**AWARENESS OF THE USE OF ENVIRONMENTAL MANAGEMENT IN THE CONTROL AND PREVENTION OF MALARIA**

**(IWO OSUN STATE)**

**ABSTRACT**

The transmission of malaria is significantly influenced by environmental factors. Consequently, the regulation of these variables can effectively decrease the burden of the illness. At the community level, environmental management strategies can be utilised to supplement existing approaches of malaria control in order to combat the disease. This study evaluates the existing understanding and methods used to regulate mosquito ecology and the environment for the purpose of controlling malaria in a rural, agricultural area of Osun state, Nigeria. A total of 408 respondents from the Iwo local government area were randomly selected for household surveys, while qualitative data was obtained through focus group discussions and in-depth interviews. The findings indicate that the inhabitants of Iwo possess a strong understanding of the connections between mosquitoes, the ecosystem, and malaria. The majority of participants indicated that cleaning the surrounding environment, removing vegetation near their homes, or eliminating stagnant water can effectively decrease mosquito populations. Additionally, 63% of respondents reported implementing at least one of these methods to safeguard themselves against malaria. Many respondents believe that these environmental management practices are effective for controlling malaria. However, it is uncertain whether these techniques are truly effective in reducing the populations of disease-carrying insects or decreasing the prevalence of malaria in different ecological habitats within local government areas. Additional investigation is warranted to ascertain the impact of various environmental management strategies on mosquito populations and malaria transmission in this area, and greater engagement in successful methods should be encouraged.

**TABLE OF CONTENT**

**ABSTRACT**

**CHAPTER ONE: INTRODUCTION**

1.1 Background to the Study

1.2 Statement of the Problem

1.3 Objective of the Study

1.4 Significance of Study

1.5 Research Questions

1.6 Research Hypotheses

1.7 Scope of the Study

**CHAPTER TWO:REVIEW OF RELATED LITERATURE**

2.1 Conceptual Review

2.2 Theoretical Review

2.3 Empirical Review

**CHAPTER THREE: RESEARCH METHODOLOGY**

3.1 Research Design

3.2 Area of study

3.3 Population of the study

3.4 Sample size

3.5 Sampling Techniques

3.6 Instrumentation

3.7 Reliability of the instrument

3.8 Validity of the instrument

3.9 Procedure for Data Collection

3.10 Data Analysis Technique

**CHAPTER FOUR: DATA ANALYSIS AND RESULTS**

4.1 Demographic Description of Data

4.2 Data Analysis

4.2.1 Hypothesis testing

4.3 Discussion of the Findings

**CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS**

5.1 Conclusion

5.2 Recommendations

**REFERENCES**

Appendix: Questionnaire

**CHAPTER ONE**

**INTRODUCTION**

**1.1 Background To the study**

The vast majority of malaria deaths occur in Africa, south of the Sahara, where malaria also presents major obstacles to social and economic development. Malaria has been estimated to cost Africa more than US$ 12 billion every year in lost GDP, even though it could be controlled for a fraction of that sum (WHO, 2020). There are at least 300 million acute cases of malaria each year globally resulting in more than a million deaths (WHO 2020). Around 90% of these deaths occur in Africa, mostly in young children. Malaria is Africa's leading cause of under-five mortality (20%) and constitutes 10% of the continent's overall disease burden. It accounts for 40% of public health expenditure, 30-50% of in-patient admissions, and up to 50% of outpatient visits in areas with high malaria transmission (WHO, 2020). Malaria accounts for over 60% of outpatient visit in Nigeria and other sub-Saharan African countries. Prompt access to effective anti- malarial treatment is one of the major strategies for reducing the burden of malaria (Adeyemi et al., 2020). Prompt access means having treatment available as near to home as possible so that it is given within 24hrs of onset of symptoms. Malaria is the leading cause of death for both adults and children in Tanzania, killing 100,000-125,000 people annually (CDC, 2021). Environmental conditions play an important role in the transmission of malaria, as macro-environmental factors, such as climatic conditions (temperature and rainfall), micro-environmental factors, such as local topography, and human land use and management greatly influence vector abundance (Ezirim et al., 2024). Environmental management is an underutilized but promising technique for vector control, because it decreases the available breeding habitat for mosquitoes by removing or modifying stagnant or slow-moving water sources (Olowookere et al., 2017). It is estimated that 42% of the malaria burden in Sub-Saharan Africa could be prevented through environmental management (Ezebialu et al., 2021).

Human activities play an important role in influencing the transmission of infectious diseases, including malaria (Uduma et al., 2023). Human-induced micro-environmental changes, such as the construction of irrigation schemes and dams, have been shown to dramatically increase mosquito populations in an area by creating new breeding habitat (Olowookere et al., 2017). Malaria is thus a particular problem in agricultural areas, as land use changes implemented to improve crop yields often result in an increased presence of surface water. Environmental management is an important component of malaria control, as it can be used to regulate these micro-environmental conditions, reducing the amount of slow-moving water present in an area, and thus creating land less suitable for sustaining mosquito populations. This method has been successful in reducing the malaria burden in many different ecological, socioeconomic, and epidemiological conditions (Airaodion et al., 2023). Environmental management was first used on a large- scale basis in the early 1900’s, fell out of practice in the 1940’s with the onset of DDT spraying, and only began to be implemented again for malaria in the 1980’s (Ejike et al., 2017).

Environmental management consists of installing and maintaining drains, removing pools of stagnant water, managing vegetation, irrigating intermittently, and altering rivers to create faster flowing water (Abdullahi et al., 2020). Additional techniques include filling holes and larviciding (Nwajiaku et al., 2019). Multiple studies have shown that the reduction of mosquito-breeding habitat through environmental management has significantly decreased mosquito abundance in surrounding areas (Nworie et al., 2018). Additionally, in Nepal, community-based environmental management consisting of clearing vegetation in ponds, draining and filling areas that collect water, and repairing irrigation canals resulted in a reduction in malaria cases by 35% in the intervention villages in 1983 versus the baseline year (1982) (Omole et al., 2024). This form of malaria control is relatively inexpensive, simple for local communities to implement and maintain, and not harmful to humans or the local environment (Ekeleme et al., 2023). Therefore, community-level environ- mental management, if implemented as part of an integrated vector-management program and paired with control strategies, such as mosquito nets, could prove effective at reducing malaria burden.

Whereas environmental management activities often are performed by a central authority or a set of volunteers/ workers (Sangho et al., 2021), there is increasing emphasis on the need to enlist local communities in ongoing, decentralized malaria control activities. Yet household-level environmental management relies on sufficient community participation to achieve efficacy in reducing mosquito populations. An accurate understanding of mosquito biology and habitat requirements is likely to play a role in one’s participation in controlling these habitats to reduce mosquito populations. Studies have illustrated that a lack of understanding of mosquito biology is prevalent in African communities. For example, in a survey of 1,451 households in Kenya, 65% of respondents stated that they did not know what mosquito larvae look like (Abdullahi et al., 2020). Educational programs have been used to increase community understanding and participation in malaria control through activities such as identifying breeding habitat, observing larval mosquitoes, and teaching techniques for suppression of mosquito breeding (Al Basir &Abraha, 2023).

**1.2 Statement of the problem**

During the last 40 years, the population of sub-Saharan Africa (SSA) has almost trebled, growing by more than 15 million people each year, to the present level of over 600 million (www.fao.org). As the population continues to grow, people move away from the countryside to the cities, attracted by the hope of a better life. At present, one third of Africans in SSA live in cities, and this proportion is likely to grow in the future. In fact, it is estimated that more than half of all Africans will live in cities by 2022. Thus the urban environment has become an increasingly important feature of African life. Although malaria is primarily a rural disease, it can also be a considerable drain on populations living on the fringes of urban settlements, causing significant morbidity and mortality while also reducing productivity (). Following observation from Iwo, Osun state, malaria is a significant reoccurring public health problem in the area. This problem is likely to grow as a result of the increase in parasite strains resistant to chloroquine (Sano et al., 2024). At present the major foci of malaria control include the case management of clinical episodes of malaria, the promotion of insecticide-treated nets (ITNs), focal indoor residual insecticide spraying (IRS), presumptive treatment of malaria in pregnant women and environmental management (EM). Environmental management, through a process of social mobilization and community participation, is being encouraged by the Ministry of Health and includes filling small water collections, clearing bushes around homes and closing windows early in the evening. With a growing focus on community-level environ- mental management as a component of malaria control, it becomes crucial to determine existing beliefs regarding the link between malaria and the environment, and how these beliefs relate to environmental management practices.

**1.3 Objective of the study**

The main objective of this study is to explore community knowledge and practices on environmental management for malaria control. Specifically, our goal is to:

1. Assess the environmental management practices used by Iwo community members.
2. Evaluate the relationships among knowledge, beliefs, and environmental management practices in Iwo Local government area.
3. Identify key challenges and opportunities for improving the effectiveness of environmental management in this region as well as in a larger context.

**1.4 Research Question**

Following the objective of the study, the study will answer the following questions

1. What are the environmental management practices used by community members ?
2. What is the relationships among knowledge, beliefs, and environmental management practices?
3. What are the key challenges and opportunities for improving the effectiveness of environmental management in this region as well as in a larger context?

**1.5 Hypothesis of the study**

The following hypotheses were formulated and tested by the study

Ho: There is no relationship between some demographic/socioeconomic factors and environmental management practices

H1: There is relationship between some demographic/socioeconomic factors and environmental management practices

**1.6 Scope/Limitation of the study**

This study will focus on the awareness of the use environmental management in the control and prevention of malaria. It will explore the important role played by environment in the transmission prevention and control of malaria. It will be carried out in Iwo Local Government. A local government in Osun state Nigeria. The limitation faced by the researcher include how to get the data necessary for the study and also the availability of literature, considering the recent and limited studies in this area.

**1.4 Significance of the study**

It is now widely acknowledged that access to appropriate and effective treatment for malaria should be provided within 24 hours of onset of symptoms. A strategy to provide such access should take into account poor rural populations in malaria-endemic countries who are particularly inadequately served by the health system. Evidence from Nigeria shows that most episodes of fever are initially self-treated and over 70% of cases rely exclusively on it. However of this proportion only 15% of the actions taken were adjudged as appropriate. This pattern has been consistent across the Country as documented in several other reports. A study of health seeking behavior for childhood illnesses in 3 rural Nigerian communities showed that the most common form of first line treatment was drugs from a patent medicine vendor (49.6%), while only 3.6% did nothing. In a study conducted at Igbo Etiti and Ibarapa North in Nigeria on 105 preschool children, Brieger et al found that 74% of parents took treatment action under 8 hours of onset of illness, while nearly 96% acted within 24 hours. Unfortunately only 14.3% of these actions were judged to have been appropriate. Studies in rural areas have shown the feasibility of home management and its positive impact on the burden of malaria. There is also paucity of data on environmental management in Nigeria.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 Epidemiology of malaria**

Malaria, a mosquito-borne Protozoa disease, is older than recorded history; and probably plagued prehistoric man. The first record of a treatment for the disease dates from 1600 AD, in Peru, and utilized the quinine rich bark of the cinchona tree (Ashley & Poespoprodjo, 2020). Scientifically, it is not a newly described disease. Approximately 40% of the world’s population lives in regions where malaria transmission is endemic, mainly tropical and subtropical regions (Abbas et al., 2023). Malaria has been successfully controlled, in fact effectively eliminated, in temperate regions of the world (Battle et al., 2020). The control strategies employed in temperate regions included changes in agricultural and construction practice reducing the availability of standing water and targeted vector control using insecticides such as DDT (Carrasco-Tenezaca, et al., 2023). Industrialization and improved housing conditions were instrumental in the elimination of the disease in temperate countries (Cirera et al., 2023). The role of mosquito in the life cycle of P. falciparum requires that the parasite be able to maintain an extended infection in order to ensure transmission ability during the following season (Cirera et al., 2023).

