaria parasites while primarily feeding on animals (Burke et al., 2019; Dandalo et al., 2017). In South Africa, various *Anopheles s*pecies have been identified, including *An. gambiae* and the *An. funestus* group (Table 1.1) (Christian et al., 2018; Dahan-Moss et al., 2019) Notably, *An. arabiensis* has been recognized as the sole malaria vector in South Africa responsible for *P. falciparum* transmission (Dandalo et al., 2017). Other studies corroborate this claim, identifying *An. arabiensis* as the primary vector in the region, alongside secondary vectors such as *An. vaneedeni* and *An. parensis* (Christian et al., 2018). *Anopheles funestus*, *An. coluzzii*, and *An. gambiae* have been observed to feed and rest indoors, making them susceptible to indoor control measures. In contrast, *An. arabiensis* is known to exhibit both indoor and outdoor feeding and resting behaviours, posing a significant challenge to malaria elimination efforts (Gillies & Coetzee, 1987; Dandalo et al., 2017). In South Africa, both *An. funestus* and *An. arabiensis* dominate the northern regions of KwaZulu-Natal and have exhibited resistance to insecticides (Christian et al., 2018; Munhenga et al., 2022).

Table 1.1: *Anopheles* species collected by the 2018 South African Vector Surveillance Team (Samuel et al., 2018; (Dahan-Moss et al., 2019).

***Anopheles* species Complex, Group, or Other**	***Anopheles* Species**		
***An. gambiae* Complex**	*An. arabiensis*	*An. merus*	*An. quadriannulatus*
***An. funestus* Group**	*An. leesoni*	*An. parensis*	*An. rivulorum*
	An. rivulorum-like	*An. vaneedeni*	
Other *Anopheles* species	*An. coustani*	*An. demeilloni*	*An. listeri*
	An. marshallii	*An. pharoensis*	*An. pretoriensis*
	An. rhodesiensis	*An. rufipes*	*An. squamosus*
	An. tenebrosus		

1.4 Life cycle of *Anopheles* and malaria parasites

Anopheles mosquitoes breed in any kind of water polluted or unpolluted, they prefer to breed in water with a clear surface. The life cycle of *Anopheles* mosquitoes comprises four distinct stages: egg, larva, pupa, and adult (Figure 1.2).

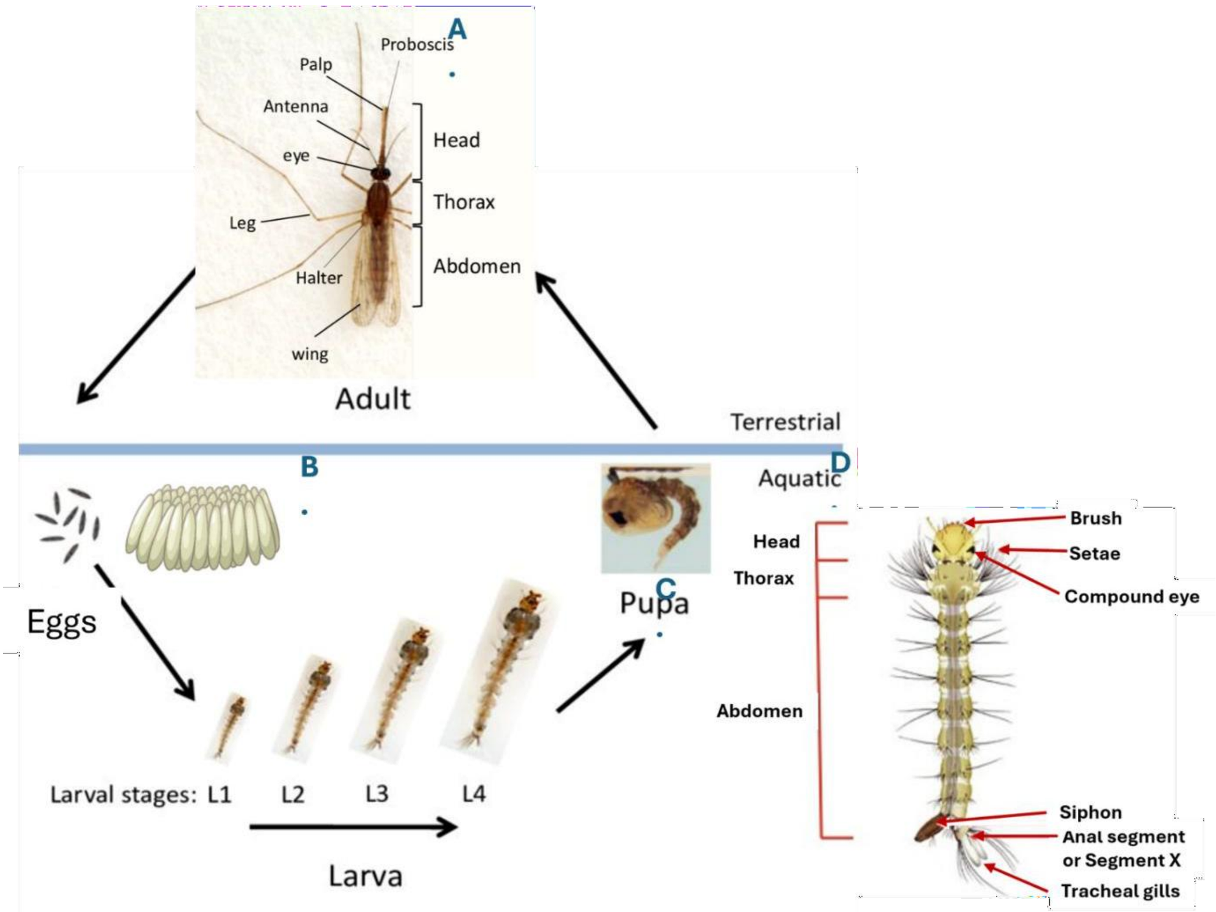

Figure 1.2: The life cycle of a mosquito showing the adult, eggs, larva and pupa (Adapted from the American Mosquito Control Association, 2016; (Rueda, 2020).

The first three stages of development - egg, larva, and pupa - are aquatic and typically take about 7 to 14 days to complete, depending on the mosquito species and environmental temperature. Following the pupal stage, the adult mosquito emerges (Rueda, 2020)(US EPA, 2022). Mosquitoes serve as hosts for the malaria parasite, specifically *Plasmodium*, which requires both humans and female adult *Anopheles* mosquitoes for its lifecycle. Depending on the species of mosquito, eggs may be laid separately or grouped together in rafts. While *Culiseta* and *Culex* lay eggs on the water's surface, *Ochlerotatus* and *Aedes* species deposit their eggs on damp soil, which will become submerged when it rains (Bosak & Crans, 2002).

Within approximately 48 hours, the eggs hatch into larvae (Figure 1.2), which inhabit the water column or the water surface. Notably, most larval species, including *Culex* and *Culiseta*, rest with their siphon tubes submerged, allowing them to breathe while hanging upside down. In contrast, *Anopheles* larvae do not possess siphon tubes; instead, they maintain a position parallel to the water's surface, utilizing a specialized breathing tube to access atmospheric oxygen. The larvae feed on microorganisms and organic matter present in their environment. As the larvae grow, it increases in size by moulting four times they before transitioning into the pupal stage. This stage is characterized as a resting, non-feeding phase, although pupae remain mobile and responsive to light changes. Eventually, the pupa transforms into an adult mosquito, which emerges to mate and seek out blood meals, thereby continuing the cycle of transmission for the malaria parasite.

During a blood meal, an adult female mosquito ingests *Plasmodium g*ametocytes, which subsequently develop into mature oocysts on the intestinal wall of the mosquito (Figure 1.3). These oocysts release a significant number of sporozoites that migrate to the salivary glands, positioning the parasites to be injected into the subsequent human host (Zekar & Sharman, 2021). Upon entering the human bloodstream, the sporozoites infect liver cells and undergo mitotic replication, forming liver schizonts. When these schizonts rupture, they release numerous merozoites into the bloodstream, where they invade red blood cells (Centers for Disease Control and Prevention, 2020).

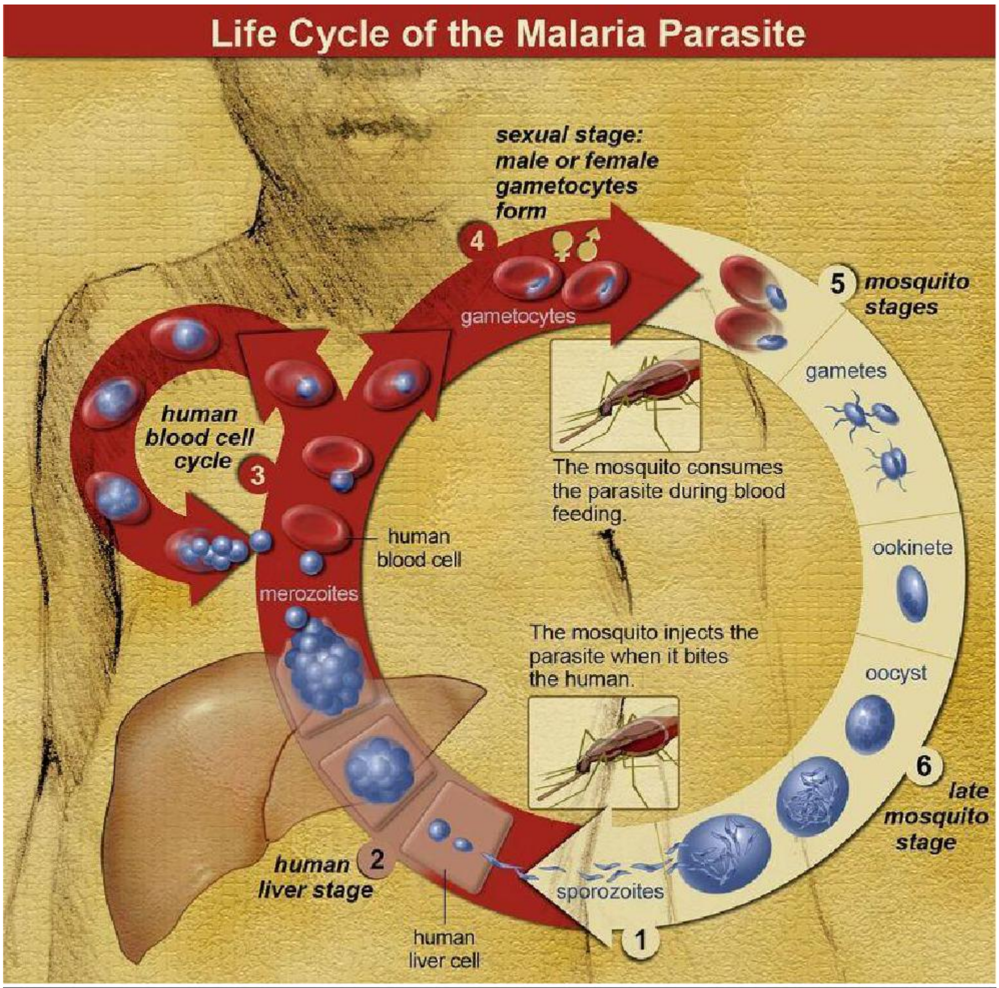

Figure 1.3: Life cycle of the malaria parasite in the human and mosquito hosts (Zekar & Sharman, 2021).

Some of the released merozoites differentiate into gametocytes, which can be ingested by another mosquito during a blood meal, thereby perpetuating the life cycle of the malaria parasite. This continual cycle of infection can lead to significant morbidity, and if not accurately diagnosed and appropriately treated, it has the potential to result in severe complications and mortality (Zekar & Sharman, 2021).

The transmission cycle of malaria involves multiple stages (Figure 1.3). Following a bitefrom an infected mosquito, *Plasmodium* sporozoites enter the human bloodstream, migrate to the liver for replication, and release merozoites that subsequently invade red blood cells. This invasion results in characteristic clinical symptoms, which include fever and chills, headache, nausea and vomiting, muscle pain and fatigue, sweating, diarrhoea in some cases, anaemia and jaundice in severe instances, due to the destruction of red blood cells. Symptoms typically appear 10 to 15 days after being bitten by an infected mosquito; however, some *Plasmodium* species can remain dormant in the liver for months or even years before causing symptoms. Untreated cases can lead to severe complications, such as cerebral malaria and multi-organ failure (WHO, 2021).

1.5 Symptoms and diagnosis of malaria

Malaria symptoms typically manifest approximately 10 to 15 days after a bite from an infected mosquito. Common symptoms include fever, headache, and chills (Stauffer & Fischer, 2003). The South African Department of Health recommends that treatment should only commence following a positive laboratory test (van Zyl, 2016). Diagnosis of malaria involves several methods; clinical diagnosis of malaria is achieved through malaria blood smear microscopy or rapid diagnostic tests (RDTs). The WHO further recommends that a microscopic blood smear examination or rapid antigen detection test be repeated until a definitive diagnosis is confirmed (WHO, 2021). Microscopy is utilized to examine a blood smear under a microscope for the presence of *Plasmodium* parasites. Additionally, RDTs are employed to detect antigens produced by malaria parasites, providing a quick and effective diagnostic tool. However, during the recent COVID-19 pandemic, many cases of malaria have been misdiagnosed as COVID-19 (Stauffer & Fischer, 2003). When malaria infections are promptly diagnosed and appropriately managed, complications and mortality can be significantly minimized. Therefore, it is crucial to accurately identify malaria patients to facilitate the timely initiation of antimalarial treatment. If *P. falciparum* malaria is not treated within 24 hours, it can progress from uncomplicated to severe malaria, which may present with symptoms such as severe anaemia, respiratory distress leading to metabolic acidosis, and multi-organ failure, potentially culminating in death (Stauffer & Fischer, 2003). Guidelines to treatment of malaria aim at preventing complicated development of malaria, eliminate further transmission and spread of the disease and importantly reduce mortality rate because of malaria infection.

The primary clinical indicator of malaria is a recorded temperature of ≥37.5 °C or a history of fever without an identifiable cause in regions known to be malaria endemic. In non-endemic areas, the disease is highly suspected in children with a haemoglobin concentration of <8 g/dl or severe palmar pallor. However, in regions with low malaria prevalence, conducting parasitological diagnoses for all febrile cases can be prohibitively expensive, given the low likelihood of detecting true malaria cases. To reduce costs, it is essential for healthcare workers to be trained to identify patients who may have been exposed to malaria prior to performing parasitological tests. The WHO (2015) emphasizes that RDTs are beneficial for managing malaria in remote areas with limited access to comprehensive healthcare services, including laboratory facilities equipped for quality microscopy. To reduce the risk of malaria infection, it is vital that people be aware of preventative and chemoprophylaxis measures.

The gold standard for malaria diagnosis involves microscopic examination of thick and thin blood films stained with either Giemsa or Wright's stains, utilizing the Romanowsky staining technique (Mbakilwa et al., 2012). Tangpukdee et al. (2009) assert that proper microscopic equipment, along with well-trained laboratory technicians, is crucial for accurately identifying malaria parasites and determining their species. Furthermore, thin blood smear examinations can quantify parasitic load in the blood.

With advancements in technology, more sophisticated diagnostic methods have been developed that demonstrate greater sensitivity in detecting low levels of parasites compared to conventional light microscopy. These advances aim to reduce false-positive results and include the use of RDTs and the quantitative buffy coat method, which necessitates less training for effective implementation (Birhanie, 2016).

Automated microscopes employing artificial intelligence (AI) have also been introduced to detect and quantify parasites on slides, thereby mitigating issues related to untrained personnel and substandard equipment quality (Torres et al., 2018). Although the initial setup cost is high, the operational cost efficiency makes this technology widely adopted, as it is more economical than other molecular diagnostics.

According to Amir et al. (2018), RDTs are considered complementary to the gold standard of traditional diagnosis via microscopic examination. RDTs can detect single or multiple *Plasmodium* species by identifying malaria antigens in the blood through a process that involves binding to dye-labelled antibodies; this agglutination produces a visible band on the nitrocellulose strip (WHO, 2018a). One specific antigen targeted by RDTs is histidine-rich protein 2 (HRP2), which is specific for detecting *P. falciparum* (Murray et al., 2008). Additionally, antigens such as *Plasmodium* lactate dehydrogenase and aldolase are effective for detecting all *Plasmodium* species responsible for malaria in humans (Murray et al., 2008).

The ultra-RDT is a recent advancement in rapid malaria diagnosis, featuring improved sensitivity that enables the detection of parasites at loads ten times lower than conventional RDTs (Das et al., 2017). Other studies suggest that this method can identify infections as much as 1.5 days earlier than traditional methods (Mwesigwa et al., 2019).

1.6 Guidelines for the treatment and prevention of malaria

The treatment guidelines for malaria aim to prevent the development of complicated malaria, eliminate further transmission, and significantly reduce mortality rates associated with the infection. These objectives align with the global goal of achieving a malaria-free world by 2030. In South Africa, the treatment for uncomplicated malaria typically involves a combination of artemether-lumefantrine or quinine with clindamycin or doxycycline (Blumberg, 2015; Shaohui et al., 2017). Treatment for malaria varies based on the specific type of *Plasmodium* parasite and the severity of the disease. Artemisinin-based combination therapies (ACTs) represent the most effective treatment for *P. falciparum* whilst for *P. vivax* and *P. ovale* chloroquine is commonly used, however resistance to this medication is becoming increasingly prevalent to these species (Migliani et al., 2014; Wernsdorfer, 2012).
For complicated cases of malaria, intravenous artesunate is preferred because it reduces the risk of hypoglycaemic effects, unlike intravenous quinine. Oral artemether-lumefantrine is subsequently administered once the patient can tolerate oral treatment (Blumberg, 2015; Van Zyl, 2016; SADOH, 2018).

To mitigate the risk of malaria infection, it is crucial that individuals are informed about preventive measures, including chemoprophylaxis. Chemoprophylaxis has proven to be one of the most effective methods for preventing transmission and acquisition of malaria, especially in high-risk areas (WHO, 2016). When considering chemoprophylactic agents, Several factors must be taken into account, including resistance patterns, medical history, transmission intensity, age, and the duration of stay in a high-risk area. Examples of chemoprophylactic agents are chloroquine, mefloquine, and doxycycline. These medications may function as causal prophylactics, inhibiting liver-stage (pre-erythrocytic) development, or as suppressive prophylactics, targeting asexual blood stages (WHO, 2016). In Southern Africa, recommended chemoprophylactic agents include mefloquine, atovaquone-proguanil, and doxycycline, alongside non-pharmacological measures such as insecticide-treated bed nets and mosquito repellents (Van Zyl, 2016; SADOH, 2017). For travellers to endemic regions, antimalarial medications can be taken as chemoprophylaxis to prevent infection. While it is essential to prevent mosquito bites, especially in humid and rainy areas where mosquito breeding is prevalent, complete prevention can be practically challenging. Therefore, it is important to focus on reducing the transmission of *Plasmodium* from the mosquito vector to humans. If transmission cannot be effectively managed, treatment of the protozoan within the human host becomes necessary, which is not only painful and costly but also poses significant health risks, including potential mortality.

Prevention strategies are crucial in controlling the spread of malaria. The primary goals of preventing and managing malaria include reducing morbidity and mortality, preventing progression to severe malaria, and eliminating subclinical cases to prevent further transmission (SADOH, 2018). Three main methods of preventing malaria are chemical measures (chemoprevention), vector control, and case management. Chemoprevention works to suppress the infection within the body, while case management focuses on early detection, accurate diagnosis, and effective treatment of malaria infections (WHO, 2016).