Now that the sequences of the three participants in the life cycle of human malaria, Plasmodium species, Anopheles species, and Homo sapiens, are all complete and available in endemic areas, perhaps new strategies of disease control will succeed. Malaria is distributed mainly between latitudes 450-670 south (Forgan et al., 2014). These regions embrace about 102 countries or areas of the world reported with indigenous malaria. These areas are typically in the tropical belt. In studying the malaria situation and distribution, China and India have continued to report downward trends. However, the malaria situation continues to deteriorate in rural area where intensive economic, social, behavioural and technical factors are taking place, particularly in Asia and America, while in the remaining area, it is fluctuating. African countries lying in the tropical belt have been known to be highly endemic for malaria, particularly in the early 1970s when malaria deaths were estimated to be in the order 9,750,000 annually. The most common type of malaria caused by P. vivax occurs in the temperate regions, whereas P. falciparum is largely confined to the tropics, P. malariae is considerably rarer and has a focal distribution, P. ovale, rather than P. vivax is the benign relapsing fever in West Africa but it is found less frequently in other parts of Africa. This pattern of distribution is because P.vivax (not P. ovale) requires Duffy blood group receptors on erythrocyte membrane and these receptors are lacking in many Africans, particularly west African (Gadji et al., 2023). Chloroquine-resistance and P. falciparum malaria has now been confirmed in more than 40 countries, but the situation tends to deteriorate further, especially in Africa, as the drug pressure on the parasites increase in the absence of substantive vector control. Sulfadoxine/pyrimethamine resistance has now been reported from 11 countries and resistance to mefloquine reported in the Philippines, the United Republic of Tanzania and Thailand. P. falciparum continues to be sensitive to these drugs in Middle America, the Caribbean, West Africa and most countries in Asia, west of India.

In many of rural areas the health infrastructure is not sufficiently developed to ensure that the favorable epidemiological situation is maintained (Jawo et al., 2022). Their epidemiological situation is precarious as they are under the constant threat of intensification and spread of specific malaria problems, such as resistance of parasites to drugs or vectors to insecticides, thus making control measure less effective and more costly. Although efforts are being made to incorporate appropriate anti-malaria activities into developing primary health care systems, progress appears to be slow, managerial and organizational problems persist (Kariuki & Kamau, 2022).

In Africa north of Sahara, transmission continued to be limited to a small facet. The total number of cases reported in this area increased from 453 in 1983 to 666 in 1984. An increase of transmission was observed in the northern provinces of Morocco. In Africa south of the Sahara, the malaria situation did not change. In the malarious areas, endemicity varies greatly from place to place although in general, malaria prevalence has remained unchanged. It has been estimated that some 115 million cases occur in meso-endemic zone and 231 in areas where malaria is hyper-endemic to holo-endemic. In most of these countries, vector control operations are not feasible, especially in rural areas, for a variety of technical, operational, administrative and financial reasons. The only action that could be currently attempted in these countries is the prevention and reduction of mortality and morbidity through the rational use of anti-malaria drug. But one of the major constraints hampering the implementation of these anti-malaria actions is the lack or shortage of trained personnel for the planning, organization, monitoring and evaluation of programmes that are carefully designed with clearly stated objectives and targets that can actually be implemented and maintained according to the available resources and local conditions (Lalloo et al., 2016).

In America, among the problem affecting the anti-malaria programmes, the most important are the resistance of the principal vector, Anopheles albimanus in Middle America from the south of the Mexico to Panama as well as Haiti and resistance of P. falciparum to chloroquine in South America, especially in Brazil and Colombia (Amazonas areas, Magdalema valley and the areas of Catatumbo and Turbo). All these countries were affected by the finance crises which led to a limitation of the anti-malaria measures.

In Asia west of India which has about 215 million people, about 181 million people live in areas which are originally malarious, 15 million people live in areas which have been freed from the disease and 35 million in areas where risk is limited. However, Bahrain, Cyprus, Israel, Jordan, Kuwait, Lebanon, Qatar remained free of indigenous malaria. The surveillance schemes operated in these countries are considered adequate to avoid the re-establishment of transmission despite the very high number of imported cases. Among the countries with nation wide anti-malaria activities, a reduction in the number of cases reported was observed in the Islamic Republic of Iran, Saudi Arabia, the Syrian Arab Republic and the United Arab Emirates.

In India, where some 370 million people live in high transmission area, the overall malaria situation appears to have stabilized around an incidence level of some 2 million cases reported (Mbye et al., 2016). During 1984, national monitoring teams confirmed the resistance of P. falciparum to chloroquine in new area in Andhra, Pradesh, Bihar, Gujarat and Orissa states. Vector in rural area, Anopheles culicifaecies is resistant to DDT and occasionally also to mal-action in treated areas of many districts. Its resistance to fenitrothion and propoxur has also been reported in some areas along the Gujarat/Maharashtra border. Countries like Australia, Brunei, Jerusalem, the Democratic People’s Republic of Korea, Hongkong, Japan Macoa, Mongolia, Singapore, large areas of China and most of Oceanic are considered to be free of malaria (Nascimento-Carvalho et al., 2019). Endemic malaria accumulates in certain areas of Turkey following the peak of the epidemic in 1977 with 115,000 cases; emergency measures had reduced the incidence to 29,000 cases in 1979. Recent survey in France has shown that number of imported cases in these countries alone was in the order 2,000 compared with some 50 cases reported to World Health Organization. Also Adenosine Triphosphate deficiency in non-immune Negro males seems to lower morbidity and mortality level in P. falciparium infection (Olasope, et al., 2023).

**2.1.2. The Role of Climate on the Spread of Malaria**

Climate can influence all three components of the life cycle of malaria parasites. It is thus a key determinant in the geographic distribution and seasonality of malaria.

Rainfall can create collections of water (breeding sites) where Anopheles eggs develop into adulthood, a process that takes place in damp areas. Such breeding sites may dry up prematurely in the absence of rainfall, or conversely, they can be flushed, and destroyed by excessive rains (Paaijmans & Huijben, 2020).

Once adult mosquito has emerged, the ambient temperature, humidity and rains determine their chances of survival. To transmit malaria successfully, female Anopheles must survive long enough after they have been infected (through blood meal on an infected human) to allow the parasite they now harbor to complete their growth cycle (extrinsic cycle). The cycle takes 9-12 days at 250C or 770F (Sarfo et al., 2023). Warmer ambient temperatures shorten the duration of the extrinsic cycle /transmission. Conversely, below a minimum ambient temperature (150C or 590F for Plasmodium vivax, 200C or 680F for P. falciparum), the extrinsic cycle may not be completed. This explains in part why malaria transmission is greater in warmer areas of the globe (tropical and semi-tropical areas and low altitudes particularly for P falciparum (Jassey et al., 2023). It has been speculated that current trends of global warming may increase the geographic range of malaria and may be responsible for malaria epidemics (Bello, 2021).

Climate also determines human behaviours that may increase contact with Anopheles mosquitoes between dusk and dawn, when the Anopheles are most active. Hot weather may encourage people to sleep outdoors or may discourage people from using bed nets. During the harvest season, farmers may sleep in the fields or nearby locals, without protection against mosquito bites (Adepoju & Akpan, 2017).

**2.1.2.3 The Parasite**

Human malaria results from infection with Plasmodium falciparum, P. vivax, P. ovale, or P. malariae. Plasmodium falciparum causes a large majority of the clinical cases and mortalities (Aina et al., 2013). Plasmodium is a protozoan parasite of the Phylum Apicompleza, Class Sporozoea. Reproduction generally is both sexual and asexual. Locomotion of mature organisms is by body flexon, gliding, or undulation of the longitudines ridges. Flagella is present only in microgametes, pseudopods ordinarily absent (AIRS, 2015).

**Life cycle of malaria parasite**

Malaria is transmitted by the bites of infected female anopheline mosquitoes or by inoculation of infected blood (e.g. transfusion malaria, congenital malaria) (Dawaki et al., 2016). Malaria parasite shows a complex life cycle involving alternating cycles of asexual division (schizogony) occurring in man (intermediate host) and sexual development (sporogony) occurring in female Anopheles mosquito (definitive host). (Mbunge et al., 2023). Therefore, Plasmodium shows alternation of generation and alternation of hosts (Chala & Balcha, 2023).

**Human cycle**

The infective stage called sporozoites, are injected from the mosquito salivary glands into subcutaneous capillaries and circulate to the liver where they invade parenchyma cells. Annah (2023) outlined the process of Plasmodium life cycle in man as follows:

1. primary exoerythrocytic schizogony

ii. erythrocytic schizogony

iii. gametogony

iv. secondary exoerythrocytic schizogony

**Primary exoerythrocytic schizogony**: Within one hour of infection all the sporozoites leave the blood stream and enter into liver parenchyma cells. The sporozoites which are elongated, spindle-shaped bodies become rounded inside the liver cells. They undergo a process of multiple nuclear division, followed by cytoplasmic division and develop into primary exoerythrocytic schizont. This varies in size according to species from 24-60nm in diameter and contains 2,000- 50,000 merozoites (Habane et al., 2022). Primary exoerythrocytic schizogony consists of only one generation. The duration of this cycle varies, for P. falciparum, P. vivax, P. ovale and P. malariae it is 6,8,9 13-16 days respectively (Chemeda et al., 2023). When primary exoerythrocytic schizogony is complete, the liver cell ruptures and releases merozoites in the blood stream.

**Erythrocytic schizogony:-** The merozoites liberated from primary exorythrocytic schizogony enter the blood stream and invade red blood cells where they multiply at the expense of the host cells. The age of erythrocytes is an important determinant of its susceptibility to invasion by different species of the parasite. Only young erythrocytes are infected by P. vivax and P. ovale, and only old subpopulation of erythrocytes is susceptible to P. malariae, in contrast, P. falciparum can develop in erythrocytes of all ages. Here they pass through the states of trophozoites, schizonts and merozoites. Depending on the species, about 6-32 nuclei are produced followed by cytoplasmic division and the red cell ruptures to release the individual merozoites, which then infect fresh red blood cells (Ahmed et al., 2020), it is at the time of the escape of merozoites that chill and fever beset the host (Pyrexia) (Ayanore et al., 2019). Erythrocytic schizogony may be continued for a considerable period, but in the course of time the infection tends to die out. P. falciparum differs from the other forms of malaria parasite in that developing erythrocytic schizonts occur in internal organs, so that only ring forms are found in peripheral blood. This process is approximately 72 hours for P. malariae and 48 hours for the other three species.