The WHO defines vector control as "measures of any kind against malaria-transmitting mosquitoes, intended to limit their ability to transmit the disease" (WHO, 2018d). Vector control has been shown to be an effective and economical approach, particularly through the use of insecticide-treated mosquito nets (ITNs) and indoor residual spraying (IRS) (Fillinger & Lindsay, 2011). The ITNs have been recognized as one of the most successful and effective methods, contributing to a 68% decrease in malaria cases in Sub-Saharan Africa from 2000 to around 2015 (Bhatt et al., 2015).

In Sub-Saharan Africa, vector control remains crucial for reducing malaria infections. Various control programs employing different strategies have been implemented to eliminate malaria worldwide (Brooke et al., 2013). Avoiding mosquito bites is essential for preventing malaria, and current vector control methods recommended by the WHO include IRS and ITNs (WHO, 2022a). While IRS is the primary method for protecting individuals indoors, *Anopheles arabiensis* can rest and feed both indoors and outdoors, which hinders the effectiveness of indoor control techniques. IRS utilizes insecticides from five main classes: carbamates, organochlorines, organophosphates, pyrethroids, and neonicotinoids. Notably, resistance to the propoxur carbamate insecticide has been observed in *An. funestus* and *An. arabiensis* in northern KwaZulu-Natal (Christian et al., 2018; Munhenga et al., 2022).

The ITNs are mosquito nets impregnated with pyrethroid insecticides, such as permethrin, deltamethrin, and *alpha*-cypermethrin (Syme et al., 2021). The ITNs significantly reduce exposure to mosquito bites during the night. The latest generation of these nets combines synergists with pyrethroids to combat insecticide resistance effectively. Additionally, insecticidal sprays and mosquito coils are utilized to provide temporary relief from mosquito bites (Van Zyl, 2016).

Larval source management is an integral component of an integrated vector control strategy, involving the application of insecticides such as organophosphates, juvenile hormone mimics, and spinosyns to water bodies that serve as breeding grounds for mosquitoes (Derua et al., 2019; WHO, 2019). This approach is advantageous as it targets outdoor resting and feeding vectors, thereby mitigating mosquito breeding around water sources (Obopile et al., 2018). However, the success of malaria vector control is often hindered by the development of insecticide resistance among mosquito species, dynamic vector behaviour, and the invasion of new areas by these vectors (Sande et al., 2017). To effectively disrupt the transmission cycle, particularly concerning *Anophelesa arabiensis*, which is a significant vector in South Africa, it is essential to implement additional protective measures for individuals outdoors, such as enhanced use of mosquito repellents. This strategy could supplement the existing vector control measures in the region.

Indoor residual spraying (IRS) is another widely employed method for reducing malaria transmission and involves applying insecticides inside homes to eliminate mosquitoes (Zinszer et al., 2019). With this intervention, the inner walls of roughly 80% of a targeted household area are treated with insecticide (Zinszer et al., 2019). Between 2015 and 2018, approximately 68 countries were reported to be using IRS with various formulations of insecticides, including carbamates, organochlorines, pyrethroids, and organophosphates (Zinszer et al., 2019; WHO, 2018). While both ITNs and IRS have demonstrated significant effectiveness, they primarily provide protection indoors, leaving individuals vulnerable to mosquito bites when outdoors.

To address this gap, the WHO recommends the use of mosquito repellents for personal protection in outdoor settings, particularly in malaria-endemic areas (WHO, 2019). However, it is important to note that there is currently insufficient evidence to support the use of mosquito repellents as a public health intervention for large populations aimed at malaria prevention. Thus, widespread administration of mosquito repellents is not yet recommended as a primary preventive measure (Nguyen et al., 2018; WHO, 2019).

1.7 Insecticide resistance

The ongoing and extensive use of insecticides in agricultural practices and malaria vector control programs has led to the development of insecticide resistance within vector populations (Mbacham et al., 2019; WHO, 2022b). Notably, resistance in *Anopheles funestus* to pyrethroids, certain carbamates, dieldrin, and bendiocarb has been documented in both Ghana and South Africa (Okoye et al., 2008; Coetzee & Koekemoer, 2013). Furthermore, *An. arabiensis* has demonstrated resistance to deltamethrin, dichlorodiphenyl-trichloroethane (DDT) organochlorines, and carbamates (Brooke et al., 2013; Munhenga et al., 2022). A significant example of operational impact due to insecticide resistance was observed when pyrethroid resistance in *An. funestus* facilitated the re-invasion of this species into South Africa (Coetzee et al., 2013). Additionally, *An. arabiensis* was found to be resistant to benzene hexachloride in Zimbabwe in 1949 (Ngarivhume et al., 2015).

Insecticide resistance can be attributed to metabolic and physiological factors, as well as specific genetic mutations in mosquitoes (Hargreaves et al., 2003; Hemingway et al., 2004). In many instances, the increased metabolism of insecticides by vector enzymes, along with modifications at target sites, has rendered conventional insecticides less effective (Hemingway et al., 2004). During the height of the malaria epidemic in South Africa from 1996 to 2000, *An. funestus* was significantly involved in disease transmission (Brooke et al., 2001). Given its high transmission capacity and resistance to propoxur, a widely used carbamate insecticide, this species, is of considerable epidemiological interest. Propoxur, also known as Baygon is commonly used against domestic pests, ants and moths including *Anopheles* mosquitoes. While *An. arabiensis* has also shown resistance to propoxur, it holds less epidemiological significance due to its lower transmission intensity compared to *An. funestus*. The resistance observed in these mosquito species is believed to result from elevated levels of mixed-function oxidase enzymes, which play a role in the detoxification of pyrethroids (Brooke et al., 2015).

The continued development of insecticide resistance remains a pressing concern for malaria vector control efforts as it undermines the effectiveness of most malaria control measures if left unaddressed (Hunt et al., 2011; Venter et al., 2017). As such, it is critical to explore and develop new and alternative compounds to effectively manage mosquito populations and reduce the global burden of malaria.

1.8 Current strategies and challenges

Sub-Saharan Africa continues to bear the brunt of malaria's impact, largely due to the interplay of climatic, ecological, and socio-economic factors. It is essential to recognize malaria as a preventable and treatable condition. Vector mosquitoes typically bite during dusk and dawn; therefore, community-level strategies such as IRS have emerged as cost-effective and impactful in reducing malaria transmission rates. IRS represents a fundamental intervention for personal protection against mosquito bites and is widely endorsed due to its efficacy. In areas with high transmission rates, insecticide-treated nets are crucial preventive tools (Raman et al., 2021).

In South Africa, where malaria prevalence is relatively low compared to other southern African countries, a multifaceted approach to combat malaria is employed. Public health measures focus on vector control, prompt case management, surveillance, and community engagement. A cornerstone of this strategy is IRS, where insecticides are applied to the interior walls of homes to kill mosquitoes that transmit malaria. This method has proven effective in reducing malaria transmission. The effectiveness of supplementary measures - including the use of mosquito repellents, window and door screens, and mosquito coils - does extend beyond community-level initiatives (Balmith et al., 2024).

Despite these efforts, several challenges hinder the complete eradication of malaria in South Africa. Insecticide resistance with mosquitoes developing resistance to commonly used insecticides, including DDT, compromise the effectiveness of IRS. Cross-Border Transmission with the movement of people between South Africa and neighbouring countries with higher malaria prevalence leads to imported cases, complicating local control efforts. Issues around community acceptance with some residents resisting IRS due to concerns about the smell, stains, or potential health effects of insecticides like DDT, reducing coverage and efficacy (Moss et al., 2012).

Human behaviours significantly influence malaria transmission in South Africa. Key factors include exposure to mosquito bites, population movement and environmental changes Activities such as sleeping outdoors, night-time outdoor engagements, and inadequate use of mosquito nets increase contact with malaria-carrying mosquitoes (Monroe et al., 2015). Migration, tourism, and labour movements to and from malaria-endemic regions can spread the parasite to previously unaffected areas, complicating control efforts (Croft, 2014). Additionally, environmental changes like deforestation and climate variability can enhance mosquito breeding habitats, further affecting malaria dynamics (Ryan et al., 2020).

Cross-border collaborations, such as the Lubombo Spatial Development Initiative (LSDI) involving South Africa, Mozambique, and Swaziland, played a crucial role in these achievements (Chisenga et al., 2023). The LSDI focused on coordinated malaria control efforts across borders, leading to substantial reductions in malaria prevalence. In 2012, South Africa adopted a malaria elimination strategy targeting zero local transmission by 2018. This initiative led to a significant reduction in malaria cases, from 64,622 in 2000 to 8,126 in 2020, marking an 87% decrease. Malaria-related deaths also declined by 91%, from 459 in 2000 to 38 in 2020 (Moonasar et al., 2016b).

To further combat malaria, suggested interventions include voluntary screening at borders, enhanced active case detection, and health promotion activities. Efforts to control imported malaria focus on cross-border initiatives, particularly targeting sources in Mozambique. KwaZulu-Natal's significant progress toward malaria elimination is partly attributed to these collaborative efforts (Wangdi et al., 2015).

The WHO defines malaria elimination as the sustained cessation of local transmission, characterized by a reduction to zero incidence of indigenous cases and the prevention of reestablishment of a specific malaria parasite species within a designated geographical area due to intentional interventions (WHO, 2017).

In 2009, the Southern African Development Community established the Malaria Elimination Eight (E8) initiative, uniting Angola, Botswana, Eswatini, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe to eradicate malaria by 2030. South Africa is on track to achieve malaria elimination by 2028, as outlined in its National Malaria Elimination Strategic Plan (Maharaj et al., 2012). Eliminating malaria offers significant health and economic benefits, aligning with South Africa's 2030 National Development Plan and the United Nations Sustainable Development Goals. Success in this endeavour is expected to enhance trade, tourism, health, and economic growth across Southern Africa (Raman et al., 2021).

The RTS,S/AS01 malaria vaccine, known as Mosquirix®, has achieved significant milestones in combating malaria. The RTS,S/AS01 vaccine has received approval and is implemented in specific regions; nonetheless, its efficacy in decreasing malaria cases among children in high-transmission areas is moderate. South Africa has not incorporated the RTS,S/AS01 malaria vaccine into its national immunization program. The vaccine has been predominantly implemented in nations exhibiting elevated malaria transmission rates, including Ghana, Kenya, and Malawi. (El-Moamly and El-Sweify, 2023). The malaria burden in South Africa is comparatively lower potentially affecting the prioritization of vaccine deployment. South Africa maintains its emphasis on established malaria control strategies, which encompass vector control measures such as indoor residual spraying alongside timely diagnosis and treatment.

1.9 Mosquito repellents for personal protection

Diseases transmitted through mosquito bites have seen a global increase, largely due to mosquitoes' adaptation to urban environments. Climate change has further expanded in hot and humid areas conducive to mosquito breeding. Such climates facilitate the proliferation of mosquitoes, thereby contributing to the emergence of drug-resistant populations worldwide (Leal Filho et al., 2023; Traoré et al., 2020). While eliminating breeding sites is crucial in combating mosquito reproduction, complete eradication of all breeding habitats is often impractical. Particularly in forested areas near urban centres, some breeding sites may remain unnoticed, allowing mosquito populations to rebound.

In light of these challenges, Tavares et al. (2018) suggested that the use of mosquito repellents could effectively prevent biting activity in both indoor and outdoor environments, such as beaches, swamps, and forests, whether during the day or at night. Repellents consist of natural or synthetic chemical substances that, when applied to clothing or skin, effectively deter mosquitoes from landing and biting.

The WHO defines a repellent as "any chemical or substance that causes mosquitoes to avoid host skin (contact repellent) or inhibit mosquitoes from entering an area or a room (spatial repellent)" (WHO, 2018d). The mechanism of action for both natural and synthetic repellents involve the formation of a vapor layer on the skin, which emits odours unpleasant to mosquitoes. This results in altered flight paths and avoidance of contact with the host. The primary application methods for these repellents include sprays, gels, and lotions.

Mosquitoes detect humans through a variety of olfactory cues, such as ammonia, carbon dioxide, mixed phenols, carboxylic acids, and lactic acids (Watentena & Okoye, 2019; Ray, 2015). Repellents are designed to reduce the risk of mosquitoes landing on and biting humans, thereby minimizing the transmission of malaria.

Repellents can be employed in three methods:

i. **Push-only**: This method deters mosquitoes from approaching the human host.
ii. **Pull-only**: This approach attracts mosquitoes into traps situated at a distance from the human host.
iii. **Masking**: This method blocks mosquitoes' attraction to humans (Ray, 2015).

Research indicates that the push method is the most effective means of providing personal protection compared to the other two strategies (Ray, 2015). Furthermore, combining repellents in a push-pull strategy has demonstrated improved effectiveness over either method used individually (Ray, 2015). Mosquito repellents can be synthesized or derived from natural plant extracts.

Repellents can be applied topically or utilized spatially. Topical repellents are directly applied to the skin, necessitate consistent user adherence, and provide solely personal protection. Conversely, spatial repellents establish a protective zone by volatilizing repellent into the atmosphere, thereby offering protection to many individuals within a specified radius. The predominant spatial repellent is the mosquito coil, which functions by releasing pyrethroid volatiles into the atmosphere by gradual combustion. Like topical repellents, this strategy necessitates nightly adherence and consistent procurement. Another category of spatial repellents is referred to as emanators. Emanators integrate repellent compounds with low vapor pressure into a substrate like paper or agar gel, facilitating the passive release of repellent volatiles at ambient temperature. In contrast to topical repellents and mosquito coils, emanators do not necessitate adherence and may remain effective for prolonged durations, contingent upon the formulation (Tambwe et al., 2014).

1.10 Synthetic repellents

The major drawback of the synthetic repellent N,N-diethyl-3-methyl-toluamide (DEET) (Figure 1.5A) is its association with various side effects, resistance, insensitivity, and mutagenicity to mammals (Thireou et al., 2018). As a result, researchers continue to screen chemicals in the quest for an ideal mosquito repellent that possesses high efficacy and a robust safety profile. Two insecticides under investigation are Insect Repellent 3535 (IR3535) and picaridin (Figure 1.5B,C) (Tavares et al., 2018). According to Tavares et al. (2018), an ideal mosquito repellent is expected to adhere to several key characteristics (Table 1.2).

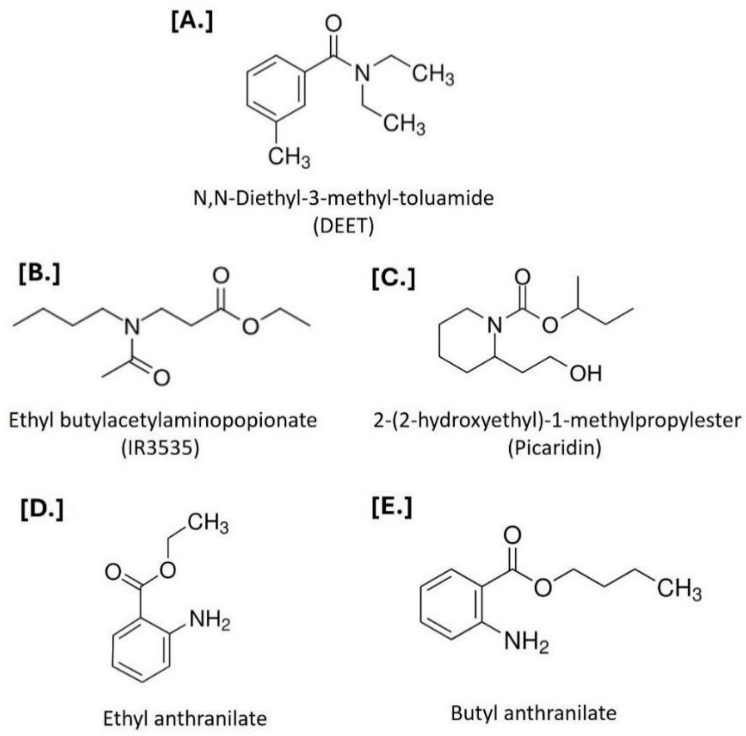

Figure 1.4: Synthetic repellents designed to repel mosquitoes (NCBI, 2025a, 2025b, 2025c, 2025d, 2025e).

Table 1.2: Characteristics of an Ideal Mosquito Repellent (Tavares et al., 2018).

Characteristics
Protects from biting insects
Has fewer adverse effects
Offers protection for an extended duration
Is commercially affordable
Exhibits water and sweat resistance
Has low skin penetration
Remains unreactive when in contact with materials like plastics, synthetic fibers, and glass
Possesses a pleasant scent or is unscented

1.10.1 N,N-Diethyl-3-methyl-toluamide

Discovered in 1946 by the U.S. Army, N, N-diethyl-3-methyl-toluamide (DEET) has become the gold standard in insect repellents (Figure 1.4.A) (Ho et al., 2019; NCBI, 2025a). This compound is the most widely used active ingredient, known for its effectiveness in repelling insects. Its mechanism of action involves the inhibition of insect olfaction via the inhibition of acetylcholinesterase and serves as a contact repellent, as mosquitoes can detect DEET with their tarsi upon direct contact with treated skin (Jahn et al., 2010). Despite its efficacy, DEET is also the most toxic repellent available, leading to recommendations against its use among pregnant women and children under six months of age. Reports indicate that it can cause a range of adverse effects including burning sensations, eye irritations, blisters, and in severe cases, coma or even death (Ho et al., 2019).

1.10.2 Insect Repellent 3535

In response to the drawbacks of DEET, significant efforts have been made by researchers to develop insect repellents that are less toxic while maintaining comparable effectiveness. One such alternative is insect repellent 3535 (IR3535) discovered by the German Merck Company (Colombo and Souza, 2021).

The active ingredient in IR3535 is ethyl butylacetylaminopropionate (Figure 1.4.B) (NCBI, 2025b), derived from *beta*-alanine. IR3535 is a biodegradable, colourless, and nearly odourless compound found in various commercial formulations, including sprays, lotions, aerosols, and wipes. At concentrations ranging from 7.5% to 19.5%, it provides an estimated duration of action between two to eight hours, exceeding the effectiveness of DEET concentrations which offer 3 to 4 hours of protection at 50% concentration and only slightly more at 100% (extending its protection from 3 to 5 hours) (Tavares et al., 2018). While IR3535 has been associated with some side effects, such as eye irritations and damage to clothing and plastics, it demonstrates exceptional skin tolerance and a superior safety profile when compared to DEET (Ho et al., 2019). This underscores the ongoing need for continued research into mosquito repellents, particularly as new formulations emerge that aim to improve safety, efficacy, and durability.

1.10.3 Picaridin and Other Less Commonly Used Synthetic Repellents

Picaridin, chemically known as 1-piperidinecarboxylic acid 2-(2-hydroxyethyl)-1-methylpropylester (Figure1.4.C) (NCBI, 2025c), is a colourless and nearly odourless liquid available in various formulations, including sprays, lotions, creams, and solutions. This repellent is increasingly favoured by consumers over DEET due to its non-greasy application and efficacy against all three common mosquito vectors at concentrations as low as 20% (Tavares et al., 2018). Picaridin functions by creating a vapor barrier that not only deters insects from biting but also disrupts their olfactory sensory neurons, making it effectively less detectable to mosquitoes.

In addition to picaridin, ethyl anthranilate (Figure1.4. D) (NCBI, 2025d) has emerged as a promising yet less commonly used synthetic repellent. It has been shown to be non-toxic and is considered a safer alternative to DEET (Islam et al., 2017; Singh and Sheikh, 2021; Van Roey et al., 2014). Furthermore, another repellent, butyl anthranilate (Figure 1.4.E) (NCBI, 2025e), demonstrates even greater repellent activity than ethyl anthranilate (Zhao et al., 2019). Both compounds are noted for their high efficacy and eco-friendly profiles, positioning them as attractive alternatives in the market (Afify et al., 2014). Ethyl anthranilate and butyl anthranilate not only provide effective protection against mosquito bites but also contribute to a growing array of safer options for consumers (Zhao et al., 2019). As public awareness of safety and environmental impacts increases, the shift towards these innovative repellents emphasizes the importance of developing alternatives that prioritize both user safety and functionality in repelling insects, making them valuable competitors to traditional repellents like DEET (Marques et al., 2021).

Despite the availability of numerous repellents, there is a necessity to identify a new generation of compounds that address the aforementioned constraints (Katritzky et al., 2008).

1.11 Innovation in mosquito control: natural alternatives

In response to growing concerns regarding the adverse effects associated with the indiscriminate and prolonged use of synthetic repellents, there is a burgeoning interest in natural alternatives. Recent research has underscored the potential of natural substances, such as plant extracts and essential oils, along with animal by-products (such as cow and elephant dung) as innovative mosquito repellents (Mukherjee & Ghosh, 2020; Pawar et al., 2019; Trongtokit et al., 2005).

Within the African context, over 60 plant species across 30 families have been identified for their mosquito-repelling properties. Traditional uses range from burning plant parts to create smoke, to applying powders from crushed plant materials directly on the skin or hanging whole plants indoors to deter mosquitoes (Pavela & Benelli, 2016). Furthermore, several clinically effective anti-malarial drugs have their origins in plant derivatives, such as quinine from *Cinchona* and artemisinin from *Artemisia* (Pasvol, 2005).

The increasing resistance to synthetic insecticides and antimalarial medications intensifies the urgency to explore novel, naturally sourced compounds for both treatment and management of malaria. Persistent inquiry into the efficacy of traditional plant species used for mosquito repellence is crucial to develop empirically validated solutions for local communities.

1.12 Natural mosquito repellents: Harnessing Nature

The ongoing research into natural mosquito repellents highlights a shift towards more sustainable and eco-friendly alternatives to synthetic products that often carry negative environmental consequences and long-lasting adverse effects to public health. Many synthetic repellents contribute to the development of resistance in mosquito populations and harm non-target organisms (Kim et al., 2020). In contrast, plant extracts and essential oils offer a promising solution given their efficacy and lower risk of resistance (Table 1.4).

The identification of over 60 plant species in Africa alone that can repel mosquitoes illustrates the rich potential of natural remedies (Table 1.3) (Govere et al., 2000c; Maharaj et al., 2010; Mavundza et al., 2011). Techniques such as burning plant parts, hanging the plant in the house or applying powdered extracts not only leverage local resources, but also provide culturally relevant methods for mosquito control (Mavundza et al., 2011). *Lippia javanica* (*Umsuzwane*) and *Aloe ferox* (*iNhlaba*) were reported as two of the most used phyto-repellents in KwaZulu-Natal, South Africa (Mavundza et al., 2011). The repellent efficacy was confirmed with *L. javanica* (alcohol extract) providing 76.6% protection, compared to *A. ferox* (DCM extract of the fruit) providing the most efficacy of 68% (Maharaj et al., 2010; Mavundza et al., 2011)Mavundza et al., 2010; 2011). However, ethanol extract of *Psidium guajava* leaves and *Leonotis Leonurus* flowers provided 100% efficacy comparable to DEET (Table 1.4).

Table 1.3: Overview of some of the most frequently reported plant-based mosquito repellents (Amer and Mehlhorn, 2006; Asadollahi et al., 2019a; Nerio et al., 2010; Pavela and Benelli, 2016; Reegan et al., 2014).

Plant Name	Scientific Name	Active Ingredients	Scent Properties	Repellent Uses
Citronella 	*Cymbopogon spp.*	Citronellal, citronellol, geraniol	Strong lemon-like scent	Extracted oil is widely used in candles, sprays, and lotions to repel mosquitoes.
Neem 	*Azadirachta indica*	Azadirachtin, nimbin, salannin	Earthy, slightly sulphurous scent	Neem oil or crushed leaves create a natural barrier against mosquitoes.
Lemongrass 	*Cymbopogon citratus*	Citral, geraniol, citronellal	Fresh citrusy aroma	Essential oil is a common ingredient in natural mosquito repellents; leaves can be crushed and applied directly.
Eucalyptus 	*Eucalyptus globulus*	Eucalyptol (1,8-cineole), p-cymene	Refreshing, medicinal scent	Often combined with other oils to enhance mosquito-repellent effect.
Lavender 	*Lavandula angustifolia*	Linalool, linalyl acetate	Sweet, floral fragrance	The scent from the oil or crushed flowers deters mosquitoes.

Plant Name	Scientific Name	Active Ingredients	Scent Properties	Repellent Uses
Marigold 	*Tagetes spp.*	Limonene, ocimene, tagetone	Pungent, earthy smell	Emits a strong aroma that repels mosquitoes; can be planted around homes or crushed for topical application.
Basil 	*Ocimum basilicum*	Estragole, linalool, citronellal	Sweet, herbaceous aroma	Leaves can be crushed for direct skin application or oil can be used in sprays.
Peppermint 	*Mentha piperita*	Menthol, menthone, limonene	Refreshing, minty scent	Used in sprays and ointments; fresh leaves can be rubbed on the skin to repel mosquitoes.
Garlic 	*Allium sativum*	Allicin, ajoene	Pungent, strong odour	Crushed garlic or oil can be applied to skin or used around homes to ward off mosquitoes.
Catnip 	*Nepeta cataria*	Nepetalactone	Mild, minty scent	Studies suggest it is more effective than DEET as a mosquito repellent, typically used in oil or spray form.

Table 1.4: South African plants evaluated for mosquito repellent properties against the *Anopheles arabiensis* mosquito (Asadollahi et al., 2019b; Chalannavar et al., 2013; Govere et al., 2000c; Maharaj et al., 2010; Mavundza et al., 2011).

Plant species	Plant Part	Extraction	Repellency (%)
Psidium guajava	Leaves	EtOH	100
Leonotis leonurus	Flower	EtOH	100
Psidium X durbanensis	Leaves	EtOH	98
Capparis tomentosa	Leaves	Water	97
Chenopodium opulifolium	Roots	Water	97
Leonotis leonurus	Leaves	Water	97
Carpobrotus dimidiatus	Leaves	Water	97
Psidium guajava	Leaves	Water	95
Leonotis leonurus	Leaves	EtOH	92
Psidium X durbanensis	Leaves	Water	88
Capparis tomentosa	Leaves	EtOH	87
Chenopodium ambrosioides	Leaves	DCM/MeOH (1:1)	87
Sida cordifolia	Whole plant	DCM/MeOH (1:1)	87
Leucas martinicensis	Leaves	DCM	86
Nuxia floribunda	Leaves	DCM/MeOH (1:1)	85
Carpobrotus dimidiatus	Leaves	MeOH	85
Alternanthera sessilis	Leaves	Water	85
Litogyne gariepina	Roots	DCM	83
Datura stramonium	Leaves	DCM/MeOH (1:1)	81
Chromolaena odorata	Leaves	MeOH	80
Leonotis leonurus	Flower	Water	78
Lippia javanica	Leaves	EtOH	77
Chromolaena odorata	Leaves	DCM	76
Mundulea sericea	Leaves	DCM/MeOH (1:1)	76
Mundulea serice	Leaves	DCM	72
Aloe ferox	Fruit	DCM	68
Chromolaena odorata	Whole plant	MeOH	68
Chromolaena odorata	Leaves	DCM/MeOH (1:1)	67
Eclipta prostrata	Whole plant	Water	67
Chenopodium opulifolium	Stems	Water	67
Dichrostachys cinerea	Leaves	MeOH	67
Cymopogon excavatus	Leaves	EtOH	66
Dichrostachys cinerea	Stems	DCM/MeOH (1:1)	65
Pelargonium reinforme	Leaves	EtOH	63
Chromolaena odorata	Whole plant	DCM	61

Where: DCM: dichloroemethane; MeOH: methanol. EtOH: ethanol

The comparable efficacy of the various plant-based repellents against *Anopheles* mosquitoes emphasizes the importance of continuing to explore and validate these natural options. This not only aligns with a growing preference for organic products but also supports biodiversity and ecosystem health.

Additionally, the use of essential oils from plants known to possess repellent properties, such as lavender and eucalyptus demonstrate the practical viability of these substances (Reegan et al., 2014). Given the promising results and increased public awareness regarding the dangers of synthetic chemicals, there is an opportunity for further development and commercialization of these natural repellents, potentially leading to safer, more effective mosquito control strategies worldwide. The focus on biocompatible repellents that biodegrade into less harmful by-products could also contribute to more responsible environmental management, ensuring that mosquito control does not come at the cost of ecological integrity (Maharaj et al., 2010). Continued research and innovation in this field are essential to harness the full potential of nature's offerings against mosquito-borne diseases.

Considering public concern over the use of synthetic chemicals for insect repellent, there has been a growing interest in finding natural alternatives that are both effective and environmentally friendly for preventing malaria transmission. Plant-derived medicines are often preferred over synthetic compounds due to their biodegradability and potential lower toxicity (Asadollahi et al., 2019a; Rajak et al., 2024). In South Africa, where plant products are readily accessible, they are frequently utilized in malaria treatment and mosquito control (Batista et al., 2009). Research has revealed that certain plant species, including *Cymbopogon* spp., *Eucalyptus* spp., and *Ocimum* spp., contain essential oils with repellent properties (Nerio et al., 2010). Essential oils extracted from various plant parts, including leaves, bark, roots, and seeds have demonstrated larvicidal, adulticidal, repellent as well as antiplasmodial benefits, with leaves being the most used (Maharaj et al., 2010; Mavundza et al., 2013; Van Zyl et al., 2006). Often, plant materials are dried and burned to release the essential oils in the smoke as a repellent method; for example, burning *Artemisia* (*Asteraceae*) has been found to be effective against mosquitoes (Batista et al., 2009).

Malaria control and potential elimination, particularly in low malaria-endemic areas like South Africa, Botswana, and Swaziland, is feasible (Cock, Selesho, van Vuuren, 2019). Unfortunately, developing countries face challenges in implementing Western models for malaria treatment due to the associated high costs. This highlights the urgent need to develop cost-effective repellents and antimalarial drugs, including traditional medicines. In Africa, numerous plants have traditionally been used to repel mosquitoes; however, there is limited scientific data validating and compiling the effectiveness of these plants. While many plants possess compounds that may not exhibit significant therapeutic benefits in isolation, they often demonstrate synergistic effects when combined with other extracts (Yang et al., 2024). Again, not enough research has been undertaken to identify possible effective combinations. Thus, there is a pressing need to investigate which plants and plant-derived formulations can be used to repel mosquitoes effectively to benefit communities at large.

1.12.1 Community use of phyto-repellents

In South Africa, many communities, particularly in rural areas, use traditional phytomedicines to repel mosquitoes, drawing on indigenous knowledge passed down through generations, and are preferred by many due to their affordability and accessibility. Community members, especially elders and traditional healers, play a crucial role in preserving and sharing this knowledge, ensuring that natural mosquito repellents remain an accessible and culturally significant method of protection against mosquito-borne diseases like malaria (Mavundza et al., 2011).

However, when malaria symptoms appear, health-seeking behaviour varies. Some individuals rely first on traditional medicines, such as herbal infusions and remedies prepared by traditional healers, believing in their effectiveness for treatment (Agbonon et al., 2010; Ngarivhume et al., 2015; Nyirenda and Chipuwa, 2024). Others, especially those with greater access to healthcare facilities, seek Western medicine, including antimalarial drugs and diagnostic services. Although the South African Department of Health and health organizations promote the use of modern treatments like ACTs, trust in traditional healing remains strong. Many communities adopt a dual approach, using phyto-repellents for prevention while turning to Western medicine for treatment, highlighting the coexistence of indigenous and biomedical health practices in malaria prevention and management. As such living in South Africa many do know about malaria, but the level of this knowledge has not been investigated in an area where malaria is not endemic such as the Vaal Triangle, Gauteng.

In this study, community knowledge, attitudes and perceptions towards malaria was assessed, as well as community knowledge on the various plants used as mosquito repellents.

1.13 PROBLEM STATEMENT

Malaria remains a public health problem in the Southern African region, where vector control programmes must be strengthened to reduce and prevent malaria transmissions, as well as ensure that community members are aware of measures to prevent malaria infections. Insect repellents play a critical role in preventing mosquito bites and thereby reducing malaria transmission. Due to the spread and development of insecticide resistance, as well as the rising financial impact and operational costs of in-/out-door spraying with insecticides, there is need to investigate alternative repellents that can be used in the primary healthcare context (Govere et al., 2001). However not enough is documented on phytomedicines, plants and natural substances used as mosquito repellents, as such natural products traditionally used by the community as insect repellents should be collated and investigated.

1.14 RESEARCH QUESTION

Are the community well informed on how to prevent mosquito bites and prevent malaria and what traditional methods are used by communities to repel mosquitoes in the Vaal Triangle, Gauteng, South Africa?

1.15 AIM OF THE STUDY

The aim of this study was to assess the knowledge of communities on mosquito repellents and malaria management and to assess the more commonly used plants and plant-derived formulations as mosquito repellents in the Vaal Triangle, Gauteng, South Africa.

1.16 OBJECTIVES

1.16.1 To ascertain the knowledge of the community including traditional healers on malaria management in the Vaal Triangle, Gauteng, South Africa.

1.16.2 To assess community knowledge about malaria, focusing on its causes, transmission, and symptoms.

1.16.3 To examine community perceptions and attitudes towards malaria prevention practices.

1.16.4 To investigate the knowledge and usage of traditional medicines as a means of self-protection against mosquito bites from traditional healers and the community living in the Vaal Triangle, Gauteng, South Africa.

1.16.5 To collate knowledge on vector control practices by community members in the Vaal Triangle areas of South Africa.

1.16.6 To gather knowledge on plant and natural traditional methods used to repel mosquitoes.

1.17 SIGNIFICANCY OF THE STUDY (DISSEMINATION & TRANSLATION)

Traditional medicine continues to play a very important role in primary health care as it is affordable and accessible to many poor communities in South Africa. It was proposed that the findings of this study will contribute additional and new knowledge on plants/plant derivative formulations and other natural methods used traditionally as mosquito repellents the Vaal Triangle in South Africa. The research findings will be published in international or national journals to contribute towards policies in malaria prevention and elimination.

CHAPTER TWO: RESEARCH METHODOLOGY

2.1 STUDY DESIGN

A descriptive cross-sectional study research design was used in this study to assess community knowledge and preventative practices for malaria and collate knowledge on phytomedicines used mosquito repellents by the community (Figure 2.1). The study was conducted using semi-structured questionnaire which included both quantitative and qualitative data. Data was collected from participants in one-on-one interviews both physically from individuals (n=216) and through focus group interviews with traditional healers (n=203) using the questionnaire, there were no online questionnaires administered in this study. Focus group interviews and questionnaire engagement was followed upon informed verbal and/or signed consent. The interview was semi-structured which allowed for interactive engagement to get more knowledge on the traditional practices being used to prevent mosquito bites and malaria management and control by the community.

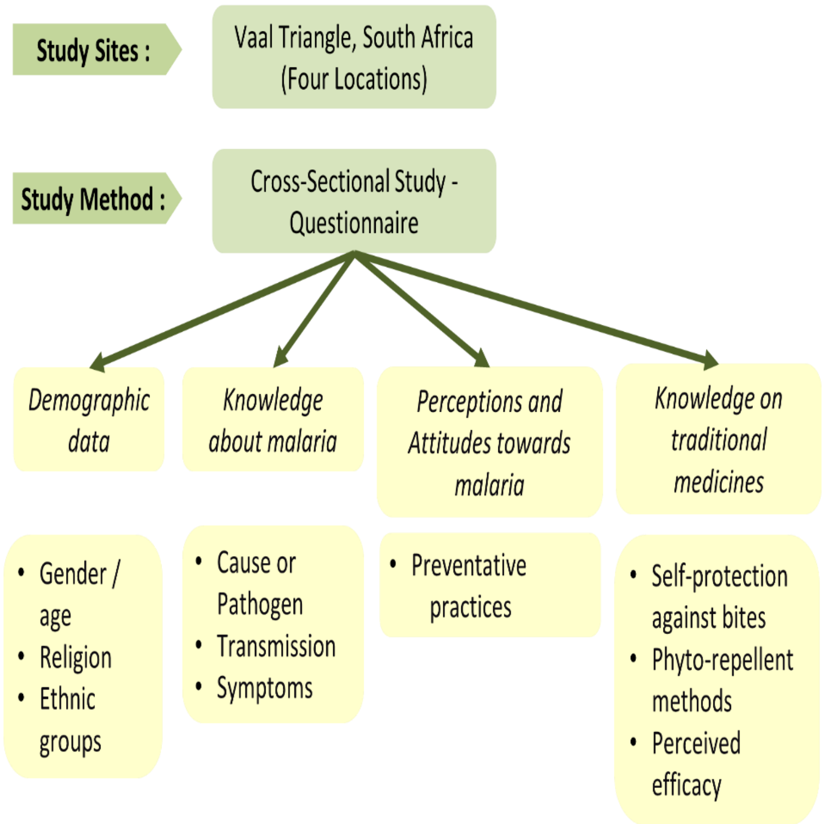

Figure 2.1: Summary of research methodology instrument setting and components.

2.2 STUDY SETTING

The study was carried out in the Vaal triangle an area situated in the Highveld region of South Africa, 60km south of Johannesburg. Vaal triangle is a triangular area made up of complex industrial towns which include Vereeniging, Vanderbijlpark, Sasolburg and townships of Boipatong, Bophelong, Sebokeng and Sharpeville. It is an area under Sedibeng District Municipality and inhabits more than one million inhabitants with people of different nationalities that work in the Acer Mittal industry (Yes Media CC, 2022).

A descriptive cross-sectional study was conducted using a semi-structured questionnaire to assess knowledge and perceptions on malaria prevention practices and management and to gather data on the plant/plant-derived products used to repel mosquitoes by community members from the areas in the Vaal Triangle. Participants were community members which included: -

- Outpatients / accompanying hospital visitors from the study site A. Study site A is a hospital which is one of the large regional hospitals in Gauteng located at the entrance of one of the townships in the Vaal Triangle, 20km south of Vereeniging. The hospital is surrounded by 33 clinics which include four Community Health Centres (CHCs) and these are points of referrals from which patients are sourced including all patients brought in by Emergency Medical Service as emergency cases that may be trauma or critically ill in the Vaal Triangle. The hospital provides services to the catchment population of about 1,125,207. (LOCALPROS (2025) Vaal Triangle (Vanderbijlpark to Vereeniging). (2025)).
- Traditional healers of the Sedibeng Traditional Healers Association led by their leader Bishop study site B Community Hall.
- Outpatients / accompanying hospital visitors from study site C hospital which is situated in Vereeniging, 62.4km south of Johannesburg.
- Outpatients / accompanying hospital visitors from study site D located in Vanderbijlpark, about 60 km south of Johannesburg.

2.3 POPULATION AND SAMPLING

By including different population groups, the study was more comprehensive allowing for comparison of knowledge and practices between the educated professionals, the general public and the traditional practitioners. As well as to identify the knowledge gap which is required for further health education interventions.

Participants were chosen using a random sampling method amongst the groups around the Vaal Triangle from community members which included outpatients/accompanying hospital visitors at study site A (~100/day), study site B (~75/day) and study site C (~70/day). Traditional healers of the Sedibeng Traditional healers Association were also invited to participate through their community leaders (~200 members). The total sample size across all study sites was estimated to be 377 as calculated by Raosoft sample size calculator (Raosoft, 2004) with an estimated population of <20,000 at 95% confidence interval and 5% margin of error. There were 419 participants in all, all of whom were members of the public in the study sites. Of these, 216 were community members who answered the paper questionnaire, and 203 were traditional healers who took part in the focus group interviews and answered the questionnaire.