**Gametogony:** After malaria parasites have undergone erythrocytic schizogony for certain period, some merozoites develop within red cells into male and female gametocytes known as macro-gametocytes and micro-gametocytes respectively.

They develop in the red blood cells of capillaries of internal organs like spleen and bone marrow. Only mature gametocytes are found in the peripheral blood. They do not cause any febrile condition in human host. These are produced for the propagation and continuance of the species. The micro-gametocytes of all the four species of Plasmodium are small in size. Cytoplasm stains light blue and the nucleus is diffuse and large, on the other hand, the macro-gametocytes are large, the cytoplasm stains deep blue and the nucleus is compact and small (Tairou et al., 2022). Although the longevity for mature gametocytes may exceed several weeks, their half-life in the blood stream may be only 2 or 3 days, while waiting for the mosquito to take them up (Tong et al., 2017).

**Secondary exoerythrocytic schizogony:** In case of P. vivax and P. ovale, some sporozoites on entering into hepatocytes enter into a resting (dormant) stage before undergoing sexual multiplication while others undergo multiplication without delay. The resting stage of the parasite is rounded, 4-6um in diameter, uninucleate and is known as hypnozoite. After a period of weeks, months or years (usually up to 2 years), hypnozoites are reactivated to become secondary exoerythrocytic schizonts and release merozoites, which infect red blood cells producing relapse of malaria. Therefore, it is the situation in which the erythrocytic infection is eliminated and a relapse occurs later because of a new invasion of the RBCs from liver merozoites. Hypnozoites are not formed in case of P. falciparum and P. malariae, therefore relapse does not occur in disease caused by the species (Dhawan et al., 2014).

**Mosquito cycle**

Sexual cycle actually begins in the human host by the formation of gametocytes, which are present in the peripheral blood. Both asexual and sexual forms of the parasite are ingested by female Anopheles mosquito during its blood meals from the patient. In the mosquito, only the mature sexual forms are capable of further development and the rest dies. In order to infect a mosquito, the blood of human carrier must contain at least 12 gametocytes and the number of female gametocytes must be in excess of number of males (Awasthi et al., 2024). Within the gut of the mosquito, the male gametocytes undergo a process of exflagellation which results in the release of up to 8 male gametes. The fertilized macrogamete is known as zygote. This occurs in 20 minutes to 2 hours, in the next 24 hours, the zygote lengthens and matures into ookinete, a motile vermiculate stage (Adeyemi et al., 2020). It enters the epithelial lining of the stomach of the mosquito and comes to lie between the external border of the epithelial cell and peritrophic membrane.

Here it develops into oocyst. It is rounded, 6-12nm in diameter with a single vesicular nucleus. It increases in size to reach a diameter of 40-50 um. Inside this develop sporozoites. The number of sporozoites in each oocyst varies from a few hundreds to a few thousands and number of oocysts in the stomach wall varies from a few to more than a hundred. On about the 10th day, the oocyst is fully mature, rupture and release sporozoites in the body cavity of the mosquito. Through body fluid the sporozoites are distributed to various organs of the body except the ovaries. They have special predilection for salivary glands and ultimately reach in maximum numbers in the salivary ducts. At this stage the mosquito is capable of transmitting infection to man (WHO, 2020).

**2.1.2.4 The Vector**

Anopheles gambiae, A. arabiensis and A. funestus transmit most of human malaria and are all found in Africa (WHO, 2020). A. gambiae, the most famous and significant of these three, is one of sixty anophline mosquitoes able to transmit malaria to humans (WHO, 2020). A gambiae is the primary malaria vector; this can be attributed, in part, to its relatively long life, strong anthropophily and endophily (the tendency to target humans for blood meal and rest inside of houses, respectively) (WHO, 2020). Adult mosquitoes normally rest during the day inside human habitat and emerge to feed at night (WHO, 2020). Their larvae tend to develop in temporary bodies of water, such as that typically found near agricultural sites or even in flood hoof prints (WHO, 2020). All these characteristics combine to make A. gambiae a successful vector.

The behaviour is remarkable and can be highlighted with comparison of the entomological inoculation rate (EIR) of infectious mosquitoes in Asia or South America and sub-Saharan Africa. The EIR measures how often one person is bitten by an infected mosquito. In Asia and South America a person’s EIR rarely exceeds

5 bites per year. In Sub-Saharan Africa, a person may have an EIR of over 1000 bites per year (Ezirim et al., 2024). Olowookere (2017) also reported that during a single night in sub-Saharan Africa, hundreds of mosquitoes typically collect in a room occupied by humans; 1-5% of these are infectious.

Some diseased control strategies deal with the Anopheline mosquito rather than the parasite. One strategy for attacking mosquitoes is to develop more effective insecticides. The main obstacles to this line of attack are growing insecticides resistance and environmental concern. The publication of A. gambiae genome (Ezebialu et al., 2021) should help to identify the genes involved in resistance and to design chemicals for attacking new targets in the mosquito. The failure of the WHO’s malaria eradication program was, to a significant degree, due to increasing resistance to DDT and the fact that people did not want their homes to be sprayed (Airaodion et al., 2023). The current and most widely used technique for vector control is insecticide treated bed-nets. Genomics may prove key in the development of new insecticides and may also improve the longevity of available insecticides (Ejike. 2017).

**2.1.2.5 The Host Factor**

Factors in humans that determine the status of malaria are acquired and inborn. An acquired strain-specific immunity has been observed that appears to depend upon the presence of low-level parasitaemia that somehow inhibits new infections or maintains the infection at a non symptomatic level. This so called premunition or concomitant immunity, is soon lost after the parasites disappear from the blood. Exoerythrocytic forms in the liver cannot alone support premunition, and they elicit no host inflammatory response (WHO, 2020).

Natural genetically determined partial immunity to malaria occurs in some populations, notably in Africa, where sickle cell disease (AS genotype), glucose-6-phosphate dehydrogenase deficiency, and thalassemia provide some protection against lethal levels of falciparum infection (Abdullahi et al., 2020). Most blacks in West Africa, where malaria is endemic are not infected by P. vivax because they lack the Duffy antigen (FyFy), which acts as a receptor for P. vivax; in its absence, P. vivax cannot invade erythrocytes. P. ovale frequently replaces P. vivax in this region ( Nwajiaku et al., 2019).

**2.1.2.6 Pathology and Clinical Manifestations**

Periodic paroxysms of malaria are closely related to events in the blood stream. An initial chill, which lasts from 15 minutes to 1 hour, begins as synchronously dividing generations of parasites rupture their host red cells and escape into the blood. Nausea, vomiting and headache are common at this time. The succeeding febrile stage lasting for several hours, is characterized by a spiking fever that frequently reaches 400C or more. During this stage, the parasites presumably invade new red cells. The third or sweating stages conclude the episode. The fever subsides and the patient falls asleep and later wakes feeling relatively well. In the early stages of infection, the cycles are frequently asynchronous and the fever irregular, later paroxysms may occur at regular 48-72 hour intervals, although P. falciparum pyrexia may last for 8 hours or longer and may exceed 410C. As the disease progresses, splenomegaly and to a lesser extent, hepatomegaly appears, particularly in P. falciparium infections (Nworie et al., 2018).

**2.1.2.7 Mode of Transmission**

1. Vector transmission/direct transmission

The female Anopheles mosquito is the transmitter of malaria parasite, this is facilitated by its blood meal from man and other vertebrate host. The proboscis plays a crucial role in the blood meal. Transmission depends not only upon the presence of gametocytes in the blood, but also upon the infectivity of these for mosquitoes. The growth rate of the larva of mosquito determines transmission rate and is directly proportional to the suitability of the environment to its requirements which vary from species to species. The distribution and frequency of malaria in tropical Africa depend more or less directly on the climate and among the various climatic factors involved, two surpass the others in importance: rainfall and temperature (Omole et al., 2024).

The most striking feature of malaria is its high endemicity with hardly any seasonal changes. The climatic condition favours an intense transmission of P. falciparum, the prevailing parasite, through mosquito vector of which the notorious and ubiquitous A. gambiae is the most important because of its wide distribution, breeding habits, large numbers and preference for human blood. In a general way, the transmission of malaria diminishes progressively from the equator as latitude increases (Omole et al., 2024).

(b) Blood transmission

Malaria can be transmitted by the transfusion of blood from an infected person to healthy persons. In this way the sexual blood forms continue to develop in their own periodicities and the peripheral blood forms producing attacks of fever in the recipient, but pre-erythrocytic and exo-erythrocyitc stages are not formed in the liver, because these forms originate only from sporozoites inoculated by mosquitoes. Malaria transmitted in this way is easily cured and relapses do not occur. The possibilities of acquiring malaria by heroin intravenous infection has also been established, cases of induced malaria in narcotic abusers due to P. falciparum infection were also reported in Europe (Ekeleme et al., 2023).

(c) Congenital transmission

Congenital malaria was reported by Sangho et al (2021) who concluded that intra uterine transmission from mother to child is established. Congenital infection may be achieved without damage to the placenta, infection of the placenta may break down the barrier. This applies to all species of malaria parasite. This results in still birth, abortion and death in new born babies.

Abdullahi et al (2020) studied Nigeria women and found that in most cases, the babies are infected during parturition. Malaria in pregnancy is a critical problem, various studies show that parasitaemia increases between the first and second trimester of pregnancy. Trasmammary transmission is also possible.

**2.1.2.8 Diagnosis and Treatment of Malaria**

Diagnosis of malaria involves identification of malaria parasite or its antigens/products in the blood of patients (Al Basir & Abraha, 2023). Early, prompt and accurate diagnosis and treatment of malaria is crucial to the management of the morbidity and mortality caused by the infection. Accurate diagnosis is one of the main interventions used in the global control of malaria (Sano et al., 2024). Malaria is diagnosed by the examination of the blood (Abbas et al., 2023). Immunodiagnosis has limited clinical usefulness but positive indirect hemagglutination (IHA) and indirect fluorescent antibody (IFA) tests are valuable for epidemiological surveys and with the complement fixation test, for screening potential blood donors. The diagnosis of malaria is confirmed by blood test and can be divided into microscopic and non-microscopic (Ashley & Poespoprodjo, 2020).

1. Microscopic test: For nearly a hundred years, the direct microscopic visualization of the parasite on the thick and/or thin blood smear has been the accepted method for the diagnosis of malaria in most settings, from the clinical laboratory to the field surveys. The careful examination for a well prepared and well stained blood film currently remains the ‘gold standard’ for malaria diagnosis. This includes:

i. Peripheral smear study,

ii. Quantitative Buffy Coat (OBC) Test,

(b) Rapid diagnostic test: Several attempts have been made to take malaria diagnosis out of the realm of the microscope and microscopy. These tests involve identification of parasite antigen or the antiplasmodial antibodies or the parasitic metabolic products. Nucleic acid probes and immunofluorescence for detection of plasmodia within the erythrocytes; gel diffusion, counter-immunoelectrophoresis, radio immunoassay, and enzyme immunoassay for malaria antigens in the blood fluid, and hemagglutination test, indirect immunoflourescence, optimal assay, polymerase chain reaction, immunochromatography, and Western blotting for anti plasmodial antibodies in the serus have all been developed. These are (RDTs) (Battle et al., 2019).

**2.1.2.9 Control of Malaria**

Control of malaria is undoubtedly the best method of protecting a community against the disease. During the 20th century, human efforts to control malaria and general socio-economic development including access to health care have markedly reduced the spread of malaria (Carrasco-Tenezaca, 2023). Control of this deadly menace would therefore involve three living beings: man (the host), Plasmodium (the agent) and Anopheles mosquito (the vector). Several methods are used to prevent the spread of malaria, to reduce transmission and manage morbidity among the infected. Such methods are broadly divided into transmission control and morbidity control. These controls include:

1. Chemotherapy: the treatment for various species is different (Cirera et al., 2023), chloroquine and drugs like it will kill all four species of Plasmodium when they are in the cell (Cirera et al., 2023), prompt treatment is the best means for the management of all species of malaria. This is because prompt treatment eliminates an essential component of the cycle (the parasite) and thus interrupts the transmission cycle (Cirera et al., 2023). Chemotherapy of malaria is directed at prophylaxis and presumptive treatment.

The artemisinin-based combined therapy (ACT) has in recent times been the most effective treatment for malaria. The more recent drug is Coartem, which was developed in 1994, and combines artemisinin (a compound from wormwood plant) with lumefantirine. Designed by Chinese Scientists, Coartem not only kills the parasite, it also stays long in the blood to help prevent any resistance by the malaria parasite (Forgan et al., 2014).

b. Biological control: This method of control includes natural measures; natural limiting factors are deliberately intensified without any reliance on chemical or mechanical devices. Larvivorous fish are natural enemies of mosquito larva and have been utilized with advantage for malaria control e.g. Gambusia affinis, gold fish (Carasius quratus), Romanomermis jingdeensis, a newly identified mamethid nematode has been found to parasitize larva of A. sinesis. In the semi-arid region of North Somalia, it was shown that malaria can be controlled by introduction of species for larvivorous fish (Oreochromis spilurur spiluru ) into mosquito breeding site (Zahar, 1984). Carp (Cyrinus capio) a species of tilapia eat aquatic plants, floating algae and other vegetable shelter for Anopheles; Baccillus shaerious, a larvicidal bacterium is toxic to several species of mosquito. It is capable of recycling even in highly polluted water. Coelomyes, a fungus of the Chytridomycete sub class is obligate parasite of mosquito and most are specifically pathogenic, each to a single species complex of Anopheles mosquito (Gadji et al., 2023).

c. Genetic control: This method reduces the reproductive potential of insect by altering the hereditary material of the vector species. Genetic control may be achieved by the following methods;

i. Irradiation – Males are sterilized by ionizing irradiation- the principle is that the sterilized males seek out and mate with the wild female in the natural populations thus preventing the hatching of the eggs and lowering their reproductive potential.

ii. Another method of genetic control is based on crossing sibling species of an insect. This leads to hybrid that are released, their competition with fertile male will eventually reduce the size of succeeding generation below the normal threshold where transmission of malaria is possible (Jawo et al., 2022).

**2.2.1 The epidemiology of malaria in Nigeria**

Malaria is a major public health problem and indeed a cause and consequence of underdevelopment in Nigeria. Incidence of malaria varies by weather, which affects the ability of the main carrier of malaria parasites, anopheline mosquitoes, to survive or otherwise. Tropical areas including Nigeria have the best combination of adequate rainfall, temperature and humidity allowing for breeding and survival of anopheline mosquitoes. Of the five species of Plasmodium that infect humans - Plasmodium falciparum, Plasmodium vivax, Plasmodium malariae, Plasmodium Knowlesi and Plasmodium ovale, Plasmodium falciparum causes most of the severity and deaths attributable to the disease, which is most prevalent in Africa south of the Sahara, where Nigeria has the largest population. Country-specific evidence shows that Nigeria has the largest population at risk of malaria in Africa and therefore most vulnerable to the risk of missing MDGs target. Malaria endemicity is determined by parasitemia rate and palpable Spleen rate in 2-9 year old. Nigeria is a malaria holoendemic area.

**2.2.2 Malaria zones in Nigeria**

Nigeria can be divided into three major malaria epidemiological zones, namely, forest, savannah and grass-land zones. The forest zone consists of coastal areas stretching from Osun in the South-Western Nigeria to the forest areas in the Eastern Nigeria up to the Northern portion of the forest zone of Oyo state. The Savannah zone consists of areas north of Oyo state to the central areas of Kogi and Benue states and the Grass-land zones consists of the most northern parts of Nigeria – Katsina state and areas to its north. The most dominant species of anopheles mosquito in Nigeria are anopheles funestus, anopheles gambiae complex, anopheles arabiensis and anopheles melas. The dominant vector in the forest zone is anopheles melas while the dominant vectors in the savannah zone are a combination of anopheles melas and anopheles arabiensis; the dominant vector in the grass-land zone is anopheles arabiensis.

**2.2.3 Endemicity and early malariometry**

The very etymology of endemic (―in the population) versus epidemic (―upon the population) shows the early recognition that the level of a disease, and therefore its character, vary between populations and places.

The first method used to quantify malaria endemicity - and thus the first method of malariometry - was introduced in India in 1848 and involved determining the spleen rate (the proportion of a sampled population with palpable enlargement of the spleen) found during a malariometric survey (an investigation of selected age-groups of a randomly sampled population to assess the degree of malarial endemicity in a location). The term rate has unfortunately always been used in the context of malariometric surveys despite the quantity measured being a prevalence. Thus, from the very beginning of malariometry attention was focused on the clinical manifestations of malaria infection in the human population.

However, to classify the malaria prevalence estimates obtained by surveys in an epidemiologically meaningful manner was subject to active and prolonged debate. It took over 100 years to reach a consensus that characterized prevalence values from spleen rate surveys as follows: holoendemic more than 75%, hyperendemic 51–75%, mesoendemic 11–50%, and hypoendemic less than 10%, when measured in the 2–9-year-old age- group.12 Shortly after this consensus, however, it was suggested that examination of the peripheral blood for asexual malaria parasites by microscopy during malariometric surveys to provide a parasite rate had increased specificity for malaria infection.

**2.4 THEORETICAL FRAMEWORK**

**2.4.0 Integrated Vector Management (IVM)**

New strategies for malaria prevention and control are emphasizing ‗integrated vector management‘ (IVM). This approach reinforces linkages between health and environment, optimizing benefits to both. Integrated vector management is a dynamic and still-evolving field. IVM strategies are designed to achieve the greatest disease-control benefit in the most cost-effective manner, while minimizing negative impacts on ecosystems (e.g. depletion of biodiversity) and adverse side-effects on public health. Possible health risks range from acute exposures to pesticides and their residues to bio-accumulation of toxic chemicals, as well as the development of vector resistance to some widely-used pesticides and drugs. A new WHO Global Strategic Framework for Integrated Vector Management defines IVM as a strategy to improve the efficacy, cost-effectiveness, ecological soundness and sustainability of disease vector control. IVM encourages a multi-disease control approach, integration with other disease control measures and the considered and systematic application of a range of interventions, often in combination and synergistically. Relying on a single method of vector control (e.g. chemical spraying), IVM stresses the importance of first understanding the local vector ecology and local patterns of disease transmission, and then choosing the appropriate vector control tools from the range of options available.

These include environmental management strategies that can reduce or eliminate vector breeding grounds altogether, through improved design or operation of water resources development projects; and the use of biological controls (e.g. bacterial larvicides and larvivorous fish) that target and kill vector larvae without generating the ecological impacts of chemical use.

At the same time – when other measures are ineffective or not cost effective – IVM makes judicious use of chemical methods of vector control, such as indoor residual sprays, space spraying, and chemical larvicides and adulticides. These approaches reduce disease transmission by shortening or interrupting the lifespan of vectors.

IVM also provides a framework for improved personal protection/prevention strategies that combine the use of environmental management tools/physical barriers with chemical tools for new synergies, e.g. insecticide-treated nets (ITNs). Trials using insecticide-treated bednets in some malaria-endemic African countries have shown very substantial reductions in child and infant mortality. Finally, IVM supports more accessible and affordable disease diagnosis and treatment with effective anti-malarial drugs, within the framework of a multi-disease control approach.

IVM therefore requires a fundamental restructuring of existing vector control programmes into a flexible, multi-pronged, multisectoral approach to vector-borne disease control that engages a range of government actors, communities, and agencies.

IVM is not a panacea for malaria – which is responsible for approximately 11% of the total disease burden in Africa53 – or for vector-borne disease in general. However, the large annual death toll from malaria, and the heavy burden of disease from other vector-borne diseases, the development of vector resistance to some widely-used insecticides and drugs, and the costs of developing new insecticides or insecticide-based control campaigns – all are indicators that a more multi-faceted approach to vector-borne disease is indeed warranted.

In many settings, the use of biological and environmental modification/management strategies – alongside or even in the place of insecticides – has yielded sustainable reductions in disease and transmission rates. The judicious use of insecticides, via careful and targeted application, also can preserve their long-term efficacy, slowing development of vector resistance.

In addition, a number of IVM field experiences have been documented as particularly cost effective in control of disease transmission. IVM strategies also have generated significant co-benefits to local economies in terms of development and growth – although more work is yet to be done, linking health and economic outcomes.55

**2.4.1 Human toll and economic costs of malaria**

Over 1.2 million people – overwhelmingly children – died of malaria in 2002. This figure reflects an increase in mortality in absolute terms over the previous year, according to data published by the World Health Organization (WHO) in its World health report 2004.53 Also in 2002, the total burden of disease from malaria was estimated by WHO to be 46 486 000 Disability Adjusted Life Years (DALYs) lost. This figure represents the combined toll of death, illness, and disability from the disease.

Over 85% of malaria deaths, disease, and disability occur in the African Region, with the South-East Asia and Eastern Mediterranean Regions being the second and third hardest- hit by malaria.53,56 Some experts suggest an even higher incidence of malaria cases than that reported by countries, both in Africa and globally.54

Malaria-related illness, in turn, has a direct impact on economic productivity. In the Côte d'Ivoire, farmers diagnosed as sick from malaria for more than two days out of a growing season had 47% lower yields and 53% lower revenues than farmers who missed no more than two days of work.57,58,59 In general, families highly affected by disease of various kinds may turn from growing higher value crops to less labour demanding and yield- sensitive products – with consequences for household income and nutrition.59 An analysis of economic growth over 25 years found that countries with intense malaria had rates of GDP growth that were 1.3% lower than those in comparable countries with less intense malaria. Another analysis found that countries with more than 50% of the population living at risk of infection from malaria parasites had average income levels that were one third of those in countries with less intense rates of disease, even when other confounding factors were removed.