2.4 INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria included those who agreed to participate in the study by signing the consent form and were above the age of 18 years from the public within the 3 hospital areas and community members of the traditional healer's association around the study sites. Exclusion criteria were patients who appeared too ill to participate as well as their caregiver.

2.5 DATA COLLECTION

2.5.1 INSTRUMENT

The semi-structured questionnaire was designed with guidance by the objectives of the study and clinical research literature (Padonou et al., 2018; Halidu, 2022). Many of the questions in the questionnaire had been validated by Dr Halidu (Prof van Zyl personal communication, March 2022), however they were also reassessed in a pilot study of ten community members to validate the additional questions.

The semi-structured questionnaire (Appendix A) was administered to 419 participants who consented to participate in the study using a random sampling method to the study groups in the study setting. Participation in this study was voluntary, with information sheets that informed participants of the purpose of the study and the researcher explained to potential participants before interviews commenced. Before handing out the questionnaire, informed signed consent was obtained from potential participants. The information sheet (Appendix B1) and consent forms (Appendix B2) were translated and verbally interpreted for illiterate respondents in their local languages and consent was obtained.

The questionnaire of this study comprised of four components:

1. Demographic data – there were seven items in this component of information on gender, age, religion (which has an influence on practices different ethnic groups undertake in terms of traditional medicines), level of education and occupation.
2. Knowledge about malaria causes, transmission and symptoms – component had eleven items whose aim was to obtain basic knowledge of participant on malaria as a disease, its cause, symptoms and transmission.
3. Perceptions and attitudes towards malaria prevention practices – this section consisted of sixteen questions, and these were to assess how participants perceive malaria and their attitudes towards malaria prevention practices.
4. Knowledge on traditional medicines as means of self-protection against mosquito bites – there were nine items in this section, to assess respondents knowledge of use of natural plants or plant formulations to protect themselves against mosquito bites, where they acquired the Phyto-repellent, methods of preparation and administration and how well it works against mosquitoes and if they would like to know more information about malaria and mosquito bites and how to contact them for more information.

One open ended question was included at some end of the sections allowing respondents to write and explain more about the knowledge they had and their practices and perceptions relating to the study aim.

2.5.2 PILOT STUDY

A pilot study was administered to ten community members randomly selected to cater for all study groups. The purpose of the pilot study was to validate the questionnaire sections, assess any potential challenges, and timing to complete to possibly make changes to the data collection instrument. Slight changes were made to the questionnaire to include more options in the responses in-order to gather clearer knowledge and perceptions from participants. Participants were able to complete the questionnaire in an average time of 10-15 mins without any difficulty. The pilot study results were not included in the main study.

2.5.3 PROCEDURE OF COLLECTING DATA

In order to approach and enroll outpatients/accompanying hospital visitors at the hospitals, letters of permission were sent to the Hospital Director/CEO and permission acquired from Community and the Forum leaders (Appendix C1-C4). Once permission was obtained, out-patients/visitors were randomly approached and asked to volunteer to be included in the study and complete the questionnaire. The principal researcher of this study had one-on-one sessions with some of the participants who required verbal translation/ interpretation of the questionnaire, whiles those who were illiterate, the questions were interpreted and read for them.

Study participants around the hospital sites included outpatients, patient relatives, staff and visitors who were approached individually from the hospital study sites and only those individuals that met the inclusion criteria and voluntarily completed the consent forms were included in the study.

There was no compensation for participation in the study, neither were they forced to take part. Participants were mentally and physically fit to make informed consent and participate in the study. The researcher explained and maintained confidentiality of all participants throughout the study, no form of identification was requested nor provided in the questionnaires and during interviews.

2.5.4 FOCUS GROUP INTERVIEWS

Focused group interviews were held with the community members of the Traditional healer's association from the study sites who were invited by their leaders to participate through word of mouth. A total of 203 traditional healers participated in the study in groups. The data was gathered using the same semi-structured questionnaire (Appendix A) that was created specifically for this study; no new questions were added. Focused group interviews with traditional healers sharing their knowledge are depicted in Figure 3.4. The focus groups answered questions based on the study's instrument while providing in-depth information about their knowledge, perceptions, and understandings in their own words.

Participation in the group discussions was voluntarily and upon informed consent and inclusion criteria. The interviews were conducted by the researcher over tea and water with the help of a research assistant taking notes and interpreting the questions together with the researcher in the different vernacular languages and to those that were illiterate.

The focus group interviews took place in community halls (~10-20/day) traditional healers, waiting areas and in car parks around the study sites, the researcher, research assistant and community leaders welcomed the participants. The researcher introduced themselves and the research to the group. Participants were given written information sheet and consent forms. Verbal information was also provided to inform participants of the details of the study as written in the information sheet.

To further explore the traditional healer's knowledge, open-ended questions from the instrument questionnaire (Section 2.5.1, Appendix A) served as the basis for all of the inquiries and discussions in the focus group interviews. The researcher went deeper into their expertise during these focus group interviews, focusing on the open-ended questions 2.12, 4.3, 4.6, 4.8, and 4.9 (Appendix A), which assessed their understanding of traditional remedies (plants, herbs, or any other method) used to treat malaria or to ward off mosquito bites, as well as how they prepare and apply them. The participants were assisted by the researcher and the research assistant in completing the questionnaires, ensuring that their answers to the open-ended and other questions accurately reflected their knowledge and comprehension. Through verbal quotes from traditional healers based on open-ended questions that probed their traditional knowledge on mosquito repellents (Appendix A; Questions 4.3, 4.6, 4.8, and 4.9) and malaria management (Appendix A; Question 2.12), the researcher also documented some of the most popular traditional remedies.

The questionnaires were coded by the researcher with assistance of the supervisors and numbered to ensure anonymity and no identifying information even when the data was captured using excel. The interviews and questions on the questionnaire were open-ended to encourage detailed information on the knowledge the participants had.

2.6 DATA ANALYSIS

Data collected from all the paper-based standardised semi-structured questionnaires was checked for completeness before being captured into Microsoft Office Excel. The data was captured question by question and the excel file was cleaned by reading every open-ended response to get in-depth insight of the participant's response. There were a couple of typing errors in the raw data which were fixed in the cleaning process to maintain uniformity of the document. The questionnaires were coded during the data collection process, once the data was entered, it was checked for data cleaning and coding purposes for accuracy. Data was then exported from Excel to the statistical software programme, STATISTICA version 16 for analysis purposes.

The data set was reviewed for quality assurance to ensure the information entered was accurate as it appeared on the questionnaire (Appendix A). The data was analysed by means of descriptive and inferential statistics analysis performed using Statistical Package for the Social Sciences (SPSS) statistical software (Stata version 16.0). The demographic characteristics of the data was summarised using frequencies, percentages and measure of central tendencies. Cross tabulations performed using Chi square method to compare the proportions and produce baseline data on knowledge and prevalence of malaria and preventative practices. Upon statistical consultation proportions test and factor analysis was used to compute the relation between items essential to be assessed. Logic regression models were used univariate and multivariate logistic regressions to assess the association between demographic factors and key knowledge items. The researcher for the open-ended question read all the responses and found common themes, which were used to generate the frequencies and percentages.

The statistical significance of the associations between the variables was calculated using a 95% confidence interval to assess lack of knowledge and specific preventative practices which included the use of traditional medicines. A P value less than 0.05 ($p<0.05$) was considered statistical significance and was used to assess associations between variables.

2.6.1 Descriptive Analysis

- **Demographics:** Frequencies and proportions were calculated for categorical variables, including gender, religion, education level, and occupation. The mean and standard deviation / median and interquartile range were computed for continuous variables such as age using the Shapiro Wilk test to determine the appropriate central tendency measure.

- **Knowledge About Malaria:** Frequencies and proportions were computed for each item assessing knowledge of malaria causes, transmission, and symptoms (Q2.1 to Q2.11) (Appendix A).
- **Perceptions and Attitudes:** Frequencies and proportions were summarized for each perception and attitude-related item (Q3.1 to Q3.16) (Appendix A).
- **Knowledge of Traditional Medicines:** Frequencies and proportions were analysed for items assessing the use of phytomedicines, their methods of preparation, and their efficacy against mosquito bites (Q4.1 to Q4.9) (Appendix A).

2.6.2 Inferential Analysis

- **Demographic Factors and Malaria Knowledge:** Logistic regression models were used to assess the association between demographic factors (gender, age, education level, and occupation) and key malaria knowledge items (Q2.1) (Appendix A).

2.7 ETHICAL CONSIDERATIONS

2.7.1 APPROVAL TO CONDUCT RESEARCH

The following steps were done to ensure that ethical considerations were observed.

- Approval for this study was applied for from the University of the Witwatersrand Faculty of Health Sciences the Human Research Ethics Committee (Medical) and was granted (M221039) (Appendix D).
- Approval of study was sought from the School of Therapeutic Sciences Protocol Assessment Committee of the University of the Witwatersrand, South Africa and Protocol assessment and title approval was granted (Appendix E).
- Approval to undertake the study in the Sedibeng District clinics was obtained from the Gauteng Health Research Committee (GP_202301_054) (Appendix F).
- After receiving these approvals permission to conduct the research was also requested

and granted from the Chief Executive Office of the respective community health centres and community leaders (Appendix C1, C2, C3, C4).

- Participants were informed that their participation is voluntary with no form of compensation promised and that they could stop their participation at any point in the study.
- Confidentiality and anonymity of participants was maintained throughout the study by ensuring that no form of identification was provided on any questionnaires and during the interviews.

2.7.2 INFORMED CONSENT

Participants received written and verbal information about the study. Participants were provided with an information sheet that explained all details of the study (Appendix B1). The researcher made it clear to participants that their participation was voluntarily and no financial or any form of compensation was promised. Participants were informed that they could stop at any given time. If there was agreement to participate and participant fit the inclusion criteria, they were asked to complete and sign a consent form (Appendix B2).

2.7.3 MANAGEMENT OF COLLECTED DATA

The dataset was reviewed for quality assurance prior to analysis. Specific data management steps included: checking all records for duplicates, and no duplicates were identified. Data were inspected for outliers, inconsistencies, and logical errors (e.g., unrealistic ages or mismatched categorical responses). Missing data was assessed and reported in tables where appropriate. Variables were renamed for clarity and labelled where necessary. Categorical variables were assigned appropriate value labels for analysis. Completed questionnaires, consent forms, and notes gathered during data collection in the study were stored in a safe and secure place in the Pharmacology Division with secure access of the data by the researcher and supervisors.

2.8 SUMMARY

The research design was selected to meet the study objectives. The data collection instrument was described in-depth. A small pilot study procedure was conducted at the main study site to validate the instrument. The instrument successfully met the study objectives. The research methodology, ethical considerations and data management of the study has been described.

CHAPTER THREE: RESULTS AND DATA ANALYSIS

3.1 INTRODUCTION AND APPROACH TO DATA ANALYSIS

This chapter outlines the findings of this study in assessing community knowledge and preventative practices for malaria and phytomedicines such as mosquito repellents. Data was collected by means of a data collection tool (semi-structured questionnaire) (Appendix A). The results stipulated in this section were achieved through a non-experimental descriptive cross-sectional survey. The population included community members around the Vaal Triangle, South Africa. Data was analysed using descriptive and inferential statistics (Section 2.6).

3.2 QUESTIONAIRRE RESULTS

3.2.1 Demographic characteristics of study participants

This section focuses on demographic data of the participants which comprised of seven items, namely age, gender, nationality, religion, ethnic group, level of education and occupation (Table 3.1).

A total sample of 419 participants was recruited for the study, predominantly female and individuals aged 56-65 years, with the majority being South African nationals and identifying as Black. Regarding religion, African traditional beliefs were the most reported, followed by Hinduism Educational attainment showed a notable concentration at the secondary level, with only a few having tertiary education. In terms of employment, nearly half of the participants were self-employed, underscoring a representation of entrepreneurial activity within the population (Table 3.1).

Table 3.1: Demographic characteristics of study participants (n=419).

Variables		Frequency (n)	Percentage (%)
Gender	Male	176	42.00
	Female	243	58.00
Age group	18-25	20	4.77
	26-35	76	18.94
	46-55	113	26.97
	56-65	123	29.36
	≥66	69	16.47
	Missing	18	4.30
Nationality	Lesotho	0	0.00
	Malawi	2	0.48
	Mozambique	6	1.43
	Somalia	1	0.24
	South Africa	379	90.45
	Zambia	1	0.24
	Zimbabwe	28	6.68
	Missing	2	0.48
Religion	African	262	62.53
	Buddhism	0	0.00
	Hinduism	143	34.13
	Christianity	2	0.48
	Islam	10	2.39
	Judaism	1	0.24
	Other	1	0.24
Ethnic group	Black	415	99.05
	Coloured	1	0.24
	Indian	1	0.24
	White	2	0.48
Education level	No schooling	44	10.02
	Primary level	66	15.75
	Secondary level	230	54.89
	Tertiary level	81	19.33
Occupation	Unemployed	22	5.25
	Employed	126	30.07
	Self employed	206	49.16
	Other	65	15.51

3.2.2 Knowledge about malaria

Section two of the data collection tool assessed knowledge of participants about malaria.

Table 3.2: Descriptive statistics of the responses given on 'Knowledge about Malaria'

Statement	Frequency (n)	Percentage (%)
Awareness of Malaria		
Yes	364	0.95
No	4	86.87
Not sure	43	10.26
Missing	8	1.90
Think malaria is life threatening		
Yes	330	78.76
No	19	4.53
I don't know	70	16.71
Ever had malaria		
Yes	52	12.41
No	365	87.11
I don't know	2	
How malaria is spread		
Bite of a housefly	38	9.07
Bite of infected female *Anopheles* mosquito	53	12.65
Contact with infected person	294	70.17
Climate change	33	7.88
Contact with cockroach	1	0.24
None of the above	-	-
I don't know	-	-
Can anyone recover from malaria without treatment?		
Yes	364	86.87
No	17	4.06
Not sure	38	9.07
How malaria is treated in participants area		
Western medicine	120	28.64
Traditional medicine	233	55.61
Both western and traditional medicine	66	15.75

*It is possible to choose more than one answer

Awareness of malaria was high, with nearly all affirming knowledge of the disease, although a small number were unsure (Table 3.2). A majority recognised malaria as life-threatening. Regarding past experiences, more than half reported never having had malaria. Interestingly, while quite a number erroneously believed malaria could be spread through contact with an infected person, only a few correctly identified the bite of an infected female *Anopheles* mosquito as the mode of transmission.

In terms of symptoms, headache was the most recognised symptoms, while other common symptoms like fever and chills were underreported (Figure 3.1). A notable misconception was that the majority believed individuals could recover from malaria without treatment. For treatment approaches, over half of participants relied on traditional medicine, while less than half preferred western medicine.

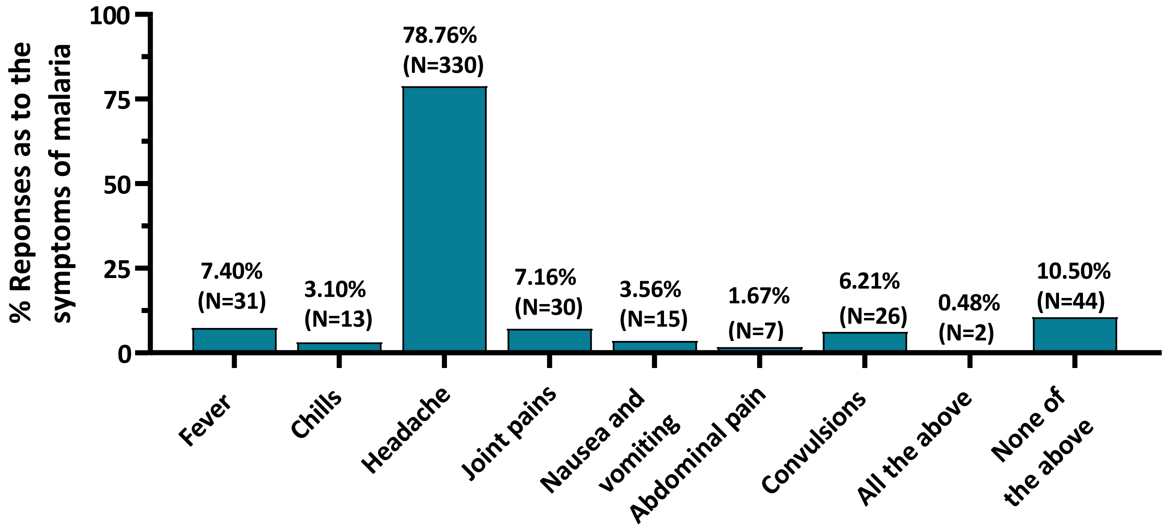

Figure 3.1: Participant's knowledge of malaria symptoms.

3.2.3 Responses on medicines used for malaria treatment

The data on medicines used for malaria treatment highlights that the most reported medication was atovaquone. (Figure 3.2). Doxycycline followed, suggesting a notable reliance on this antibiotic, which is typically used for prophylaxis rather than treatment. Less commonly mentioned were artesunate and arthemeter-lumefantrine, both of which are primary treatments recommended by the WHO and the South African Department of Health (WHO, 2024; SADOH, 2018; SADOH, 2019). Notably, mefloquine and quinine, historically significant antimalarial drugs, were not reported.

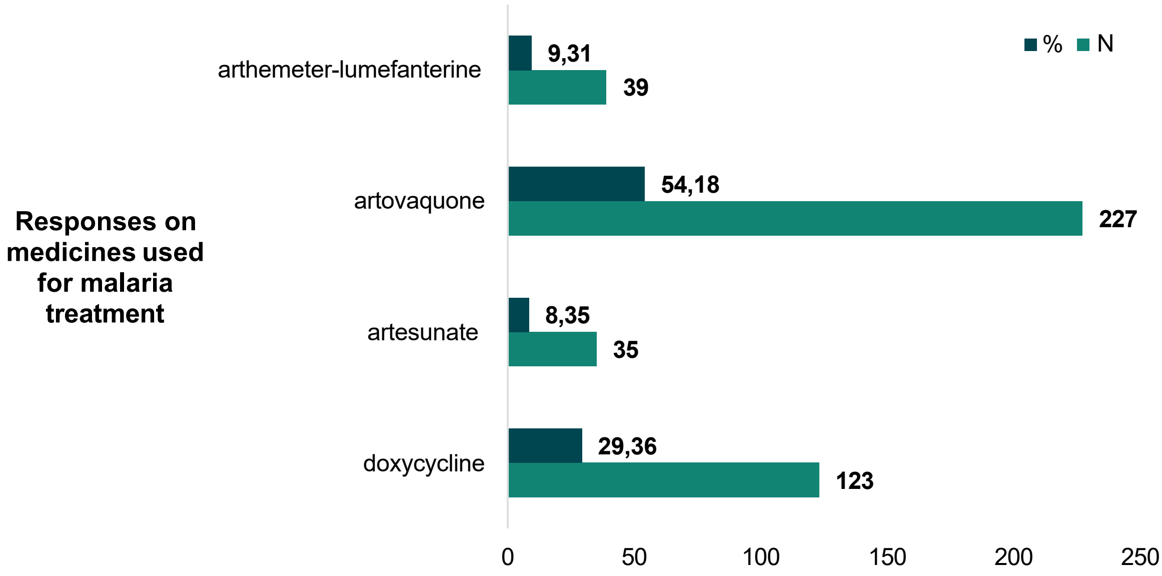

Figure 3.2: Responses on medicines used to manage malaria.

3.2.4 Perceptions and attitudes towards malaria prevention

Most participants believed malaria is preventable, though a few were unsure (Table 3.3). Regarding mosquito breeding sites, standing water was correctly identified by more than half as a primary location, while other options like garbage reflected partial understanding. Similarly, most participants recognised that mosquitoes bite predominantly between dusk and dawn, which aligns with their activity patterns (Table 3.3). A high proportion reported having used mosquito repellents, indicating widespread adoption of protective measures. However, less than half thought sleeping under a mosquito net could prevent malaria, while the others disagreed, highlighting a misconception that could undermine preventive practices. In terms of environmental control, half of the participants reported frequently cutting bushes around their homes, with less than half doing so occasionally, demonstrating some awareness of controlling mosquito resting places (Table 3.3).

Table 3.3: Perceptions and attitudes towards malaria prevention (N=419).

Statement	Frequency (N)	Percentages (%)
Think malaria is preventable		
Yes	364	86.87
No	7	1.67
Not sure	47	11.22
Missing	1	0.24
Places in which malaria mosquitoes breed		
Garbage	95	22.67
Soil	4	0.95
Standing water	294	70.17
I don't know	26	6.20
Time of the day in which mosquitoes bite		
During the day	9	2.15
All day	89	21.24
Between dusk and dawn	317	75.90
I do not know	3	0.72
Ever used mosquito repellents		
Yes	377	89.88
No	38	9.07
Unknown	4	95.46
Thinks sleeping under mosquito net can prevent malaria		
Yes	205	48.93
No	178	42.48
I don't know	36	8.59
Frequency of cutting down bushes around home to control resting places		
Often	210	50.12
Sometimes	183	43.68
Never	25	5.97
Missing	1	0.24

3.2.4 Perceptions on what is believed to provide to provide self-protection against malaria

The data on beliefs regarding self-protection methods against malaria indicates a strong preference for long-lasting insecticide-treated nets, with majority of participants identifying them as an effective preventive measure. Untreated mosquito nets were mentioned by a few, suggesting some gaps in awareness about the added benefits of insecticide treatment. Other methods included mosquito repellent and maintaining a clean environment, which reflect a broader understanding of prevention strategies. However, only a small number mentioned alternative methods under the "other" category, highlighting the limited diversity in perceived preventive measures (Figure 3.3).

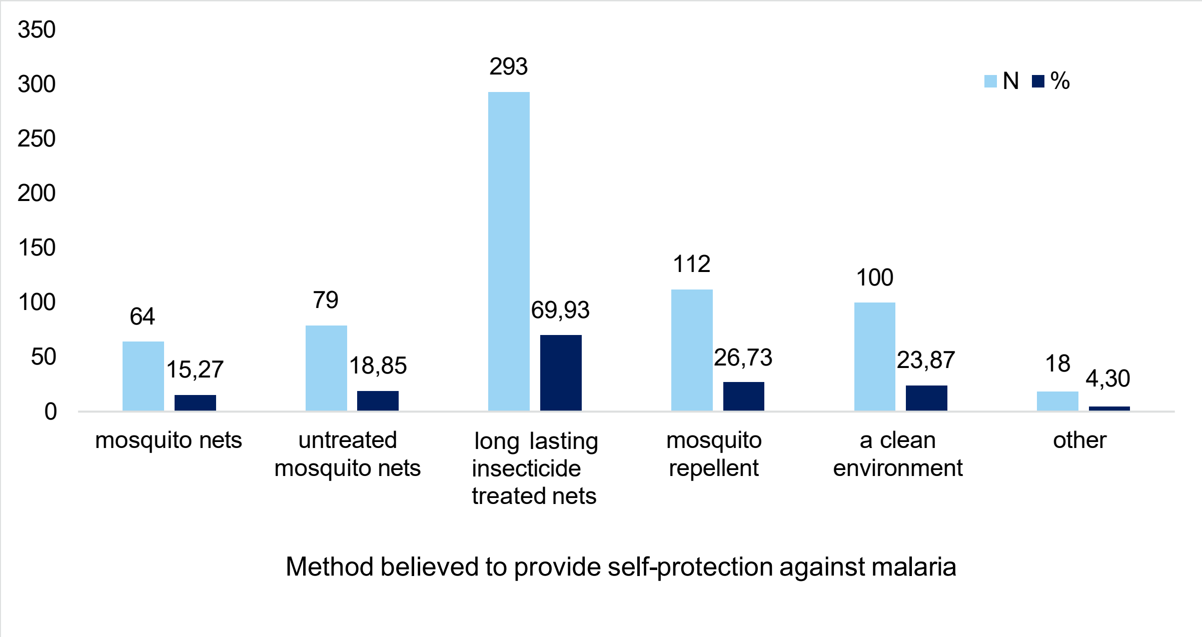

Figure 3.3: Responses on method believed to provide self-protection against malaria.

3.2.5 Knowledge of traditional medicines as mosquito repellents

The responses on traditional and alternative methods for malaria prevention and mosquito control reveal a wide variety of practices among the participants. An illustration of the engagement and participation of local traditional practitioners and their responses to traditional and alternative methods for malaria prevention and mosquito bite avoidance (Figure 3.4).

Figure 3.4: Participants sharing their knowledge on traditional methods as mosquito repellents.

The most frequently mentioned method, contributing to nearly half of responses, was unspecified traditional remedies labelled as "they do not say the name" (Table 3.4). Commonly cited specific remedies included aloe, African potato mixed with aloe, and burning specific plants like *imphepho* or lemon grass. Notably, some responses highlighted unique methods such as using cow dung or specific herbs like *umsenge-wehlathi/sphakga* .

A large proportion specifically cited *imbiza*, a traditional herbal remedy, while combinations involving lavender, mint, and catmint were also recurrent. Other methods, like burning papaya or banana leaves and preparing herbal drinks, appeared sporadically.

Responses were highest in the unspecified remedies (49.40%) followed by umsenge wehlathi *Cussonia* species which they frequently referred to as sphakga/umsenge-wehlathi. Imbiza followed to be mentioned more. Then lavender, mint, catmint, banana leaves, papaya leaves and mhlonyane/lengana as well as other methods like burning cow dung faeces were also frequent, followed by African potato and Imphepho herbs. Lemon grass and aloe were the least mentioned (Table 3.4).

Table 3.4: Responses on commonly cited traditional remedies.

Responses	Plant scientific name	Percentages (%)
Aloe	*Aloe ferox*	0.24
Lemon grass	*Cymbopogon citratus*	0.24
African potato	*Hypoxis hemerocallidea*	0.48
Imphepho	*Helichrysum odoratissimum*	0.48
Banana leaves	*Musa acuminata*	1.43
Catmint	*Nepeta cataria*	1.43
Cow dung	*Bovine feeces*	1.43
Lavender	*Lavandula angustifolia*	1.43
Mint	*Mentha piperita*	1.43
Papaya leaves	*Carica papaya*	1.43
Umhlonyane/Lengana	*Artemisia afra*	1.43
Imbiza	*Cyrtanthus obliquus and lippia javanica*	3.58
Umsenge-wehlathi Umsenge/sphakga	*Cussonia sphaerocephala Strey* *Cussonia spicata*	4.77
unspecified remedies	-	49.40

3.2.6 Factors Associated with Malaria Awareness

The logistic regression analysis revealed that when controlling for other demographic factors, males had significantly lower odds of being aware of malaria compared to females (adjusted OR: 0.25, 95% CI: 0.11–0.56, p=0.001). Participants practicing Hinduism also had reduced odds of malaria awareness compared to those practicing African traditional religions (adjusted OR: 0.20, 95% CI: 0.07–0.59, p=0.004). Additionally, individuals with no formal schooling were less likely to be aware of malaria than those with secondary education (adjusted OR: 0.18, 95% CI: 0.04–0.72, p=0.015). These findings highlight disparities in malaria awareness related to gender, religion, and education level, suggesting targeted interventions are needed to improve awareness in these groups.

Table 3.5: Univariable and multivariable logistic regression to determine factors associated with malaria awareness (N=407).

Variables	Uni-variate		Multi-variate	
	Odds Ratio (95% CI)	**p-value**	**Odds Ratio (95% CI)**	**p-value**
Gender				
Male	0.24 (0.12 – 0.49)	<0.001	0.25 (0.11 – 0.56)	0.001
Female	base	base	base	base
Age group				
18-25	3.47 (0.44 – 27.69)	0.240	-	-
25-35	1.08 (0.47 – 2.46)	0.854	1.75 (0.68 -4.51)	0.246
46-55	base	base	base	base
56-65	2.51 (1.03 – 6.09)	0.041	3.44 (0.83 -14.18)	0.143
≥66	2.79 (0.89 – 8.68)	0.077	4.36 (0.52 – 36.42)	0.174
Nationality				
Lesotho	-	-	-	-
Malawi	0.11 (0.01 – 1.92)	0.133	1.60 (0.07 – 37.36)	0.769
Mozambique	0.47 (0.05 – 4.32)	0.506	0.43 (0.03 – 5.41)	0.514
Somalia	-	-	-	-
South Africa	base	base	base	base
Zambia	2.94 (0.39 -22.34)	0.296	4.08 (0.43 – 38.64)	0.220
Zimbabwe	-	-	-	-
Religion				
African	base	base	base	Base
Buddhism	-	-	-	-
Hinduism	0.27 (0.14 – 0.52)	<0.001	0.20 (0.07 – 0.59)	0.004
Christianity	0.06 (0.003 – 1.06)	0.055	-	-
Islam	-	-	-	-
Judaism	-	-	-	-
Other	-	-	-	-
Ethnic group				
Black	base	base	base	base
Coloured	-	-	-	-
Indian	-	-	-	-
White	0.11 (0.007 – 1.89)	0.131	0.02 (0.005 – 0.57)	0.023
Education level				
No schooling	0.53 (0.21 – 1.35)	0.187	0.18 (0.04 – 0.72)	0.015
Primary level	1.04 (0.40 – 2.67)	0.936	0.44 (0.13 – 1.58)	0.213
Secondary level	base	base	base	base
Tertiary level	1.47 (0.57 – 3.74)	0.418	2.10 (0.64 – 6.85)	0.217
Occupation				
Unemployed	1.24 (0.15 – 10.10)	0.839	4.28 (0.30 – 61.05)	0.284
Employed	0.32 (0.15 – 0.71)	0.005	0.82 (0.25 -2.71)	0.750
Self employed	base	base	base	Base
Other	0.19 (0.08 – 0.48)	<0.001	0.40 (0.14 – 1.17)	0.750

3.2.7 Summary Conclusion

The analysis highlighted a high level of awareness of malaria among participants, with 95% affirming knowledge of the disease. However, significant misconceptions were identified, such as only 12.65% correctly recognising the bite of an infected female Anopheles mosquito as the mode of transmission. Traditional medicine use was prevalent (55.61%) for malaria prevention, reflecting cultural practices. Logistic regression revealed that males, individuals practicing Hinduism, and those with no formal education were less likely to be aware of malaria, indicating disparities that require targeted interventions. While most participants (86.87%) believed malaria is preventable, gaps in knowledge about prevention methods, such as the benefits of insecticide-treated nets, were noted. These findings underscore the importance of education campaigns to address knowledge gaps and promote effective malaria prevention strategies.

3.3 PROFILES OF THE TRADITIONAL REPELLENT TREATMENT

The open-ended questions and focus group discussion with traditional healers further explored how traditional healers prepare some of the mentioned traditional remedies (Section 3.3.1)" verbal quotes from traditional healers". In addition to burning cow dung, other unproven prevention measures such as smoke from burning tissue or egg holder cardboard was also mentioned as ways to drive away mosquitoes. Similar findings were reported in a study done by Manana (Manana et al., 2018). *Impepho* herbs, *imbiza*, blue gum tree leaves, *umhlonyane*, African potato, *umsenge-wehlathi/sphakga*, *zumbane*, banana leaves, papaya leaves were reported to be used to treat fever in malaria and some to repel mosquitoes. The revealed malaria prevention measures such as *umsuzwane* plant (*Lippia javanica*) smell which was reported to drive away mosquitoes by traditional healers in this study, profiles on these traditional remedies (plant monographs) were compared to literature and tabled in Table 3.6 below.

3.3.1 Verbal quotes from traditional healers on traditional remedies

The responses from traditional healer participants in the qualitative segment of the study were derived from the open-ended questions in the questionnaire (Appendix A). The researcher asked traditional healers, both individually and in groups, the following summary questions, with verbal quotes and responses recorded, based on the open-ended questionnaire questions (questions 2.12, 4.3, 4.6, 4.8, and 4.9; Appendix A)

<u>**Researcher:** As a traditional healer which traditional remedies (plant/herbs/or any other method) do you use to manage malaria (**Question 2.12**) or to repel mosquitoes (prevent mosquito bites) (**Question 4.3**) and how do you prepare/use them (**Question 4.6, 4.8**)? Who taught you or how do you know these remedies (**Question 4.9)**?</u>

<u>Question 2.12</u>: If you use Traditional medicines for malaria management, please specify which ones?

Question 4.3: If YES please specify what plants /herbs are used to prevent mosquito bites. Please specify name you know the plant/herb by as mentioned by traditional healer / family member/ community member.

Question 4.6: If yes you make your own repellents with medicinal plants, how do you do this?

Question 4.8: Do you know of any other natural products/remedies/methods of getting rid of mosquitoes from your household and around your house?

Question 4.9: If yes you know some other natural products/remedies/methods of getting rid of mosquitoes, where did you learn about this information / who taught you this method?

Below are some of the consensus verbal quotes recorded responses of what they said to these open-ended questions.

<u>RESPONSES:</u>

Traditional healer participant #1:

"I give my patients lengana/mhlonyane (artemisia afra) for ubuhlungu wa malaria (pain of

malaria) I learnt this from my grandfather he came from Mozambique, how I prepare it I can't share I mix with other herbs you will sell my secrets"

Traditional healer participant #2:

"I mix lengana and phate yangaka (Artemisia afra and Helichrysum Caespititium) to treat malaria pain and you can also make lotion and apply on body in my house to chase away mosquitoes they don't make much noise if you do that"

Traditional healer participant #3:

"Imphepho and imbiza is a mixture of different herbs that we use to treat malaria and to drive away bad spirits by burning these herbs too we chase mosquitoes from house however I can't share how I make my mixtures and use to treat my patients"

Traditional healer participant #4:

"We place zumbani/umsuzwane/musudzungwane under the bed before sleeping or burn the leaves before sleeping or make lotion using the leave and apply mosquito wont bite, zumbani can also be made into tea and drink for pain and headache of malaria"

Traditional healer participant #5:

"we use African potato for many treatments even for malaria we make tea and we burn the dried leaves and mix with red oil and apply to avoid mosquito biting"

Traditional healer participant #6:

"My Gobela (traditional teacher) taught me we mix Imbiza herbs such as Spakga/ umsenge-wehlathi umsenge to treat malaria symptoms"

Traditional healer participant #7:

" Burn papaya or banana leaves to chase mosquitoes, you can also boil papaya leaves and make tea to help with malaria"

Traditional healer participant #8:

"Make cow dung cakes with fresh and dried cow dung mud vessel and coconut husk for generating smoke that chase mosquitoes"

Table 3.6 Profiles of the traditional treatment and repellent methods.

Responses	Other Common/African names	Plant scientific name	Family	Other species and Chemical components	uses	How they are used/prepared traditionally
mhlonyane **(isiZulu)** 	African wormwood (Eng.); wilde-als (Afr.); umhlonyane (isiXhosa); mhlonyane (isiZulu); lengana (Tswana); zengana (Southern Sotho)	*Artemisia afra*	Asteraceae		- Helichrysum and artemisia afra leaves, makes a pleasant insect repellent effective at keeping flies and mosquitoes away - used in natural insecticidal sprays and as a moth repellent	- burning a mixture of *Helichrysum* and *Artemisia afra* leaves repel mosquitoes -make insecticide sprays - roots, stems and leaves are taken as enemas, poultices, infusions, body washes, lotions, smoked, snuffed or drunk as a tea
Umsuzwane **(isuZulu)** 	Musudzungwane(Tshivenda) -Umsutane (siSwati) -Usuzwane (Sotho) -Zumbane (Shona) - Koorsbossie (Afr) -Fever Tea / Wild sage (Eng)	*Lippia javanica*	Verbenaceae	*Lippia asperifolia* -Repellent essential oil, *piperitenone carvone, caryophyllene, limonene, linalool*	- traditionally for malaria treatment and mosquito repellent -Used to alleviate fever and pain -treatment of coughs, colds and bronchial problems -affective against fever, in malaria, influenza, measles, lung infections.	- combination with Artemisia afra for enhanced efficacy against fever and influenza - as hot leaf infusions, sometimes with milk -leaves, twigs and roots make tea - mixed with another herb *Artemisia afra* -volatile oils produced repels and controls insects - dry bulb layers used to relieve headaches
Imphepho **(isiZulu)**	-Mphepho (xhosa) -fragrant Helichrysum (Eng) - Kooigoed, kruie (Afr)	*Helichrysum petiolare*	Asteraceae	*H. odoratissimum, H. petiolare, H. cymosum, H. nudifolium* *flavonoids, triterpenoids,*	-potential anti-inflammatory, antihypertensive effects - traditionally used to treat fungal infections, menstrual disorders, urinary tract infections, and hypertension	- smoke of the burning leaves is inhaled as a pain reliever - burning a mixture of *Helichrysum* and *Artemisia afra* leaves, makes a pleasant insect repellent effective at

				*diterpenoids, steroids*		keeping flies and mosquitoes away
African potato 	star flower, (Eng.); sterblom, geelsterretjie, gifbol (Afr.); moli kharatsa, lotsane (S Sotho); inkomfe, inkomfe enkulu (Zulu), inongwe, ilabatheka, ixhalanxa, ikhubalo lezithunzela (Xhosa), tshuka (Tsw.). Wrongly called African potato.	*Hypoxis hemerocallidea* ''Wrongly called African potato''	Hypoxidaceae	*H. colchicifolia* *H. villosa* *Hypoxoside, phytosterols*	- treat urinary diseases, prostate hypertrophy, cancer, burns, wounds, skin diseases, and respiratory problems -immune-boosting properties in HIV - hypoxoside a phytochemical used to boost the immune system in cancer and HIV - phytosterols and other bioactive compounds contributing to its medicinal properties	-rootstock makes infusions and decoctions that treat a wide variety of ailments - African medicine hailed as`miracle muti' and `wonder potato'
Umsenge **(isiZulu)** 	cabbage tree (Eng.); kiepersol (Afr); umsenge (isiZulu); umsenge-wehlathi(isuZulu)	*Cussonia spicata* *Cussonia sphaerocephala*	Araliaceae	*Cussonia sphaerocephala* *-pentacyclic triterpenoids ursolic oleanolic acid* exhibit anti-tumor activities	- traditionally used in South Africa for treating various ailments, including malaria, gastrointestinal problems, and sexually transmitted diseases - potential effectiveness against malaria parasite	- roots are succulent and edible, used in the treatment of Malaria - root extracts have shown significant in vitro antiplasmodial activity, against malaria parasite - mashed roots treat fevers and malaria - bark is used for stomach ulcers
Papaya leaves	Papaya Pawpaw	*Carica papaya L*	Caricaceae	*alkaloids, saponins,*	- Papaya leaves are traditionally used to cure malaria in parts of	- some cultures boil and drink papaya leaves to treat malaria,

				*glycosides, phenolic compounds, flavonoids, terpenoids, tannins.*	Indonesia, India, Latin America, and Africa. - used to reduce fever, increase appetite, deworm, and improve breast milk supply - Contains alkaloid carpain - acts as an insect neurotoxin -other uses include tea or juice, treat symptoms of dengue fever, improve blood pressure	-use it as a bath to avoid insect bites - the leaf extract has demonstrated larvicidal activity against the Aedes aegypti mosquito -burn dry papaya leaves to repel mosquito
Cow dung cakes 	Cow faeces (Eng) Inkomo ukusinda (isuZulu)	Bovine faeces		Cow dung contains plenty of *menthol, ammonia, phenol, indol, formalin*	-Cow dung coils -Manure -Cow dung reduces mosquito population	-Make cow dung cakes with fresh and dried cow dung, mud vessel and coconut husk for generating smoke that repels mosquitoes

(Goldblatt and Manning, 2000) (Van Wyk et al., 1997) (Van Wyk, 2011) (Mahlangeni et al., 2018) (Viljoen et al., 2022a)(Viljoen et al., 2022b). (Govere et al., 2000a) (Ludere et al., 2013) (V. J. Maharaj et al., 2019) (Olivier et al., 2010; Pascual et al., 2001; Viljoen et al., 2005) (Maroyi, 2013; Mujovo et al., 2008; Nxumalo et al., 2023; Van Wyk, 2008) (Govere et al., 2000a) (Bassey et al., 2023; Hostettmann, 1996; Mwinga et al., 2019) (Gwaza et al., 2013; Mwinga et al., 2019; Viljoen et al., 2022c) (Bapela et al., 2014; De Villiers et al., 2010; Pillay et al., 2008; Ponou et al., 2014) (Julianti et al., 2014; Nafiu et al., 2019) (Alemayehu et al., 2024) (Collins et al., 2007) (Amadi et al., 2018; Saxena and Sandhwar, 2023)

3.4 SUMMARY OF RESULTS

A cross-sectional study was conducted within the Vaal Triangle in South Africa, encompassing a cohort of 419 participants, primarily female (58%) and predominantly identifying as Black South Africans. The findings of this study emphasised a high level of awareness regarding malaria, with 95% of participants expressing knowledge of the disease. However, notable misconceptions persist, particularly concerning malaria transmission. A significant 70.17% of participants incorrectly believed that malaria could be transmitted through contact with an infected individual, contrasting with only 12.65% who accurately identified the bite of an infected female Anopheles mosquito as the mode of transmission.