**2.4.2 Vector control tools within an IVM framework**

In integrated vector management, appropriate vector control solutions are highly dependent on the local behaviour of malaria vectors, on local ecological, hydrological and environmental conditions, and on patterns of disease transmission. Continuous feedback on vector breeding requirements and behaviour and on disease incidence, and subsequent fine-tuning of strategies, is a prerequisite to applying IVM principles to more effective vector control. Indeed, the early history of environmental management offers ample evidence of projects that failed because the local vector behaviour was poorly understood, i.e. bush-clearance programmes carried out for a vector that thrives in sunlight. Below are brief summaries of key issues that may arise.

**2.4.3 Environmental modification**

Better engineering design of dams, irrigation schemes that allow for alterations in level and flow of water, and flushing of reservoirs can help reduce the availability of vector habitats.51 In addition, irrigation schemes that permit intermittent irrigation of fields, as well as alternation between cycles of irrigated and non-irrigated crops, have proven very successful in controlling Anopheles mosquitoes in rice-growing regions of China, India, and other parts of Asia.63,63 Such schemes control vectors by disrupting breeding cycles. However, improved design or redesign of water resource systems, irrigation systems, and dams is most likely to occur when major infrastructure investments are being planned, and thus it is critical that health and environment issues be considered by development actors at the outset of design processes through effective health impact assessment.

**2.4.4 Environmental manipulation**

In specific settings, time-limited changes in local vegetation, shade, and drainage patterns provide an effective way to reduce vector habitats. For instance, the creation of shade over the breeding grounds of malaria vectors that prefer sunny locales can help reduce vector propagation. Conversely, for malaria vectors that thrive in shadier habitats, the removal of overgrowth, weeds, and aquatic plants may significantly reduce breeding potential and thus vector abundance. In Oaxaca, Mexico, the clearance of algae from rivers, in a sustained community action programme, has been an important component in an integrated nationwide malaria control programme that has reduced malaria incidence from 15 121 cases in 1998, to 4996 cases in 2001.65

**2.4.5 Human settlement sitting and management**

More strategic placement of new human settlements away from potential malaria- breeding areas can also reduce transmission, since malaria vectors typically do not travel more than a few kilometers from their breeding grounds. Better management and control of man-made sites where malarial mosquitoes may easily reproduce – such as water wells and bore holes – may help reduce malaria breeding close to human settlements. Some vectors prefer to take blood meals from animals – instead of, or along with, human hosts. Therefore, strategic placement of animal pens and corrals may potentially divert vectors from human to animal hosts (zoo prophylaxis). Ongoing research in Kenya on the interactions between malaria, livestock, and agriculture is examining if and how different patterns of livestock management may actually help reduce malaria disease transmission to humans.

**2.4.6 Applying IVM in rural versus urban settings**

In tropical Africa, where malaria is most widespread, some environmental management strategies will work best in areas of relatively low and more seasonal transmission (such as urban locales and their periphery), at certain altitudes, and also at the northern and southern fringes of malaria distribution. Here, breeding sites may be fewer, more easily identifiable, and more amenable to control. For instance, environmental management may have potential in urban centres and port cities of Africa south of the Sahara, where large populations are aggregated on relatively small surfaces and where urban development has already degraded major vector breeding grounds.

**2.4.7 Cost-effectiveness of IVM**

There is a need for more frequent and rigorous economic analysis of malaria-control programmes at field and country level, so that the costs and benefits of alternative approaches may be compared. Many malaria vector-control programmes lack the capacity to carry out thorough cost-effectiveness evaluation of the intervention options at their disposal, even though WHO guidelines for such analysis have been available for over a decade. In a recent study, in Sri Lanka, () has indicated that the costs of periodic river flushing to eliminate mosquito breeding habitats compared favourably with the use of insecticide- impregnated bed nets as a mosquito-control measure. When the broader macroeconomic benefits of such approaches are considered, then the benefits of integrated vector control may outweigh additional costs to an even greater extent.

**2.5 EMPIRICAL REVIEW**

**2.5.1 Environmental Management and Malaria**

Environmental management consists of installing and maintaining drains, removing pools of stagnant water, managing vegetation, irrigating intermittently, and altering rivers to create more fast flowing water (Kariuki & Kamau, 2022). In Ethiopia, reduction of mosquito breeding grounds through environmental management has been shown to significantly reduce mosquito abundance in surrounding areas. A study (Nascimento-Carvalho et al., 2023) in a rice-growing area of Sri Lanka found that after the implementation of a community-based ecosystem management program to control mosquitoes, the abundance of adult Anopheles was significantly lowered during the rainy season. Additionally, in Zambia it has been shown that shortly after the implementation of a large-scale environmental management program, annual incidence of malaria was halved among the affected community (Paaijmans & Huijben, 2020). This form of malaria control is relatively inexpensive, is simple for local communities to implement and maintain, and is not harmful to the local environment or human.

Additionally, community approval and involvement has been seen as a necessary component of malaria control in today’s more democratic Africa (Mukabana et al 2006). Community-implemented environmental management programs are therefore an important bottom-up component to the largely top-down system of disease control, acting as a beneficial addition to methods such as insecticide-treated net (ITN) use and indoor residual spraying (IRS).

**2.5.2 Effects of Knowledge on Malaria-Prevention Behavior**

One key factor in combating the burden of malaria is decreasing exposure to the disease, both by reducing vector populations and by lowering contact between humans and infected mosquitoes. Additionally, increasing people’s use of healthcare facilities and anti-malarial drugs are important to decreasing malaria morbidity and mortality.

People’s knowledge and perception of malaria influence both prevention and treatment- seeking behaviors (Sarfo, 2023). A study in Zimbabwe concluded that there is a significant relationship between people’s knowledge of the causes of malaria and their preventative measures taken against it, and that a household’s level of understanding of the purpose of an insecticide spraying program is directly correlated with their compliance with having their house sprayed (Jassey et al., 2023).

Local knowledge and perceptions of malaria are likely to influence the success of environmental management programs as well. If people have a comprehensive understanding of the mosquito life cycle and habitat requirements, it is likely that they will be more effective in controlling these habitats to reduce mosquito populations. For example, in East Africa people often state that they clear grasses and bushes around the home to prevent malaria. This practice was introduced to Tanzania by the British colonial government as a general hygienic measure in order to keep the household free of rats, snakes, and mosquitoes, and while it does not necessarily lower malaria risk, it may reduce the number of mosquitoes resting in vegetation (Bello, 2021). Few studies have examined the efficacy of this practice, but the little evidence that exists indicates that this practice is ineffective in reducing populations of Anopheles mosquitoes (Adepoju & Akpan, 2017). Additionally, different species of Anopheles tend to exhibit either exophilic (outdoor) or endophilic (indoor) resting behavior. The two primary vectors in the study area, A. gambiae and A. funestus are both highly endophilic (Aina, 2013). Thus, clearing vegetation outdoors is likely to have minimal effects on resting behavior, and therefore would be ineffective as a mosquito control technique. The belief that clearing vegetation decreases mosquito populations results in management methods that are less helpful for malaria control. Performing activities that do result in a lower mosquito burden is therefore a more efficient use of a household’s time and resources.

Additionally, a case study of an integrated vector management program in Kenya showed that among 67 community malaria control volunteers, no one knew what larval mosquitoes looked like, or what habitat they lived in (Mbunge et al., 2023). In another study of 1,451 households in Kenya, 65% of respondents stated that they did not know what mosquito larvae look like (Annah, 2023). Therefore, the first step in the introduction of an environmental management campaign is to ensure that communities understand the processes of vector ecology, how these processes are linked to their surrounding micro-environment, and how performing management techniques will impact malaria in their community. If properly implemented, environmental management is a promising approach. It is a method that a community can take ownership of, maintain through participation and cooperation, and sustain through continual education of community members.

**2.5.3 Community Participation and Education**

In order for environmental management techniques to succeed in reducing the malaria burden in an area, widespread community participation is essential. If only a small percentage of people destroy breeding habitats around their homes, mosquitoes will simply breed in nearby bodies of water and no reduction in the total mosquito population will occur. Therefore, a threshold amount of stagnant water must be drained in order for mosquito populations to be significantly reduced in a community. This highlights the importance of viewing environmental-based malaria control as a collective action problem. In this situation, if the majority of people in a community contribute a small amount of time to performing environmental management, the entire community will benefit from reduced malaria incidence. Collective action is important for other forms of malaria control as well, particularly those that focus on reducing vector populations. For example, in Burkina Faso the collective use of insecticide-treated nets reduced malaria incidence by 90% for all community members, even those not sleeping under nets (Habane et al., 2022). The high net usage was sufficient to decrease the number of malaria-infected mosquitoes enough so that malaria rates in the entire area were reduced. It is only with extensive participation from community members that a significant reduction in mosquitoes, and thus malaria burden will occur.

Educational programs have been used in many situations to increase community understanding and participation in malaria control activities. In India, one program used folk theatre to teach people about malaria control and prevention .

This activity led to a significant increase in knowledge and participation in bio- environmental malaria control activities. In Sri Lanka participatory exercises were conducted in the field to identify mosquito breeding sites (Ayanore et al., 2019). An integrated vector management program in Kenya taught community volunteers how to identify larval mosquitoes using live specimens (Tairou et al., 2022). Additionally, the Farmer Field School is an important example of a successful integrated vector management education program targeting agricultural areas. The Field School curriculum includes participatory exercises to identify breeding habitat, sample and identify adult mosquitoes, observe larval mosquitoes, learn techniques for source reduction and suppression of mosquito breeding, and map the village to identify areas on which to focus coordinated environmental management efforts (Dhawan et al., 2014). All of the above programs were all successful in increasing community knowledge and participation in effective malaria control techniques.

In order to develop and implement a successful educational campaign, it is fundamental to conduct an a priori assessment of the community’s knowledge, attitudes, and practices related to the issue. This baseline data on existing community perceptions and actions helps in the development of the content of an educational program. There are two primary objectives of this project. The first is to assess rural people’s knowledge and understanding about the relationship between local environmental conditions and mosquitoes, as well as their knowledge and practices related to how one can alter the environment to reduce mosquito populations. The second is to examine the diversity of knowledge and practices along demographic lines, such as age, gender, formal education, religion, and socioeconomic status. Therefore these data will provide a preliminary picture as to the existing knowledge and practices related to environmental management for malaria control.

**CHAPTER THREE**

**RESEARCH METHODOLOGY**

**3.1 Study Design**

It is a term used to describe a number of decisions which need to be taken regarding the collection of data before they are collected (Panda & Mohapatra, 2024). It provides guidelines which direct the researcher towards solving the research problem and may vary depending on the nature of the problem being studied. According to Hjelm (2024) research design means the structuring of investigation aimed at identifying variables and their relationship, it is used for the purpose of obtaining data to enable the investigator test hypothesis or answer research question by providing procedural outline for conducting research. It is therefore, an outline or scheme that serves as a useful guide to the researcher in his efforts to generate data for his study. This cross-sectional study used mixed methods (both quantitative and qualitative). It is used to obtain the peoples opinion through questionnaire.