Additionally, there was a widespread misconception that malaria could be managed, and individuals could recover without treatment, a belief held by 86.87% of the participants. Regarding prevention and self-protection measures, a high proportion of participants (89.88%) reported using mosquito repellents; however, there was a limited understanding of the effectiveness of sleeping under mosquito nets as a preventive measure, with only 48.93% believing in their efficacy. Furthermore, 69.93% of participants identified long-lasting insecticide-treated nets as an effective preventive measure.

With respect to demographic factors influencing malaria awareness, logistic regression analysis revealed that males (adjusted OR: 0.25, 95% CI: 0.11–0.56, p=0.001), those practising Hinduism (adjusted OR: 0.20, 95% CI: 0.07–0.59, p=0.004), and individuals with no formal schooling (adjusted OR: 0.18, 95% CI: 0.04–0.72, p=0.015) were significantly less likely to be aware of malaria, highlighting a critical need for targeted educational interventions. In terms of traditional medicine practices, a notable finding was the widespread use of various traditional remedies for mosquito repellence, with the most frequently mentioned method being unspecified remedies referred to as "they do not say the name," accounting for 49.40% of responses. These results underscore the complex interplay between knowledge, beliefs, and practices surrounding malaria prevention and treatment within the studied community and suggest the importance of tailored interventions to address specific gaps and misconceptions.

CHAPTER FOUR: DISCUSSION OF RESULTS

4.1 INTRODUCTION

Modern antimalarial medications and mosquito control programs have drastically reduced the incidence of malaria; however, malaria remains a public health challenge. Assessment of community's knowledge, attitudes, and perceptions about malaria disease are critical in the development of malaria control strategies. Traditional methods continue to play a vital role in communities; various plants have traditionally been used to treat malaria and repel mosquitos especially where conventional treatments access may be limited. Malaria-related knowledge varies between endemic and non-endemic areas, so assessing community knowledge, attitudes, and perceptions is vital for developing targeted education and health programs that will help to achieve malaria elimination goals and prevent resurgence. This chapter discusses the important findings reported during data analysis in chapter three as per the research goals and objectives.

4.2 DISCUSSION OF MAIN RESULTS

This study aimed to assess communities' knowledge of mosquito repellents and malaria management and assess the more commonly used plants and plant-derived formulations as mosquito repellents in South Africa. The findings of this study indicate high levels of malaria awareness in the community, however there was a significant identification of persistent misconceptions about malaria transmission and treatment. Despite the misconceptions there was significant knowledge on traditional medicines for both malaria management and mosquito bite prevention given Vaal Triangle area is non-endemic to malaria. These findings are similar to the findings reported by (Munzhedzi et al., 2021a) and some of the mentioned traditional remedies in this study also concurs with the study by (Manana et al., 2018).

The research tool in this study presented four sections to participants within the questionnaire, and the results are discussed below.

4.2.1 Relating to the demographic profile

In this study, the majority of participants were black adult adults aged between 46 and 55 years old and 56 and 65 years old (Table 3.1). Age is a significant factor in both knowledge and preventative practices for malaria. As age increases, exposure to knowledge and practice of malaria prevention also tends to increase (Demissie et al., 2021).

Regarding religion, traditional African beliefs were most common, 62.53%, followed by Hinduism, 34.13%, in this study (Table 3.1). Religious beliefs, including the role of God and spirits, influence perceptions of malaria. Many communities blend traditional/religious beliefs with modern prevention methods (Beer et al., 2012). Literature has reported a significant impact on malaria knowledge and prevention because of religious beliefs and socio-cultural practices.

Educational attainment in this study showed a notable concentration at the secondary level (54.89%) and (19.18%) of participants with a tertiary education attainment (Table 3.1). A study conducted in Cameroon highlighted the importance of education in shaping community knowledge, attitudes, and practices related to malaria control in the surveyed regions of Cameroon (Sofeu-Feugaing et al., 2024).

In terms of occupation in this study, about half of the participants (49.16%) were self-employed, which highlights a representation of entrepreneurial activity within the population. One study by (Tetteh et al., 2023) in Ghana on associated factors of malaria found that socio-economic status, including employment, plays a significant role in malaria knowledge, preventative practices and prevalence.

4.2.2 Relating to knowledge about malaria

Malaria remains a significant public health concern worldwide, with effective prevention and treatment strategies heavily dependent on community knowledge and perceptions. The study's first objective was to ascertain the knowledge of the community members on malaria.

The study found that while 95% of participants affirmed knowledge of malaria, a large number 70.17% erroneously believed it could spread through contact with an infected person (Table 3.2). Misconceptions about malaria transmission, particularly the belief that it can spread directly from person to person, have been documented in various studies. For example, a study in Ethiopia found that some community members believed malaria could be transmitted through direct contact with an infected person. This study from Shewa Robit Town, conducted in the northeastern region of Ethiopia, found that over 20% of respondents associated malaria transmission with factors such as lack of personal hygiene, exposure to cold weather, hunger, chewing maize stalk, body contact with malaria patients, flies, and respiratory routes (Abate et al., 2013). This reflects a gap in perceived susceptibility, which may lead to inadequate preventive measures (Omaka-Omari and Nwimo, 2015). It is important to note that malaria is primarily transmitted through the bite of an infected female *Anopheles* mosquito. It is not contagious and cannot spread directly from one person to another through casual contact, as clarified by the WHO (WHO, 2024). In the current study, only 12.65% correctly identified the bite of an infected female *Anopheles* as a transmission mode (Table 3.2). Previous studies have shown that malaria knowledge is often based on second-hand information in non-endemic regions, leading to misconceptions (Fitchett and Swatton, 2022). In contrast to the current study that interviewed 400 participants, the results showed that 99% (95% CI: 97.8–99.8%) had heard about malaria before and correctly associated malaria with mosquito bites. They further reported that malaria can kill if it is not treated. (Manana et al., 2018)

While 78.76% recognized malaria as life-threatening, 86.87% believed one could recover from malaria without treatment (Table 3.2). This finding highlights a discrepancy between perceived severity and actual health-seeking behaviour. This misconception was higher in the current study compared to a study that assessed malaria knowledge among mothers in Ghana, where 96.1% believed malaria was life-threatening; however, 18.9% of respondents thought it was possible to recover from malaria without treatment (Adum et al., 2023). When compared to Adum et al. (2023), the study shows that cultural views, education programs, and demographic disparities all contribute to different perceptions regarding the severity of malaria. The severity of the condition is more likely to be underestimated in communities with lower literacy rates and less access to health information. Furthermore, the idea that recovery is achievable without medical intervention may be supported by cultural values and a dependence on conventional treatments such as traditional remedies.

The current study revealed that 55.61% of participants preferred traditional medicine, while only 28.64% preferred Western medicine (Table 3.2). This aligns with the concept of observational learning, where community norms and cultural practices shape health behaviours. Similar findings have been reported in malaria-endemic regions where traditional beliefs influence treatment choices. In a study conducted by Adera in Southwest Ethiopia, 43.0% were found to use traditional medicine for malaria for reasons including greater accessibility (82.0%), low cost (48.0%), lack of awareness of modern medicine (25.0%) and some believed that traditional medicine is better (7.0%) (Adera, 2003). A comparative study in five western African countries found about 50.0% of the 996 Ghana respondents used some form of traditional treatment for malaria (Aikins et al., 1994). Similar findings were reported in a study in central Côte d'Ivoire where more than half of the respondents (n=136: 59%) exclusively used traditional treatments for malaria. In comparison, a third of the interviewees (n=76: 33%) used modern and traditional methods (Essé et al., 2008).

The most identified malaria symptoms were headaches (78.76%), fever (7.40%), and chills (3.10%), which were underreported in this study (Figure 3.1). Similar study findings were reported where only 21.0% of the respondents could identify the 3 most common symptoms of malaria with fever and chills underreported in the study by (Munzhedzi et al., 2021b) in Limpopo, South Africa. This was attributed to most of the participants being unemployed, with more than three-quarters having at least a primary education level (Munzhedzi et al., 2021b). Comparatively, in another KAP study conducted in Mamfene Kwa-Zulu Natal, South Africa the most frequently reported signs and symptoms of malaria included headache 78.0%, fever 54.0%, feeling cold 60.0% and vomiting 30.0% (Manana et al., 2018). Also, contrary to the current study, respondents in a study in Cameroon reported fever as the most cited sign 64.7%, followed by headache 39.1%, body pain 31.9%, and chills 22.8% (Mbohou Nchetnkou et al., 2020) and this trend was attributed to a high proportion of participants being educated. In the current study, 87.11% of respondents reported never having malaria, which might explain the simultaneous misconceptions about transmission, treatment and the underreporting of the major symptoms of maria reflecting cognitive dissonance. When individuals lack direct experience with a disease, they may justify their perceived knowledge and or minimize the need for medical interventions. Another reason might be that knowledge of malaria symptoms is usually high in areas endemic to malaria, where people are aware of the clinical manifestations of the disease (Deressa et al., 2004).

4.2.3 Relating to medicines used for malaria management

The current study also investigated knowledge of drugs used for malaria management, and the study findings indicate that atovaquone was the most reported antimalarial medication, cited by 54.18% of participants, followed by doxycycline at 29.36%. Notably, artesunate (8.35%) and artemether-lumefantrine (9.31%), both primary treatments recommended by the (WHO), were less commonly mentioned. Additionally, mefloquine and quinine, historically significant antimalarial drugs, were not reported (Figure 3.2). These observations align with specific trends identified in previous African studies while highlighting some deviations. The prominence of atovaquone in the current study contrasts with some African settings where its use is less prevalent. For instance, a study analysing antimalarial dispensing patterns in South Africa found that atovaquone-proguanil accounted for 19.21% of dispensed antimalarials, while chloroquine was the most dispensed at 49.39% (Truter & Lamprecht, 2017). This suggests that atovaquone's usage may vary by region and availability.

Doxycycline's notable usage in the findings is intriguing, given its primary role as a prophylactic agent rather than a first-line treatment for malaria. This could indicate a gap in knowledge regarding appropriate treatment protocols or a reliance on available medications for treatment purposes.

The relatively low mention of artesunate and artemether-lumefantrine is concerning, as these are WHO-recommended first-line treatments for uncomplicated malaria. A study assessing adherence to antimalarial drug policy among doctors in Delta State, Nigeria, reported that artemether-lumefantrine was prescribed in 71.9% of uncomplicated malaria cases, highlighting a higher adherence to guidelines in that region (Obiebi, 2019). However, in this current study, most participants had secondary level education attainment compared to the Delta state study amongst doctors with better knowledge. Another assessment done at Chris Hani Baragwanath Hospital (CHBAH), South Africa demonstrated strong adherence to WHO guidelines, with 93.1% of malaria cases treated using artemether-lumefantrine and 50% of severe cases receiving artesunate. Unlike this current study, which reported high awareness of atovaquone (54.18%) and doxycycline (29.36%), CHBAH did not use these as primary treatments. However, quinine was still used in 50% of severe cases, indicating partial adherence to WHO recommendations favouring artesunate (Fox et al., 2021).

The lack of reports on mefloquine and quinine usage may reflect a shift away from these drugs due to concerns about side effects and the development of resistance. Again, most of the study participants in this current study, even if they were aware of malaria, had never had malaria and lacked direct experience, which could justify their lack of knowledge of the drugs. However, quinine remains in use in some regions; the Nigerian study mentioned above found that quinine was prescribed in 27.6% of complicated malaria cases (Obiebi, 2019).

South Africa's current malaria treatment guidelines recommend artemisinin-based combination therapies (ACTs) as the first-line treatment for uncomplicated *Plasmodium falciparum* malaria, with artemether-lumefantrine being the preferred regimen. For severe malaria cases, intravenous artesunate is the treatment of choice, offering superior efficacy and safety compared to quinine. ACTs are considered safe in pregnant women during the second and third trimesters, while caution is advised during the first trimester due to limited safety data. These guidelines align with the WHO's recommendations for malaria treatment (National Department of Health, 2019).

Overall, the knowledge findings in this study underscore regional variations in antimalarial prescribing practices and potential gaps in adherence to WHO guidelines. However, this might be because malaria is not very prevalent in these areas. The knowledge demonstrated was from community/peer information through "hear say" or rural urban migration from high-risk areas of South Africa and cross-border migration from endemic regions. It is important to note that addressing these discrepancies is crucial for effective malaria control and treatment outcomes.

4.2.4 Relating to perceptions and attitudes towards malaria

An overwhelming majority of participants believed that malaria is preventable (86.87%) (Table 3.3), which suggests a high perceived benefit of preventive measures. However, 42.48% disagreed that sleeping under a mosquito net prevents malaria, representing a perceived barrier that could lessen adherence to this key prevention method. This finding correlates to the fact that some participants might not perceive malaria as a burden due to the Vaal Triangle area being non-endemic to malaria. Hence, not much information is shared or shown about the use and effectiveness of mosquito nets. In a study conducted in Bukoba and Zanzibar rural districts of Tanzania on the use of bed nets, respondents' conceptualisation of risks was considered more important for mosquito net use, with many citing barriers to comfort and "feeling trapped" as reasons for not using them. Others echoed sentiments, noting that some people never use mosquito nets but never get sick, while some who use nets still got malaria (Koenker et al., 2013). Research shows that when individuals doubt the effectiveness of a preventive measure, they are less likely to adopt it (Win et al., 2024). About 2% of the participants from a cross-sectional survey in three communities in Mamfene, KwaZulu-Natal, were found to use bed nets; however, in high-risk areas of South Africa, IRS is the most common preventative practice, a programme facilitated by the government (Manana et al., 2018).

Correct identification of standing water as a primary mosquito breeding site and awareness of mosquito activity patterns between dusk and dawn (Table 3.3) suggest an accurate understanding of exposure risks. Supporting this finding are several studies reported in literature. In a similar study, 79.1% of the study participants mentioned stagnant water as a breeding site for mosquitoes, and about 82.7% reported mosquito biting on human beings at nighttime (Menjetta, 2021). This concurs with the study by Deressa et al. (2004) in Ethiopia. Similarly, 72.6% of interviewees cited stagnant water as a malaria breeding location in a knowledge assessment study in Amahara National Regional State, Ethiopia (Molla Gedefaw, 2013).

However, in the current study, partial misconceptions about garbage as a breeding site (Table 3.3) indicated some gaps in perceived susceptibility, which could hinder comprehensive vector control (Ohba et al., 2015). The fact that standing water was correctly identified as a mosquito breeding site, but garbage was also considered suggests a gap that may affect prevention behaviours. Similarly, in another survey, around 18% of respondents incorrectly identified garbage as a breeding site for mosquitoes, while a significant portion correctly identified stagnant water (Rajvanshi et al., 2021). When people receive incomplete or conflicting information, they may rationalize their actions to support their pre-existing beliefs. This misconception leads to efforts to clear bushes and grasses instead of addressing stagnant water, a primary breeding site for mosquitoes (Romay-Barja et al., 2016). On the other hand, dumped garbage can indirectly contribute to mosquito populations by providing artificial breeding sites where water can be collected (Sangkachai et al., 2024). Improper waste disposal can create conditions conducive to mosquito breeding; for example, discarded tyres and containers can collect stagnant water and become breeding sites (Rosser et al., 2024).

Half the participants reported frequently cutting bushes, while others cleared them occasionally to control mosquitoes (Table 3.3). This demonstrates observational learning, as individuals likely adopted these practices after witnessing their effectiveness in reducing mosquito populations (Gyapong et al., 2010). This is consistent with other studies. For instance, 54.1% of households interviewed in a KAP study in the eastern region of Ghana mentioned clearing bushes as a preventative control method (Lopez and Brown, 2023a). In support of this, 56% of respondents in another study said they frequently cleared the bushes to avoid mosquito resting places (Opiyo et al., 2007).

The widespread use of mosquito repellents (89.88%) (Table 3.3) demonstrates that individuals are acting upon their knowledge, suggesting a widespread adoption of protective measures. The majority in this study credited their knowledge of mosquito repellents to traditional practices, social media, newspaper adverts, and flyers on buildings advertising the different insect repellents. Some of the participants mentioned clinic visits as their source of information. The use of mosquito repellents varies between malaria-endemic and non-endemic regions and is influenced by factors such as perceived risk, accessibility, and cultural practices (Pistone et al., 2010) (Worrall et al., 2005). The preference for mosquito repellents over mosquito nets may be influenced by peer behaviour or perceived social norms. In this current study, respondents were asked which type of mosquito repellent they preferred, insecticide spray/mosquito coils, most probably because of their higher availability, which was in agreement with other studies in Ghana (Lopez and Brown, 2023b). Previous studies suggest that if community members frequently discuss or use a particular method, others are more likely to adopt it (Mboera et al., 2010). Ghanaians were reported to use mosquito-repellent coils (52.8%) and anti-mosquito sprays (24.7%) to prevent mosquito bites. Despite these measures, none of the respondents reported using mosquito nets, highlighting a reliance on repellents over bed nets in this community (Lopez and Brown, 2023a). In contrast Hlongwana et al. (2009) reported that in Swaziland, a country designated for malaria elimination, nearly all participants (99.7%) accurately linked malaria to mosquito bites whereas in this study on 12.65% (Table 3.2) correctly linked malaria to mosquito bite. However, the use of repellents as a preventive measure was not prominently featured in their responses (3.8%) which is contrary to this current study where 89.88% (Table 3.3) reported using repellents (Hlongwana et al., 2009).

While community knowledge is generally strong, misconceptions about mosquito nets, breeding sites, and transmission pathways highlight areas for targeted health interventions. However, using mosquito repellents and maintaining an environmental cleanliness demonstrates active engagement in prevention, suggesting that external cues to action, such as health campaigns and peer influence through channels such as mass community events, may encourage protective behaviours (Moonasar et al., 2012).