**3.2 Study Area**

Iwo is a prosperous agricultural region located approximately 45 km apart from both Ibadan and Osogbo. The size of this region is 245 square kilometres, and it has a population of 191,348. According to the 2006 Nigeria National census numbers, it is the most densely populated Local Government in the State of Osun. Due to its abundant agricultural resources, this location serves as a significant hub for trading commodities such as cocoa, kolanuts, foodstuff, yams, meat, and lumber. The Odo-Ori market in Iwo is widely renowned and draws traders from both local and distant areas. Iwo is strategically located due to its position along the railway tracks connecting Ibadan. This contributes to the commercial and economic progress of Iwo and other towns and local governments in the vicinity. The Oluwo of Iwoland holds the position of the traditional ruler and serves as the Chairman of the Council of Obas in the Iwo Zone. He has the position of both political and spiritual leader in Iwoland. There are approximately eighty-one (81) district towns and villages, each led by a Baale (District Head) and his Chiefs. These individuals are appointed by the Oluwo to protect and preserve the culture and traditions of the cities and villages on behalf of the Oluwo. Significant features in the ancient town include Bowen University, Sharia College of Nigeria, the confluence of River Oba and River Osun, a state-owned radio-vision station, and the recently created Oloba Cattle Hub.

**3.3 Sources of Data**

The data for this study were generated from two main sources; Primary sources and secondary sources. The primary sources include questionnaire, interviews and observation. The secondary sources include journals, bulletins, textbooks and the internet.

**3.4 Population of the study**

A study population is a group of elements or individuals as the case may be, who share similar characteristics. These similar features can include location, gender, age, sex or specific interest. The emphasis on study population is that it constitute of individuals or elements that are homogeneous in description (Udoyen, 2019). In this study the population constitute of the whole people in Iwo Local Government . According to the Federal republic of Nigeria Official Gazette 2006 census population of Iwo Local Government is 427,878. Accordingly Osun grew at 2.5% annual growth rate which reveals that between 2006 and 2018 the projected population figure or growth was 700,126. Therefore , one –quarter of this population forms the population of Iwo Local Government household according to the Federal Republic of Nigeria Official Gazette which is 175,032. Hence, this forms the population of the study.

**3.5 Sampling technique**

The work tries to look at the awareness of the use of environmental management on the control and prevention of malaria. Convenience sampling technique was employed for the study. The convenience sampling technique also known as accidental sampling technique relies on data collection from population members who are willing and available to participate in the study.

**3.6 Sampling size**

A sample of 408 was drawn from the population of the study. This sample size was drawn using population and sample size determined by Philip Meyer. The suggestion is that a sample of 408 will do for a population of 175,032.

**Table 1: Population and Sample size determined by Meyer**

|  |  |  |
| --- | --- | --- |
| **S/N** | **Population Size** | **Sample Size** |
|  | Infinity | 384 and Above |
|  | 500,000 | 384 |
|  | 100,000 | 383 |
|  | 50,000 | 381 |
|  | 10,000 | 370 |
|  | 5,000 | 357 |
|  | 3,000 | 341 |
|  | 2,000 | 322 |
|  | 1,000 | 278 |

**3.7 Instrumentation**

This is a tool or method used in getting data from respondents. In this study, questionnaires and interview are research instruments used. Questionnaire is the main research instrument used for the study to gather necessary data from the sample respondents. The questionnaire is structured type and provides answers to the research questions and hypotheses therein. This instrument is divided and limited into two sections; Section A and B. Section A deals with the personal data of the respondents while Section B contains research statement postulated in line with the research question and hypothesis in chapter one. Options or alternatives are provided for each respondent to pick or tick one of the options.

**3.8 Reliability**

The researcher initially used peers to check for consistence of results. The researcher also approached senior researchers in the field. The research supervisor played a pivotal role in ensuring that consistency of the results was enhanced. The instrument was also pilot tested.

**3.9 Validity**

Validity here refers to the degree of measurement to which an adopted research instrument or method represents in a reasonable and logical manner the reality of the study (Prince Udoyen: 2019). Questionnaire items were developed from the reviewed literature. The researcher designed a questionnaire with items that were clear and used the language that was understood by all the participants. The questionnaires were given to the supervisor to check for errors and vagueness.

**3.11 Method of Data Collection**

The data for this study was obtained through the use of questionnaires administered to the study participants. Observation was another method through which data was also collected as well as interview. Oral questioning and clarification was made.

A total of 408 household surveys were conducted in the study area.1 Within each village, households were selected for inclusion in the study at random from rosters provided by village leaders. Half of the surveys were conducted with male heads of household and half with female primary caregivers.

Qualitative data collection activities were held in eight of the ten study villages. Four focus group discussions (FGDs) were conducted with village members to discuss the topic matter contained in the surveys in more detail. FGDs were conducted with women in the study area.

**3.12 Method of Data Analysis**

The study employed the simple percentage model in analyzing and interpreting the responses from the study participants while the hypothesis was tested using probit regression.

In Probit regression, the cumulative standard normal distribution function is used to model the regression function when the dependent variable is binary, that is, we assume:

E(Y|X)=P(Y=1|X)=Φ(β0+β1X)

Y=β0+β1+X1+β2X2+⋯+βkXk+u

P(Y=1|X1,X2,…,Xk)=Φ(β0+β1+X1+β2X2+⋯+βkXk)

**CHAPTER FOUR**

**PRESENTATION OF DATA AND ANALYSIS**

**4.1 Demographic Distribution**

Table 4.1 summarizes key demographic and socioeconomic characteristics of the 408 survey respondents. As intended, the sample was split nearly evenly between males and females, and the average age of respondents was 42 years. Approximately two-thirds of respondents were Muslims and one-third were Christians. Educational attainment was quite low; 40% of respondents had no education and 53% had only a primary school education. The majority of the sample (83%) engaged in crop farming as their main occupation, 7% were pastoralists or mixed farmers (crops and livestock keeping), and 5% were employed in business activities. People younger than aged 17 years and adult students were not interviewed for the study.

**Table 4.1. Demographic and Socio-economic Characteristics of Respondents (*n* = 408)**

|  |  |
| --- | --- |
| **VARIABLE/OPTIONS** | **NUMBER (%)** |
| **Age (yr)** |  |
| 17–29 | 76 (19) |
| 30–49 | 207 (51) |
| 50–69 | 86 (20) |
| 70–95 | 39 (10) |
| **Gender** |  |
| Male | 199 (49) |
| Female | 209 (51) |
| **Religion** |  |
| Christian | 144 (35) |
| Muslim | 264 (65) |

|  |  |
| --- | --- |
| **EDUCATION** | |
| None | 160 (40) |
| Primary school | 217 (53) |
| Secondary school or above | 30 (7) |

|  |  |
| --- | --- |
| **OCCUPATION** | |
| Crop farming | 338 (83) |
| Pastoralist/mixed farming | 30 (7) |
| Business owner/employee | 20 (5) |
| Other | 18 (5) |

**4.2 Community Knowledge on Malaria, Mosquito Ecology, and the Environment**

Nearly all respondents (97%) listed mosquitoes as agents for transmitting malaria. In addition to mosquitoes, other common responses included an unclean environment (30%) and dirty water (18%).2 Eighty-seven percent of respondents believed that greater/heavy rainfall during the wet season increases mosquito populations, leading to more malaria cases during this time. This is supported by a health officer:

During rainy seasons there [is] stagnated water all over the area, and most of the people have maize farms close to their houses, thus the grasses in the farms contribute to mosquitoes, (IDI, community health worker).

The majority of the respondents (90%) believed that reducing the population of mosquitoes reduces malaria. Environmental cleanliness was a common theme when respondents were asked about methods to reduce mosquito populations (Table 4.2). Cleaning the environment around one’s home (e.g., removing artificial containers and garbage) was the most commonly listed method (50%), followed by using mosquito nets (40%), clearing vegetation around the home (39%), and draining stagnant water (33%). Seventy-three percent of respondents listed at least one of the three environmental management techniques (cleaning, clearing vegetation, and/or draining water) as a method to reduce mosquito populations.

The belief that tall grasses and bushes foster mosquito breeding was pervasive among community members in FGDs as well as among community leaders and health workers in IDIs, because many were confident that cleaning the environment and cutting grasses and bushes around the home could help to reduce mosquito populations. To illustrate this, when asked about ways to reduce mosquito populations, one focus group participant stated, Generally it is environmental cleanliness, to destroy all mosquito breeding places like filling with sands all areas with stagnated water, slashing all tall grasses around our houses and so on, (FGD, female community member).

Whereas knowledge on the link between adult mosquitoes, environmental conditions, and malaria was relatively high among respondents, knowledge related specifically to mosquito larvae was generally lower. Although 75% of the respondents agreed with the statement that reducing the population of mosquito larvae reduces malaria, 5% said no, and 20% did not know. There also was a wide range of responses when asked about locations where mosquito larvae can be found. Whereas most respondents stated that larvae can be found in stagnant water (65%), nearly 30% stated that they did not know where larvae can be found. In FGDs, beliefs about the habitats in which mosquito larvae live were quite varied, with responses ranging from sources of stagnant water (e.g., ponds and lowland farms) to areas that are ecologically unlikely to support larval Anopheles mosquitoes (e.g., bushes, latrine pits, and rubbish pits). One participant said, ‘‘They are found under the bed. You know the larvae like to live in areas where it’s cool and quiet,’’ (FGD, female community member). However, the plenary corrected her by saying that those are not mosquito larvae, rather they are adult mosquitoes.

**Table 4.2. Methods used to Reduce Mosquito Populations in the Community**

|  |  |
| --- | --- |
| **METHODS** | **NUMBER (%)** |
| Clean environment around home | 203 (50) |
| Use bednets | 163 (40) |
| Clear vegetation around home | 159 (39) |
| Drain stagnant water around home | 135 (33) |
| Spray insecticides inside home | 126 (31) |
| Spray insecticides outside of home | 120 (29) |
| Use larvicides | 53 (13) |
| Drain rice fields | 10 (2) |
| I don’t know | 20 (5) |

**4.3 Environmental Management Practices for Malaria Control**

Study participants were asked the question, ‘‘What can people do to protect themselves from malaria?’’ A follow-up question was asked to determine whether the respondent practised each method that (s)he mentioned. Table 3 lists the methods used by respondents to prevent malaria.

Mosquito net use was extremely high among respondents, as 87% stated that they used nets for malaria prevention. 3 Other than net use, the next three techniques that were mentioned most frequently by survey respondents were all environmentally related: ‘‘cleaning residential surroundings’’ (50%), ‘‘clearing grasses and bushes around the home’’ (32%), and ‘‘draining stagnant water’’ (18%). Sixty-three percent of respondents stated that they practice at least one of these three environmentally related techniques to protect themselves from malaria. An important issue raised in FGDs and IDIs was the belief that increased community participation is crucial for the success of these environmental management practices. In an interview, a village chairman stated,

Up to this moment few people [drain stagnant water]… hence this cannot help to reduce mosquitoes, thus collaboration is needed…. I suggest that there should be a program emphasizing cleanliness of the environment. A few people should attend a seminar concerning environmental sanitation who will later visit house to house to provide education on cleanliness of the environment. I suggest that these people should come from this village.