4.2.5 Relating to perceptions on what is believed to provide self-protection against malaria

The strong preference for LLINs (69.93%) (Figure 3.3) indicates that many participants recognized the effectiveness of LLINs and suggested that individuals observe and adopt behaviours widely practiced in their community. However, contrary to this, a survey in West Africa, Ivory Coast, confirmed that LLIN use was low at 6.0%. Most respondents preferred mosquito coils and indoor spraying, citing the net design as a determinant factor as not being accommodative enough for two people (Doannio et al., 2006). Methods like LLINs may not be used as much when people are worried about how well they work (Ingabire et al., 2017). In the current study, the mention of untreated mosquito nets (18.85%) (Figure 3.3) suggests a knowledge gap regarding the added protection from ITNs, indicating a potential perceived barrier to optimal protection (Parker et al., 2017). Research suggests that when individuals do not fully understand the superior efficacy of a health intervention, they may underutilize or mis-prioritize available options (Deressa et al., 2007). In 2023, 78.0% of the 195 million ITNs delivered to sub-Saharan Africa were advanced variants nets, such as pyrethroid-PBO and dual-active ingredient ITNs, these offer enhanced protection against malaria by addressing mosquito resistance to traditional pyrethroid insecticides reflecting a strategic shift to combat insecticide resistance (WHO, 2024).

The results of this current study may be due to the fact that South Africa does not provide its citizens with bed nets as part of its mosquito control program. However, the South African Department of Health recommends that people use bed nets to protect themselves from malaria (SADOH, 2019). Similar to these finding, it has been reported that only 20.0% of households with bed nets had ITNs, and 68.0% of these nets were being used (Perez et al., 2009). Despite their known protective advantages, only 8.6% of cases and 23.4% of controls reported using treated nets (Canavati et al., 2019). Even though bed nets are effective means of prevention, mosquito populations are becoming resistant to pyrethroids threatens the long-term usefulness of LLINs. (Parker et al., 2017).

Other preventative methods included mosquito repellent use, maintaining a clean environment, and getting rid of breeding sites, reflecting a broader understanding of preventative measures. However, only 4.30% mentioned alternative methods, implying a lack of diverse cues to action, meaning that awareness campaigns may primarily focus on LLTNs and mosquito repellents while neglecting alternative strategies(Moshi et al., 2017).

4.2.6 Relating to traditional medicines such as mosquito repellents

The majority of participants referred to using "traditional remedies" without specifying them (Table 3.4) reflecting a deeply rooted cultural reliance on indigenous treatments. The inability or unwillingness to specify these remedies could be attributed to several factors. First, traditional remedies are often passed down orally within communities, with knowledge restricted to specific groups, such as traditional healers or elders as with the traditional healer participants in this study (Figure 3.4). This secrecy may stem from cultural beliefs that disclosing specific remedies to outsiders could weaken their potency or lead to their misuse. Second, some participants may have lacked detailed knowledge about the ingredients or preparation methods of the remedies they use, relying instead on trust in traditional healers. Third, as seen in literature on indigenous health practices, traditional medicine is sometimes intertwined with spiritual or ritualistic elements, which may discourage individuals from discussing specific details with researchers, particularly those perceived as external to their cultural framework (Cortés et al., 2025; Silambarasan et al., 2017). Traditional medicine use in malaria-endemic regions is often rooted in cultural practices and oral traditions rather than written documentation (Ngarivhume et al., 2015). Understanding these barriers is essential for developing culturally sensitive health interventions that respect traditional knowledge systems while promoting scientifically validated malaria prevention strategies.

This study identifies aloe, African potato mixed with aloe, imphepho (*Helichrysum species*), lemon grass, umsuzwane (*Lippia javanica*), lengana/umhlonyane (*Artemisia afra*), and umsenge-wehlathi (*Cussonia spicata/sphaerocephala strey*) as commonly used traditional medicines for malaria and some as mosquito repellents. These align with previous research showing that A*loe vera* has some insect-repelling properties. At the same time, *Helichrysum* species (imphepho) are known in South African traditional medicine for anti-inflammatory and antimicrobial properties, with potential mosquito-repelling effects(Antunes Viegas et al., 2014; Pascual-Villalobos and Robledo, 1999). Burning a mixture of *Helichrysum* and *Artemisia afra* leaves makes a pleasant smelling insect repellent (Lourens et al., 2004).

The main reason mosquito repellents are so widely used in African communities is because of traditional knowledge passed down through the generations and is frequently discussed verbally within communities, ensuring that long-lasting efficient practices are maintained (Mavundza et al., 2011). To support the current study findings umsuzwane, also known as musudzungwane (*Lippia javanica),* and cow dung was also reported to be used by 16.5% of participants (Munzhedzi et al., 2021a). In line with this study, 22.0% of the people who participated (Manana) also stated these practices. (Manana et al., 2018). The use of smoke from burning plants, cow dung, and other natural materials specific plants (such as, imphepho, lemon grass, papaya or banana leaves) has been a long-standing practice across different cultures to repel mosquitoes and other biting insects (Debboun and Goodyer, 2022; Pavela and Benelli, 2016). Studies show that smoke from burning certain plant

materials releases bioactive compounds such as monoterpenes, sesquiterpenes, aromatics, alcohols, aldehydes, and esters, which can repel or intoxicate mosquitoes, similar to commercial mosquito coils (Table 3.6) (Azizullah et al., 2021; Van Wyk and Prinsloo, 2020). In Zimbabwe, Tanzania, and parts of West Africa, burning cow dung cakes has been used historically as a mosquito deterrent due to its ability to produce strong-smelling smoke that masks human scents (which attracts mosquitos), thus disguising human kairomone cues and disrupting mosquito host location, thereby avoiding mosquito bites (Table 3.6) (Amadi et al., 2018; Maharaj et al., 2010;(Youmsi et al., 2017).
In various African countries, including Kenya and Guinea Bissau, a significant percentage of the population uses plant burning to repel mosquitoes, and this method is also noted for its effectiveness in rural Zimbabwe and Malawi (Karunamoorthi and Husen, 2012); (Karunamoorthi et al., 2009). It is proposed that, cow dung, either by itself or in conjunction with other plant species that repel mosquitoes, may be utilized to make products that complement each other activities to repel mosquitoes (Mukherjee and Ghosh, 2000).

The use of lavender, mint, catmint, and imbiza (a traditional herbal remedy) (Table 3.4) aligns with research showing that essential oils from these plants contain mosquito-repelling compounds such as linalool, menthol, and nepetalactone (Amer and Mehlhorn, 2006). Herbal drinks for malaria prevention have been documented in traditional medicine and in this study traditional healers reported making tea using roots, leaves and twigs of mhlonyane (*artemisia afra*), umsuzwane/zumbane (*lippia javanica*), papaya leaves, imphepho (*helichrysum petiolare*) and African potato (*hypoxis hemerocallidea*) (Appendix G; Table 3.6). These findings concur with studies suggesting that some herbal infusions may have immune-boosting or antiplasmodial properties, such as lengana/umhlonyane ,umsuzwane and African potato, as mentioned by traditional healers in the current study (Viljoen et al., 2022c; Willcox and Bodeker, 2004).

Participants talked about a wide range of ways to keep mosquitoes away, from traditional methods like burning dried leaves and using plants that give off bad smells (Table 3.1) to non-traditional methods like aerosols and insect repellents (Naserrudin et al., 2023). Using herbs, smoke, and plant-based repellents could be socially reinforced behaviours - those in which people pick knowledge by imitation, observation, and cultural transmission. The continued use of herbal remedies and burning organic materials raises the possibility that these customs are inherited and culturally embedded rather than purely evidence-based (Kropi et al., 2024). Individuals in malaria-endemic communities often trust traditional practices due to historical use and accessibility, perceiving them as more natural or safer than synthetic repellents (Deressa et al., 2004). Traditional malaria prevention methods are part of ethnomedical knowledge, where communities rely on local plants, spiritual beliefs, and environmental modifications as protective measures (Stoffersen et al., n.d.; Tisgratog et al., 2016). The diversity of reported practices (such as, use of umsuzwane, imphepho, sphakga, imbiza, burning banana leaves) (Table 3.1) (Table 3.6) suggests that communities have localized knowledge systems, which reflect the adaptation of malaria prevention methods to their environment (Aikins et al., 1994). In this current study, most traditional healers responded that this knowledge was passed down to them from their elders/traditional teachers, whom they mostly referred to as "Gobelas'.

These study findings align with existing ethnobotanical, health behaviour, and ethnomedical literature on the role of traditional medicine in mosquito repellent use (Manuel et al., 2020; Mavundza et al., 2011) (Table 3.6). While many traditional practices promise to provide culturally acceptable and accessible alternatives, scientific validation remains limited. There is a need for scientific validation and integration with conventional malaria prevention strategies. Plant-based remedies like lavender, mint, and catmint have been scientifically validated for mosquito-repellent properties (Amer and Mehlhorn, 2006). However, burning papaya leaves and banana leaves lack strong empirical evidence, though the smoke may act as a general insect deterrent, just as evidenced with cow dung cakes (Kweka et al., 2008; Manuel et al., 2020; Mukherjee and Ghosh, n.d.). Promoting evidence-based interventions, while respecting traditional knowledge systems can help bridge the gap between local beliefs and global health recommendations (Ngarivhume et al., 2015), The reliance on unspecified traditional remedies indicates possible misconceptions about their effectiveness and raises safety concerns. Some traditional methods may not provide complete protection, increasing the risk of malaria transmission if used instead of proven interventions like ITNs (Willcox and Bodeker, 2004). Many communities, such as Guinea Bissau, Kenya, and north-eastern Tanzania, now use traditional plant-based repellents because synthetic commercial repellents are expensive and because of the rise in insecticide resistance (Kweka et al., 2008). Individual participant views based on prior experiences could be the cause of this. Given this, more studies are required to ascertain the efficacy of these novel malaria prevention strategies and to encourage community members to employ the more established ones (Manana et al., 2018).

4.2.7 Factors associated with malaria awareness

Univariable and multivariable logistic regression were used to determine factors associated with malaria awareness.

4.2.7.1 Gender Disparities in Malaria Awareness

According to the study, men are far less likely than women to be aware of malaria (adjusted OR: 0.25, 95% CI: 0.11–0.56, p=0.001) (Table 3.5). This aligns with existing literature suggesting that women are more likely to be health-conscious and participate in health-related discussions. Research shows that women are more exposed to health education interventions, particularly in programs related to maternal and child health(Tolhurst et al., 2008). Additionally, gender stereotypes roles often place women in caregiving positions, increasing their likelihood of acquiring health information (Tangi et al., 2023). However, in the current study, these findings might also be due to the higher number of female participants, 58.0%, compared to male participants, 42.0% (Table 3.1). The lower awareness among men highlights the need for gender-specific malaria awareness campaigns targeting male populations.

4.2.7.2 Religious Influence on Malaria Awareness

In this study, individuals practising Hinduism had reduced odds of malaria awareness compared to those following African traditional religions (adjusted OR: 0.20, 95% CI: 0.07–0.59, p=0.004) (Table 3.5). This suggests that cultural customs and religious beliefs impact health literacy. Previous research showed that religious beliefs can influence how people seek health care, promoting or hindering awareness and preventative actions (Koenig, 2012) (Kropi et al., 2024). Communities that uphold traditional African beliefs may occasionally integrate knowledge about malaria into their cultural health practices, which raises awareness(Ahorlu et al., 2006). This current study had several participants who were traditional healers who believed in African traditions. Most of them referred to malaria as the “disease of Africa” mostly meaning from neighbouring African countries surrounding them. They related body pains and fever to it and prescribed their patient's traditional remedies to alleviate the symptoms. This finding underscores the importance of engaging religious leaders in malaria awareness initiatives to guarantee culturally appropriate messages.

4.2.7.3 Educational Disparities in Malaria Awareness

Individuals with no formal schooling had lower odds of being aware of malaria than those with secondary education (adjusted OR: 0.18, 95% CI: 0.04–0.72, p=0.015) (Table 3.5). This result supports previous research emphasizing the role of education in health literacy. Higher education levels are strongly associated with better access to health information, comprehension of disease prevention measures, and an increased likelihood of engaging in health-promoting behaviours(Dike et al., 2006; Manana et al., 2018). Studies in sub-Saharan Africa have shown that individuals with lower educational attainment are less likely to use malaria prevention strategies such as ITNs and IRS (Yaya et al., 2017). Addressing this gap through literacy programs and simplified health messaging can enhance malaria awareness among populations with limited formal education. Consistent with these findings, there is a noteworthy correlation between families' educational attainment and accurate understanding of mosquito breeding sites, with higher education levels being associated with a better comprehension of stagnant water as the principal breeding site (Madani et al., 2017;Opiyo et al., 2007).

CHAPTER FIVE

CONCLUSION, LIMITATIONS AND RECOMMENDATIONS OF THE STUDY

5.1 CONCLUSION

This study assessed malaria awareness, misconceptions, and preventive practices among residents of the Vaal Triangle, South Africa. The findings reveal high general awareness of malaria but significant gaps in accurate understanding—particularly regarding its transmission and the necessity of medical treatment. Misconceptions that malaria can be spread through direct contact or managed without treatment indicate persistent misinformation that could hinder effective control efforts.

Although preventive measures such as the use of mosquito repellents were common, understanding of the protective value of mosquito nets remained limited. Strengthened health education emphasizing scientifically proven interventions is therefore essential.

Demographic analysis identified males, individuals practicing Hinduism, and those with no formal education as groups with lower malaria awareness. Targeted interventions addressing these populations' specific informational needs could enhance community-wide knowledge and prevention practices.

Traditional medicine emerged as an important cultural element in malaria prevention, reflecting deep-rooted reliance on indigenous health practices. Integrating traditional healers and community leaders into health promotion initiatives may improve community engagement and trust in modern interventions. However, the safety and efficacy of traditional remedies require scientific validation to ensure their appropriate incorporation into malaria control programs.

In conclusion, this study underscores the interplay between knowledge, belief, and behaviour in malaria prevention. Bridging cultural practices with evidence-based health strategies—through inclusive, culturally sensitive education—will be vital for improving malaria awareness and reducing disease burden within the Vaal Triangle and similar communities.

5.2 LIMITATIONS OF THE STUDY

Despite its valuable findings, the study has several limitations. The study was conducted within a specific geographic region, the Vaal Triangle, which may limit the generalizability of the findings to other parts of South Africa or beyond. Some of the traditional healer practitioners were not keen to share their traditional methods citing it was a way of life for them they could not share. The majority of the participants were the elderly with very little literate skills, which meant more time was needed to interpret the questionnaire and to fully complete the responses, where some got impatient. Certain demographic groups, such as those with lower literacy levels, may have faced difficulties comprehending the survey questions, potentially affecting the accuracy of their responses The reliance on self-reported data may introduce recall bias and social desirability biases, as participants may not accurately remember or report their knowledge and practices. The study did not comprehensively assess the effectiveness of traditional remedies reported by participants, leaving gaps in understanding their actual impact on malaria prevention. Additionally, the use of an unvalidated questionnaire may have impacted the reliability and generalizability of the findings. Lastly, the absence of a scoring framework limited the ability to quantify and compare participants' knowledge and attitudes comprehensively. Future studies should incorporate robust quality control measures to address these limitations.

5.3 RECOMMENDATIONS

The study's findings have helped to a better understanding of malaria knowledge, attitude, and perception, as well as traditional remedies used for treatment and vector control in the Vaal Triangle community. The study found that even with a high degree of malaria awareness, community members have misconceptions that may impede malaria control efforts. The following ideas may be useful to the community, including additional endemic to non-endemic malaria locations, in order to effectively contribute to malaria elimination:

- Malaria education initiatives should be designed and implemented specifically for demographic groups with poor awareness, such as males, and those with no formal education.
- Efforts should be made to involve traditional healers in malaria prevention programs to ensure that culturally relevant information is properly communicated.

- Public health activities should focus on dispelling common myths about malaria transmission and treatment, emphasizing that malaria cannot spread through human contact and that medical intervention is required for recovery.
- More efforts should be made to increase the efficacy of sleeping under mosquito nets, particularly insecticide-treated nets, in addition to other preventive measures like repellents.
- Additional research should be conducted to assess the efficacy and safety of traditional malaria preventative and treatment remedies in order to make evidence-based recommendations for their incorporation into malaria control efforts.
- Finally, using community leaders and influencers, radio broadcasts, and visual materials in many local languages can broaden the reach and impact of malaria awareness campaigns.

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CHAPTER SEVEN: APPENDICES

7.1 APPENDIX A: Semi-structured questionnaire

WITS UNIVERSITY | FACULTY OF HEALTH SCIENCES | PHARMACOLOGY | WRIM

Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa

Participant ID: ____________________

Hospital/Site ID: ____________________

Please tick the appropriate box/boxes

1 DEMOGRAPHIC INFORMATION

1.1 Sex
- [ ] Female
- [ ] Male
- [ ] Other

1.2 Age
- [ ] 18-25
- [ ] 25-35
- [ ] 36-45
- [ ] 46-55
- [ ] 56-65
- [ ] ≥66

1.3 Place of Residence (Specify)

City/Town: ____________________

Province: ____________________

Nationality: ____________________

Country of Birth ____________________

1.4 Religion
- [ ] African
- [ ] Buddhism
- [ ] Christianity
- [ ] Hinduism
- [ ] Islam
- [ ] Judaism
- [ ] Other(Specify)

1.5 Ethnic group
- [ ] Black
- [ ] Coloured
- [ ] Indian
- [ ] White
- [ ] Other(Specify)

1.6 What is your level of education?

1 [ ] No schooling

2 [ ] Primary level

3 [ ] Secondary level

4 [ ] Tertiary level (University degree)

1.7 Occupation: ____________________

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2	KNOWLEDGE ON MALARIA CAUSES, TRANSMISSION **AND** SYMPTOMS
2.1	**Are you aware of Malaria?** 1Oves 2ONo 3ONot sure
2.Z	**De you think malaria is a life-threatening disease?** ILJYes 2ONo 3D1 da not know
2.3	**Have you ever had malaria?** ILJYes 2ONo
Z.4	**If 'Yes' how many times?**
2.5	**What causes malaria ?** 10 *Plasmodium* parasite *Select the best option* 2LJDirty water 3LJInfected Anopheles mosquito 4LJI do not know sOother(Specify)
2.6	**How is malaria spread?** ILJthrough the bite of a housefly *Please tick the appropriate box/boxes* 2LJby eating contaminated food 3LJthrough the bite of an infected female *anopheles* mosquito 4LJthrough close contact with an infected person sOrelated *to*climatic changes 6LJthrough contact with a cockroach 1Orelated toswimming in rivers and ponds 8LJ none of the above 9LJI do not know
2.7	**What are the most common symptoms of malaria?** ILJfever *Please tick the appropriate box/boxes* 2LJchills 3LJheadache 4LJjoint pains SLJnausea and vomiting 6LJabdominal pain 7LJconvulsions 8LJall ofthe above 9LJ I do not know
Z.8	Can anyone be infected with malaria? ILJYes zONo **3ONatsure**
2.9	**Is it possible to recover from malaria without any treatment?** ILJYes 2ONo 3ONot sure
2.10	**How is malaria treated in your family/community?** ILJWestern medicine *Please tick the appropriate box/boxes* 2LJTraditional medicine 3LJBoth western and traditional medicine 4LJI do not know

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Z.11	**If you use Western medicines for malaria management which of the following drugs are you familiar with?** 1I7Doxycycline (Doxycyl; Doxitab) *Please tick the appropriate box/baxes* zC]Artesunate(Garsun) 3CJAtovaquone-Proguanil (Malarone; Numal, Malanil) 4LJArthemeter-Lumefanterine (Coartem) SLJMefloquine (Lariam; Mefliam) 6[=:=]Quinine (Aspen quinine) 7LJI do not know 8LJDO not use Western medicine 900ther (Specify)
2.12	**If you use Traditional medicines for malaria management please specify which ones?** 1LJYes (Specify) 2LJDo not use Traditional medicines
2.13	**Are there mosquitoes in your area?** ILJYes 20No 30Notsure
Z.14	In which season are mosquitoes more common in your area? ILJDry season *Please tick the appropriate box/boxes* 2LJRainy season 3LJBoth seasons 4LJI do not know
3	**PERCEPTIONS AND ATTITUDES TOWARDS MALARIA PREVENTION PRACTICES**
3.1	**Do you think malaria is preventable?** 10ves 20No 301 do not know
3.2	**In which places do mosquitoes breed ?** ILJGarbage *Please tick the appropriate box/boxes* 2LJSoil 3LJStanding water 4LJRunning water/river SLJI do not know
3.3	**At which time of the day do mosquitoes bite?** ILJduring day time *Please tick the appropriate box/boxes* 2LJallday 3LJbetween dusk and dawn (anytime at night) 4LJI do not know
3.4	**Which of these do you think will provide means of self-protection against mosquitoes?** 1Duntreated mosquito nets 2LJLong lasting insecticide treated nets (LLITNs) 3LJMosquito repellents 4LJA clean environment SLJAII of the above 6LJI do not know 7D Other (specify)

3.S Have you ever used mosquito repellents?