This statement highlights two important issues: that the village chairman believes a formal educational program on environmental management practices would be highly beneficial and that this program should be implemented by trained community members, not by outside educators.

**Table 4.3. Practices used by Respondents to Protect Themselves from Malaria**

|  |  |
| --- | --- |
| **PRACTICES** | **NUMBER (%)** |
| Use a bednet | 356 (87) |
| Clean residential surroundings | 202 (50) |
| Clear grass/bushes around the home | 131 (32) |
| Drain stagnant water | 73 (18) |
| Spray insecticides inside or outside home | 46 (11) |
| Take anti-malarial drugs intermittently | 40 (10) |
| Use mosquito coils | 27 (7) |
| Burn local herbs/plants | 8 (2) |

**4.4 Factors Associated with Environmental Management Practices**

Multivariate analysis was used to determine the correlation between a number of demographic/socioeconomic factors and environmental management practices. Table 4.4 presents marginal effects calculated from a probit regression testing for these correlations.

The first regression examines whether the respondents indicated that they drain stagnant water to protect them- selves from malaria. Education was significantly correlated with this practice. With each increase in educational attainment category (from no education, to primary school education, to secondary or above), the respondent was 9.6% more likely to practice this form of malaria control (P = 0.004). Respondents who owned a greater number of durable goods (e.g., radio, television, telephone, motor- cycle) also were significantly more likely to perform this practice (P = 0.042) and housing size was marginally associated. As the respondent’s housing size increased he/ she was significantly more likely to drain stagnant water (P = 0.072). Gender of the respondent was not significantly associated with performing this malaria control practice.

The second regression examines whether the respondents indicated that they clean the environment around their homes for malaria control. Gender was correlated with this practice: females are 12.6% more likely than males to perform environmental cleaning to prevent malaria (P = 0.02). Education was also positively correlated: with each increase in level of educational attainment the respondent was 9.5% more likely to perform this practice (P = 0.042). Additionally, land area was marginally significant: living on a larger plot of land was positively correlated with cleaning the environment for malaria control (P = 0.053).

**Table 4.4 Factors Associated with Environmental Management Practices for Malaria Control: Marginal Effects from Probit Regressions**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Household characteristics | Pseudo *R*2 = 0.0697 |  |  | Pseudo *R*2 = 0.0346 |  |
| Coefficient | *P-* value |  | Coefficient | *P-* value |
| Age (yr) | 0.0009 | 0.492 |  | -0.0004 | 0.823 |
| Gender | 0.0042 | 0.916 |  | 0.1259 | 0.02 |
| Education | 0.0959 | 0.004 |  | 0.0939 | 0.042 |
| Religion | 0.0378 | 0.355 |  | -0.0466 | 0.388 |
| Housing size | 0.0601 | 0.072 |  | -0.0334 | 0.464 |
| Durables | 0.0454 | 0.042 |  | 0.0278 | 0.381 |
| Land area | -0.0002 | 0.947 |  | 0.0089 | 0.053 |
| Total livestock | -0.0004 | 0.572 |  | -0.0013 | 0.184 |

**4.5 Discussion Of Findings**

The results of the survey indicate that the majority of community members in the study area have a basic understanding of the links between environmental conditions, mosquitoes, and malaria. Knowledge of mosquito ecology appears to influence which environmental management practices people choose to perform. A prevalent belief among respondents is that grass and bushes around the home as well as an unclean environment favor mosquito breeding. Consequently, many households clean around the home (50%) and clear vegetation (32%) in an attempt to prevent malaria. Although the general consensus is that clearing vegetation is of no benefit and might even worsen malaria (Opiyo et al., 2007), evidence exists that clearing may significantly reduce malaria risk in certain environments (Hustache et al., 2007). Both of these practices may limit breeding habitat (e.g., removing artificial containers or large plants that collect water) and may prevent adult mosquitoes from resting outdoors near homes. Therefore, residents who perform these practices may directly observe a decrease in contact with adult mosquitoes, leading them to conclude that the practices are effective in reducing malaria risk.

Another prevalent belief is that the presence of standing water, particularly during the rainy season, influences mosquito populations. Despite this, only 18% of respondents drain stagnant water around their homes. A number of factors may contribute to low levels of participation in draining water, including a lack of knowledge about larval mosquito ecology, the time-consuming nature of draining water, and the fact that decreasing the prevalence of stagnant water near the home does not influence the resting behavior of adult mosquitoes. In addition, although this practice may decrease populations of anopheline mosquitoes, culicine mosquitoes may remain abundant, maintaining high levels of biting and potentially transmitting other diseases. This may lead people to believe that their efforts are not effective in reducing mosquito abundance, which in turn decreases the motivation to continue to drain stagnant water. Furthermore, in lowland villages located close to swamps and flooded rice fields, the majority of mosquito breeding likely occurs in the swamps and flooded fields as opposed to around the homes. In these cases, draining water around the home would have little, if any, effect on mosquito breeding.

A significant issue to consider is the complex relationship between agriculture, mosquito populations, and malaria. Studies have found that increased populations of mosquitoes in irrigated agricultural communities do not always correlate with a greater prevalence of malaria in areas of stable transmission—called the ‘‘Paddies Paradox’’ (Ijumba and Lindsay, 2001; Ijumba et al., 2002). Ijumba and colleagues proposed a number of potential reasons for this phenomenon, including the displacement of the highly anthropophilic vector A. funestus with the less anthropo- philic A. arabiensis, and the increased wealth generated in irrigation communities, which leads to greater usage of bednets and antimalarial treatments. Thus, the relationship between mosquito populations and malaria transmission is not necessarily direct, and the belief of 90% of respondents that reducing mosquito populations reduces malaria may not be entirely correct in some of the study villages. Whereas environmental-management techniques may be effective in reducing mosquito populations in certain agro-ecological zones, reducing exposure to mosquitoes through improved housing conditions and greater bednet usage is a more crucial control technique in areas where the majority of mosquito breeding occurs in large bodies of water (e.g., irrigated rice fields and swamps).

Another important finding is that certain household characteristics were associated with environmental management practices. Although gender was not a determinant for draining stagnant water, women are significantly more likely to report that they clean around their homes for malaria prevention than men. Educational attainment was significantly positively correlated with both draining stagnant water and cleaning the environment and socioeconomic factors (ownership of durable goods and land area, respectively) were associated with each practice. This indicates that people of higher socioeconomic status tend to perform environmental management techniques around their homes more frequently. This is important to note, considering that poorer people may have a higher exposure to malaria by living in houses that offer less protection from mosquitoes (e.g., no screens on the windows and fewer bednets). Thus, it may be beneficial to target pro- grams toward those of lower socioeconomic status.

Although increasing knowledge of mosquito ecology is likely to have a positive effect on participation in environmental management, there are a number of inherent barriers that could limit high levels of community participation. These barriers include not wanting to drain useful water sources (Mutuku et al., 2006), not perceiving immediate benefits from environmental management (Lindsay et al., 2004), and lack of time and economic incentives. Ng’ang’a and colleagues (2008) found that 77% of respondents stated that lack of time was the primary reason for not draining stagnant water; 67% provided the same primary reason for not clearing vegetation along canals. Additionally, issues surrounding collective action are important to consider. If only a small percentage of community members engage in environmental management activities, it is unlikely that significant reductions in mosquito populations will occur.

This discussion highlights the fact that knowledge alone may not be a strong enough motivating force to encourage people to undertake the time-consuming practice of draining stagnant water or engaging in other environmental management techniques. Consequently, it is important to note that education is merely one component of a successful community-based environmental management program. Such a program must understand time and resource constraints along with other drivers of household behaviors. Incorporating incentives, whether economic or social, and/or mandates for participation will likely increase the effectiveness of environmental management schemes.

Additionally, the complex relationship between malaria transmission and environmental conditions emphasizes the need for further research to determine the efficacy of environmental management techniques in the different agro-ecological zones. The efficacy of different techniques should be evaluated both in relation to a reduction in anopheline mosquito populations and malaria transmission. In areas where household-level environmental management has substantial effects on reducing transmission, programs should be developed to encourage greater participation among community members. In contrast, in areas where environmental management has little effect on transmission, malaria control should focus more on preventing contact with mosquitoes through the use of bed- nets and improved housing conditions.

**CHAPTER FIVE**

**CONCLUSIONS AND RECOMMENDATIONS**

**5.1 Conclusions**

Starting from the belief that community-level environmental management is a promising component of an integrated vector management program, this study sheds light on current knowledge and practices among residents in Iwo, Osun state. Most respondents understand that there is a link between environmental conditions and malaria, and the majority engages in environmental management practices for malaria control. Yet, with limited time and resources to devote toward malaria control, it is crucial that environmental management efforts are focused on techniques that actually lead to reductions in anopheline mosquitoes in a given area. Additionally, it is important to identify areas in which environmental management will not be an effective malaria control technique and to focus control resources elsewhere for those communities.

The creation of an educational program on environmental management for malaria control, paired with incentives or regulations, could lead to significant increases in community participation in effective techniques. The program should concentrate on teaching participants about mosquito ecology, clarifying which environmental management techniques effectively lower Anopheles spp. mosquito abundance versus those that are ineffective, and stressing the importance of community participation and cooperation in the success of this form of malaria control. With greater knowledge and participation, environmental management could result in lasting, sustainable reductions in malaria burden for many communities in Nigeria and other malaria-endemic areas.

**5.2 Recommendations**

Based on the findings of this study, the following are recommended:

1. There is need to enlighten the public on the importance of practicing preventive measures at home and community levels.
2. Intensify social marketing on use of artemisinin combined therapy and its advantage.

**REFERENCES**

Abbas, F., Monroe, A., Kiware, S., Khamis, M., Serbantez, N., Al-Mafazy, AW, ... & Kigadye, E. (2023). Stakeholder perspectives on house-to-house interventions to enhance community engagement in malaria elimination in Zanzibar. Malaria Journal, 22(1), 1-10.

Abdullahi, M & Mohammad Awwal, Abdulazeez & Lawal, Mudassir & Abdullahi, Aminu. (2020). Prevalence of Malaria amongst Pregnant Women Attending Comprehensive Health Centre Dutsin-Ma Local Government Area, Katsina State, Nigeria. 3. 53-59.

Abdullahi, M. S., Abdulazeez, M. A., Mudassir, L., Aminu, A. (2020). Prevalence of malaria amongst pregnant women attending comprehensive health centre Dutsin-Ma Local Government Area, Katsina State, Nigeria. International Journal of Research and Reports in Hematology, 3(2), 53-59

Adepoju KA, & Akpan GE (2017) Historical Assessment of Malaria Hazard and Mortality in Nigeria- Cases and Deaths: 1955–2015. International Journal of Environmental Bioenergy 12(1):30–462.