1c:::::JYes 20No 30Notsure

3.5.1 If you use mosquito repellents, which of the following do you use?

ILJspray a repellent insecticide in a room
2c:::::Jburn a repellent candle
3c:::::Jburn a repellent coil
4LJapply a skin repellent (cream/gel stick/aerosol)
sc:::::Jnone of the above
6LJI do not know
7D other (specify)

3.5.2 Which skin repellent do you prefer?

ILJcream
2c=Jgel stick
3[::=laerosol
4[::=lnot applicable

3.6 If you do use a mosquito repellen, was it helpful in preventing mosquito bites?

ILJYes 20No 301 can not remember

3.7 Did you experience any bad reactions from using the mosquito repellents?

ILJYes 20No 30Not applicable

3.8 If Yes, what type of bad reaction did you experience ?

ILJItching or stinging sensation
2LJPain
3[::=JRashes
4LJI can not remember
SLJNDt applicable
6 0ther (specify)

3.9 How often do you use anti-mosquito sprays around your home?

ILJOften
2c=Jsometimes
3LJNever

3.10 Oo you think sleeping under a mosquito net can prevent malaria?

ILJYes 20No 301 do not know

3.11 How often do you clean/cut down bushes around your home to control mosquitoes resting places?

ILJOften
20sometimes
3LJNever

3.12 Stagnant/ standing water is where mosquitoes breed, how often do you clean/clear out this water around your home?

ILJOften
20sometimes
3LJNever

4	KNOWLEDGE ON TRADITIONALMEDICINES AS MOSQUITO REPEUENTS
4.1	**Do you know what traditional medicine is?** 1c::Jves 20No 301 do not know
4.2	**Do you know of any plants and herbs used to prevent mosquito bites?** 1c::Jves 20No 301 cannot remember
4.3	**If YES please specify what plants /herbs are used to prevent mosquito bites. Please specify name you know the plant/herb by as mentioned by traditional healer/ family member/ community member.** __________ __________ __________
4.4	**How do you get hold of these remedies?** 1c::JIgrow them 2c::Jfrom traditional healer 3LJfrom a herbal market 4LJfrorn a commercial shop (supermarket/pharmacy) sc::Jnot applicable 6c::Jother (specify) __________ __________
4.5	**Do you make your own repellents with medicinal plants?** 1c::Jves 20No
4.6	If **Yes you make your own repellents with medicinal plants, how do you do this?** 1Dspecify __________ __________ __________ __________ 2LJNot prepared to share this knowledge 3LJNot applicable
4.7	**If you get the repellent remedies from a traditional healer/herbalist, how do you use them?** 1c::Jburn them 2c::Jadd them to still standing water 3LJplace them on windows and doors 4LJapply on the skin sc::Juse as a spray 6LJ make a tea 1c::Jnot applicable ac::Jother !specify) __________ __________
4.8	**Do you know of any other natural products/remedies/methods of getting rid of mosquitoes fro! you! household and around your house?** 1 Yes 20No If YES please specify what they are? __________ __________ __________

4.9 If yes you know some other natural products/remedies/methods of getting rid of mosquitoes, where did you learn about this information/ who taught you this method?

____

____

____

4.10 Do you think your knowledge of self-protection against mosquito bites is enough?

1c::::::Jves 20No 30Unsure

4.11 Would you like more information about preventing mosquito bites and malaria?

1LJYes

If Yes you would like more information about mosquito bites and malaria?

Please reach out to me using the contact details provided on the information sheet

THANK YOU FOR TAKING PART IN THIS STUDY , WE APPRECIATE YOUR TIME AND CONTRIBUTION TO THE STUDY

WITS

PHARMACOLOGY

7.2 Appendix B1: Information sheet

Department of Pharmacy and Pharmacology
School of Therapeutic Sciences, Faculty of Health Sciences · Private Bag 3, Wits, 2050, South Africa
Tel: +27 11 717 2542 · E-mail: Fungai.Maburutse@students.wits.ac.za · www.wits.ac.za

Dear Volunteer Participant,

INFORMATION SHEET

My name is Fungai Maburutse, a masters by research student in the Division of Pharmacology, Department of Pharmacy and Pharmacology, School of Therapeutics Sciences, Faculty of Health Sciences at the University of the Witwatersrand. I am undertaking research on "*Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa*". Phytomedicine is the science based on medical practices that use more traditional approaches such as medicinal herbs often linked to traditional knowledge. Malaria continues to be common in most countries and most cases being reported in Africa. Even though malaria control and elimination has received great support in Sub-Saharan Africa, focus has been on man-made mosquito repellent products. Reports have shown that these man-made products contain chemicals that are harmful to the environment, therefore investigating natural and traditional practices without such chemicals plays a vital role in community health and environmental safety.

In this study we aim to gather more information about the natural and traditional practices that are used to repel mosquitoes. Which substances are used naturally, where they are sourced, how they are used (applied/formulations) and how long will they last in preventing mosquitoes from biting, according to the knowledge from community members.

As part of this research, I would like to invite you to take part in this study by answering a questionnaire. The questionnaire will be given physically to participant. The questionnaire will take about fifteen to twenty minutes. Physical administration of questionnaire engagement will be followed upon a signed consent form, the questionnaire has questions that allow interactive engagement to get more knowledge on the natural and traditional practices being used to prevent mosquito bites.

The participant will be asked of their knowledge on malaria as a disease, causes and transmission. Of vital importance to this study is their knowledge and practices on protecting against mosquito bites. Products that would have been suggested or given out to be part of the day to day traditional/natural practices in mosquito prevention will be collected and evaluated in the laboratory at Wits Research institute of malaria.

Participation in this study is voluntary and there are no known or anticipated risks neither direct benefit to you from participating in this research. You may withdraw at any given moment or not answer any questions if you do not wish to do so.

The survey will be completely confidential and anonymous, and no identification details will be asked from you, information would have given to me will be securely held and not disclosed. The data from the questionnaire will be compiled in such a way that no response will single out to identify you.

This is study has been approved by the HREC M221039 MED22-10-024.

If you have any questions afterwards about this research, you are free to contact me on the details listed below. This study will be written up as a thesis which will be available online through the WITS University library website. It will be presented at academic meetings and may also be published in scientific journals, but your identity will not be revealed. If you wish to receive a summary of this report, I will be happy to send it to you upon request.

If you have any queries, concerns or complaints regarding the way this study is conducted, please contact the Chairperson of this Committee who is Professor Paul Ruff, who may be contacted on telephone number 011 717 2301, or by e-mail on Paul.Ruff@wits.ac.za.

Thank you for reading this study information sheet.

Yours sincerely,

Ms. Fungai Maburutse (Student), Fungai.Maburutse@students.wits.ac.za, 016-931-0311

Professor Robyn van Zyl, (Supervisor), Robyn.VanZyl@wits.ac.za, 011-172-2271

Professor Shelley Schmollgruber, (Supervisor), shelley.schmollgruber@wits.ac.za, 011-488-4271

7.3 Appendix B2: Consent Form

Department of Pharmacy and Pharmacology
School of Therapeutic Sciences, Faculty of Health Sciences · Private Bag 3, Wits, 2050, South Africa
Tel: +27 11 717 2542 · E-mail: Fungai.Maburutse@students.wits.ac.za · www.wits.ac.za

PARTICIPANT CONSENT SHEET

Study title: ***Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa***

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study involves answering an open-ended research questionnaire, which is attached here to;
2. I was given time to read it, or had it read to me, in the language I best understand;
3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory;
4. I believe I fully understand why the study is being conducted and what the intended outcomes will be;
5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time;
6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

Contact details:
Fungai Maburutse, PI, 016-931-0311, or e-mail Fungai.Maburutse@students.wits.ac.za
Professor Robyn van Zyl, (Supervisor), Robyn.VanZyl@wits.ac.za, 011-717-2271
Professor Shelley Schmollgruber, (Supervisor), shelley.schmollgruber@wits.ac.za, 011-488-4271

Professor P Ruff, Chairperson of the Human Research Ethics Committee (Medical) at the University of Witwatersrand, on telephone no. 011 717 2301, or by e-mail at Paul.Ruff@wits.ac.za.
Ms. Z Ndlovu or Mr Rhulani Mkansi, Committee Secretariat, telephone nos.: 011 717 2700 or 1234, or by e- mail at: Zanele.Ndlovu@wits.ac.za or Rhulani.Mkansi@wits.ac.za

I ....(*name of participant*)

voluntarily agree/consent to participate in this study.

Participant Signature: ....**Date:** ....**.**

Witnessed by Researcher

Researcher Signature: ....**Date:** ....

.

7.3 Appendix C1: Sebokeng Hospital Director/CEO permission letter

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr F.G Mbara
Directorate: Sebokeng Hospital
Tel: +27 (0)16 930 3300
Fax: +27 (0)16 988 1964
E-mail: Godfrey.Mbara@gauteng.gov.za
Ref: 1/6/2

TO	Ms Fungai Maburutse University of Witwatersrand
FROM	Dr F.G Mbara - Acting Chief Executive Officer
DATE	10 August 2023
RE	Request to perform a study at Sebokeng Hospital

Please be informed that permission is hereby granted for you to perform a research on "Assessing Community knowledge and preventative practices for Malaria and the efficacy of Phytomedicines as mosquito repellents" at Sebokeng Hospital.

I wish you success in your research endeavors.

Dr F.G Mbara
Acting Chief Executive Officer
Sebokeng Hosp7·t
Date:/ ig •1.S2--J

1'

7.4 Appendix C2: Kopanong Hospital Director/CEO permission letter

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

KOPANONG HOSPITAL
Private Bag X031, Vereeniging, 1930

Enquiries: Ms. M. Adoons
Tel no.: 016-4287160

TO: Ms. Fungai Maburutse
University of Witwatersrand

FROM: Ms.M. Adoons – Acting Chief Director

DATE: 15 August 2023

RE: Request to perform a study at Kopanong Hospital.

Please be informed that permission is hereby granted for you to perform a research on "Assessing Community knowledge and preventative practices for Malaria and the efficacy of Phytomedicines as mosquito repellents" at Kopanong Hospital.

I wish you success in your research endeavors.

Kind regards

MS. M.V. ADOONS
ACTING CEO
DATE: 015 AUGUST 2023

7.5 Appendix C3: Johan Heyns CHC Director/CEO permission letter

G AUTENG PROVINCE

REPUBLIC:OF SOUTH AFRICA

Sedibeng District Health Services
Enquiries: Ms. N. Tuswa
Tel: 016 950 6255
Email: Nomonde.Tuswa@gauteng.gov.2:a

Ms. Fungai Maburutse
University of Witwatersrand
7 York Road
Johannesburg, 2009

Dear Ms. Maburutse

RE: ASSESSING COMMUNITY KNOWLEDGE AND PREVENTATIVE PRACTICES FOR MALARIA AND THE EFFICACY OF PHYTOMEDICINES AS MOSQUITO REPELLENTS IN SOUTHERN AFRICA

Please be informed that permission has been granted for you to carry out the above-mentioned research at Johan Heyns CHC, Kopanong Hospital and Sebokeng Hospital in Sedibeng District It is noted that you have already obtained Provincial Ethics Committee as well as Research Ethics Clearance from University of Witwatersrand (WITS).

Kindly ,,ate that a copy of the report on the findings (especially) that concerns Sedibeng District Health Services should be submitted to the Chief Director's office at the completion of the study.

This permission is also subject to the conditions stated in the protocol and any change in design and methodology must be communicated to the Chief Director.

We wish you success in your research endeavours.

ommend / Not recommended / Recommended as amended

Chairperson: Sedibeng District Research Committee
Date: oJ-/ 'Z.,D"'t.,}

Ap appcoved / App, ed as ameMed

Ms. **M.A.** Mad l.? -1
Acting Chief Director: Sedibeng District Health Services
Gauteng Hialtiepartment
Date: 1)8 / S o

NHRD RE!=: G _202301_054

Sedibeng DHS, Cnr Frikkie Meyer & Pasteur Blvd. Private Bag X 023, Vanderbijlpark

7.6 Appendix C4: Community and forum leader permission letter MOU

SEDIBENG TRADI IONAL HEALERS' ASSOC ATION

Makatolle wa Dingaka Healers

8456 Extension 15
Bophelong
Vanderbilpark
1900

Ms Fungai Maburutse
University of Witwatersrand
Johannesburg

Dear Ms Fungai

RE: MEMBERS OF MAKATOLLE waDINGAKA HEALERS UNDER THE SEDIBENG TRADITIONAL HEALERS ASSOCIATION AGREEMENT TO VOLUNTARILY PARTICIPATE IN THE COMMUNITY RESEARCH STUDY ON MALARIA.

We write to inform you that members of the Makatolle waDingaka Healers here in Sedibeng are pleased to be part of your research study in Assessing community knowledge about malaria and mosquitos. All voluntary members will participate at their own will and the knowledge they share will be out of their own accordance to share. We hope to facilitate and develop a meaningful and mutually beneficial relationship, when involved in various activities which form part of engaging Makatolle Wa Dingaka Healers within the project from the WITS working with Traditional Medicine and Traditional Knowledge.

The purpose of the collaboration is to create a platform for inclusion of traditional health practice with scientific health practice through collaborative research such as this one with the goal to promote the wellness of our people and maintain healthy communities.

For further arrangements with regards to community visits and meetings with the traditional healers' kindly contact Dr Lephoto and Mr Chauke.

igned at Boipatong on this 1st April day of 2023.

uly authorized to sign on behalf of the **Makatolle Wa Dingaka Healers.**

Dr LNN Lephoto
Chairperson

7.8 Appendix D: University of the Witwatersrand Faculty of Health Sciences Human Research Ethics Committee (M221039)

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R49 Ms F Maburutse

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M221039

NAME: (Principal Investigator)	Ms F Maburutse
DEPARTMENT:	School of Therapeutic Sciences Department of Pharmacy and Pharmacology Medical School University
PROJECT TITLE:	*Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa*
DATE CONSIDERED:	2022/10/28
DECISION:	Approved unconditionally
CONDITIONS:	This approval applies only to the study sites listed in Annex 1 attached Further sites may be added on presentation of evidence of management approval to the HREC (Med)
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Profs R van Zyl, S Schmollgruber & L Koekemoer; Mr T Rants'o
APPROVED BY:	Professor P Ruff, Chairperson, HREC (Medical)

APPROVAL APPROVAL DATE: 2023/06/27 **EXPIRY DATE:** 2028/06/26

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report**. When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **October** and therefore reports and re-certification will be due in the month of **October** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

7 September 2023
Date

Annex 1

Protocol No. M22/10/39 **Ms F Maburutse**

Study title: *Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa*

Study sites approved under this Clearance Certificate

Hospital sites	Date of HREC (Med) Approval
Johan Heyns CHC	2023/09/07
Kopanong Hospital	2023/09/07
Sebokeng Hospital	2023/09/07

Professor F Ruff
Chairperson: HREC (Medical)
University of the Witwatersrand, Johannesburg

Date: 07 September 2023

7.9 Appendix E: Approval of change of title (HREC and FHS)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG | FACULTY OF HEALTH SCIENCES

17 March 2025

To Whom It May Concern,

Confirmation of a Title Change

This letter confirms that **Ms Fungai Maburutse (2508458)** is a part-time student in the Faculty of Health Sciences at the University of the Witwatersrand, Johannesburg.

Miss Fungai Maburutse is intending to submit her dissertation for examination under the revised title:

Current Title: "**Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines as mosquito repellents in Southern Africa**"

New Title: "**Assessing community knowledge and preventative practices for malaria in the Vaal Triangle, Gauteng, South Africa.**"

Kindly contact me should you require any further information. My details are below.

Regards

Mpho Moiloa

Ms. Mpho Moiloa

Regards

Sandra Munesar
Faculty Registrar | Faculty of Health Sciences

Faculty Officer: Postgraduate – Faculty of Health Sciences
Tel: +27 (0)11 717 2510; Email: Mpho.Moiloa@wits.ac.za
Room 208, 2nd Floor, Phillip V Tobias Building, 29 Princess of Wales Terrace, Parktown, Johannesburg, 2193, SOUTH AFRICA

V
UNIVER.SJTY OF THE
WITWATERSRAND,
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax:027117172119
Tel: 02711 7172076

Reference: Ms Sandra Munesar
E-mail: Sandra.munesar@wits.ac.za

16 January 2025
Person No: 2508458
PAG

Ms F Maburutse
14 HANS VAN RENSBURG
Se 7
1911
South Africa

Dear Ms Fungai Maburutse

Master of Science in Medicine: Approval of Title

We have pleasure in advising that your proposal entitled *Assessing community knowledge and preventative practices for malaria and the efficacy of phytomedicines* as *mosquito repellents in Southern Africa* has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Ms Sandra Munesar
Faculty Registrar
Faculty of Health Sciences

100 1922 2022

7.10 Appendix F: Gauteng Sedibeng Health Research Committee Approval letter (GP_202301_054)

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Sedibeng District Health Services
Enquiries: Ms. N. Tuswa
Tel: 016 950 6255
Email: Nomonde.Tuswa@gauteng.gov.za

Ms. Fungai Maburutse
University of Witwatersrand
7 York Road
Johannesburg, 2009

Dear Ms. Maburutse

RE: ASSESSING COMMUNITY KNOWLEDGE AND PREVENTATIVE PRACTICES FOR MALARIA AND THE EFFICACY OF PHYTOMEDICINES AS MOSQUITO REPELLENTS IN SOUTHERN AFRICA

Please be informed that permission has been granted for you to carry out the above-mentioned research at Johan Heyns CHC, Kopanong Hospital and Sebokeng Hospital in Sedibeng District. It is noted that you have already obtained Provincial Ethics Committee as well as Research Ethics Clearance from University of Witwatersrand (WITS).

Kindly note that a copy of the report on the findings (especially) that concerns Sedibeng District Health Services should be submitted to the Chief Director's office at the completion of the study.

This permission is also subject to the conditions stated in the protocol and any change in design and methodology must be communicated to the Chief Director.

We wish you success in your research endeavours.

Recommended / Not recommended / Recommended as amended

Prof. OB Omole
Chairperson: Sedibeng District Research Committee
Date: 08/05/2023

Approved / ~~Not~~ approved / Approved as amended

Madolo

Ms. M.A. Madolo
Acting Chief Director: Sedibeng District Health Services
Gauteng Health Department
Date: 08/05/2023

NHRD REF: GP_202301_054

Sedibeng DHS, Cnr Frikkie Meyer & Pasteur Blvd, Private Bag X 023, Vanderbijlpark

7.11 Appendix G: ''Turn it in'' certificate

FMaburutse 2508458_MSC2025.pdf

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by Fungai Maburutse

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Submission ID: 2630584600
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Word count: 21840
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