Adeyemi, A. S., Abubakar, A. A., Idris, A. N., Afolabi, O. T. (2020). Prevalence and associated factors of malar-ia among pregnant women attending antenatal care in a tertiary healthcare facility in southern Nigeria. BMC Public Health, 20(1), 1-9.2.

Ahmed, Rezina & Dey, Dipanjan & Tyagi, Varun. (2020). Mosquito vector borne disease-malaria and public awareness in Sonitpur and Udalguri districts of Assam, India. International Journal of Mosquito Research. 7. 26-31. 10.22271/23487941.2020.v7.i5a.475.

Aina OO, Agomo CO, Olukosi YA, Okoh HI, Iwalokun BA et al (2013) Malariometric Survey of Ibeshe Community in Ikorodu, Lagos State: Dry Season. Malaria Research and Treatment. http://dx.doi.org/10.1155/2013/4872503.

Airaodion, A. I., Ijioma, C. E., Ejikem, P. I., Abali, I. O., Aminu-Ayinde, et al (2023). Prevalence of erectile dys-function in men with type 2 diabetes mellitus in Osun State, Nigeria. Direct Research Journal of Health and Pharmacology, 10(6), 45-52.9.

AIRS (2015) Nigeria Final Entomology Report. November 2014 – December 2015, Africa Indoor Residual Spraying Project. Abt Associates Inc4.

Al Basir, Fahad & Abraha, Teklebirhan. (2023). Mathematical Modelling and Optimal Control of Malaria Using Awareness-Based Interventions. Mathematics. 11. 1687. 10.3390/math11071687.

Annah, Ahimbisibwe & Extension, Kiu Publication. (2023). Evaluation of the Public Perception Regarding Malaria during Pregnancy among Expectant Mothers at Bitereko Health Center III in Mitooma District. IDOSR JOURNAL OF SCIENCE AND TECHNOLOGY. 9. 29-37. 10.59298/IDOSRJST/01.3.13111.

Ashley, E. A., & Poespoprodjo, J. R. (2020). Treatment and prevention of malaria in children. The Lancet Child and Adolescent Health, 4(10), 775-789. https://doi.org/10.1016/S2352-4642(20)30127-9

Awasthi, Kiran & Jancey, Jonine & Clements, Archie & Rai, Rajni & Leavy, Justine. (2024). Community engagement approaches for malaria prevention, control and elimination: a scoping review. BMJ Open. 14. 10.1136/bmjopen-2023-081982.

Ayanore, Martin & Tetteh, John & Ameko, Asiwome & Axame, Wisdom & Kaba, Robert & Ayanore, Augustine & Mogre, Victor & Owusu-Agyei, Seth. (2019). Reproductive-Age Women’s Knowledge and Care Seeking for Malaria Prevention and Control in Ghana: Analysis of the 2016 Malaria Indicator Survey. Journal of Tropical Medicine. 2019. 1-17. 10.1155/2019/2316375.

Battle, K. E., Lucas, T. C. D., Nguyen, M., Howes, R. E., Nandi, A. K., Twohig, K. A., Pfeffer, D. A., Cameron, E., Rao, P. C., Casey, D., Gibson, H. S., Rozier, JA, Dalrymple, U., Keddie, S.H., Collins, E.L., Harris, J.R., Guerra, C.A., Thorn, M.P., Bisanzio, D., ... Gething, P.W. (2019). Mapping global endemicity and clinical burden of Plasmodium vivax, 2000-17: a spatial and temporal modeling study. The Lancet, 394(10195), 332-343. https://doi.org/10.1016/S0140-6736(19)31096-7

Bello, Abdulrahman. (2021). Risk Status of Malaria Based on Socio-Demographic and Environmental Risk Factors in Two Communities in Lagos, Nigeria. 10.21203/rs.3.rs-488751/v1.

Carrasco-Tenezaca, M. (2023). Malaria vector ecology and housing in The Gambia (Doctoral dissertation, Durham University). Centers for Disease Control and Prevention (CDC). Global Health, Division of Parasitic Diseases and Malaria. Malaria Treatment (United States). Available at https://www.cdc.gov/malaria/diagnosis\_treatment/index.html. Accessed February 1, 2023.

Chala, Tesfaye & Balcha, Fufa. (2023). Investigation of Malaria Outbreak and Its Associated Factors at Ziway Dugda Woreda, Arsi Zone, Oromia, Ethiopia: An unmatched Case-Control Study. 10.21203/rs.3.rs-2509359/v1.

Chemeda, Gemechu & Naga, Adisu & Hiko, Desta. (2023). Malaria Outbreak Investigation in Nensebo District, West Arsi Zone, Southeast Ethiopia: A case-control study. International Journal of Epidemiology and Health Sciences. 04. 32. 10.51757/IJEHS.4.2023.700774.

Cirera, L., Sacoor, C., Meremikwu, M., Ranaivo, L., Ebo, M.M., Arikpo, D., Matavele, O., Rafaralahy, V., Ndombe, D, Duran, C. P., Ramirez, M., Ramponi, F., González, R., Maly, C., Roman, E., Sicuri, E., Pagnoni, F., & Menéndez, C. (2023). The economic cost of malaria in pregnancy: evidence from four sub-Saharan countries [version 1; peer review: pending peer review] Gates Open Research. 1-12.

Dawaki S, Al-Mekhla HM, Ithoi I, Ibrahim J, Atroosh WM et al (2016) Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment amonog Hausa communities in Kano State. MalariaJournal 15:351

Dhawan, Gaurav & Joseph, Nidhin & Pekow, Penelope & Rogers, Christine & Poudel, Krishna & Bulzacchelli, Maria. (2014). Malaria-related knowledge and prevention practices in four neighbourhoods in and around Mumbai, India: A cross-sectional study. Malaria journal. 13. 303. 10.1186/1475-2875-13-303.

Ejike, B. U., Ohaeri, C. C., Amaechi, E. C., Ejike, E. N., Oki-ke-Osisiogu, F. U., et al (2017). Prevalence of falciparum malaria amongst pregnant women in Aba South Local Government Area, Abia State, Nigeria. Nigerian Journal of Parasitology, 38(1), 48-52.10.

Ekeleme, Ngozichukwu & Ijioma, Chimaobi & Unachukwu, N & Ejikem, Patricia & Areh, J & Ogwu, C & Jeffery, E & Esangbedo, I & Amuta, Augustine & Ojiri, P & Amoji, N & Aminu-Ayinde, O & Amadi, E & Onyeukwu, N & Abali, I & Airaodion, Augustine. (2023). Attitudes and Practices of Insecticide Treated Bed Nets Usage among Rural Dwellers in Oyo State, Nigeria. International Journal of Tropical Diseases. 44. 43-58. 10.9734/IJTDH/2023/v44i151462.

Ezebialu, I. U., Eke, A. C., Okafor, I. I., Ikeako, L. C., Ugo-chukwu, E. F. (2021). A comprehensive program to pre-vent malaria in pregnancy and its impact on pregnancy outcomes in Nigeria. International Journal of Gynecolo-gy Obstetrics, 152(3), 344-350.7.

Ezirim, E. O., Anele, D. O., Okite, U. P., Abali, I. O., Ak-wuruoha, E. M., et al (2024). Awareness, Prevalence and Severity of Anaemia and Related Contributing Factors, among Pregnant Women Attending Antenatal Clinic in a Teaching Hospital in Southern Nigeria. Asian Journal of Pregnancy and Childbirth, 7(1), 38-52

Forgan RS, Blackburn, AK, Boyle, MM, Schneebeli, ST, & Fraser Stoddart, J. (2014). Topological and chemical implications of introducing oriented rings into [3]catenanes. Supramolecular Chemistry, 26(3-4), 192-201. https://doi.org/10.1080/10610278.2013.844812

Gadji, M., Cobar, G., Thiongane, A., Senghor, AB, Seck, R., Faye, BF, ... & Diop, S. (2023). Red blood cell alloantibodies in pediatric transfusion in sub-Saharan Africa: A new cohort and review of the literature. eJHaem

Habane, Fayo & Kariuki, John & Nyamai, Juma. (2022). Influence Of Socioeconomic And Environmental Characteristics On Malaria Disease Resurgence Among The Adult Residents Of Isiolo Sub-County In Kenya. European Journal of Public Health Studies. 5. 10.46827/ejphs.v5i2.133.

Hjelm, Titus. (2024). Elements of Research Design. 10.51952/9781447364061.

Jassey, Babucarr & Manjang, Buba & Camara, Jerreh & Jallow, Kaddijatou & Jawneh, Sedia & Sarr, Pa & Drammeh, Alhagie & Ndow, Ousman & Tabally, Omar & Jeng, Modou & Mbye, Aji & Conteh, Bubacarr. (2023). Overview of malaria prevention and treatment management in The Gambia: a descriptive study. JHeS (Journal of Health Studies). 1. 37-45. 10.31101/jhes.2959.

Jawo, E., Kargbo, A., Mendy, P. A., Mendy, E., & Sanyang, B. (2022). Knowledge, Beliefs and Attitudes towards Malaria Control and Prevention among Students in Higher Education Institutions in The Gambia Study Site. 35(1), 18-30.

Kariuki S, & Kamau L. (2022). A new generation of long-lasting insecticidal nets. Lancet. 2022;399:1202- 1203

Lalloo, D. G., Shingadia, D., Bell, D. J., Beeching, N. J., Whitty, C. J. M., & Chiodini, P. L. (2016). Guidelines for malaria treatment in England 2016. Journal of Infection, 72(6), 635-649. https://doi.org/10.1016/j.jinf.2016.02.001

Mbunge, Elliot & Milham, Richard & Sibiya, Maureen & Takavarasha Jr, Sam. (2023). Machine Learning Techniques for Predicting Malaria: Unpacking Emerging Challenges and Opportunities for Tackling Malaria in Sub-saharan Africa. 10.1007/978-3-031-35314-7\_30.

Mbye, H., Mane, K., Diop, M.F., Demba, M.A., Bojang, F., Mohammed, N.I., Jeffries, D., Quashie, N. Ben, D'Alessandro, U., & Amambua-Ngwa, A. (2022). Plasmodium falciparum merozoite invasion ligands, associated antimalarial resistance loci and ex vivo responses to antimalarials in The Gambia. The Journal of Antimicrobial Chemotherapy, 77(11), 2946-2955. https://doi.org/10.1093/jac/dkac244

Nascimento-Carvalho, C., Peltola, V., Shah, I., Syrogiannopoulos, G., Chen, K. T., Galli, L., ... & Tebruegge, M. (2023). Malaria in Children: An Update on Management and Prevention NMCP (2019), National Malaria Control Program, The Gambia, Annual Malaria Intervention Profile and Report in The Gambia: Global Fund, UNICEF, WHO, CRS Project 74.

Nwajiaku, L. A., Mbanugo, J. I., Azike, J. E., Igwe, I. F. (2019). Assessment of malaria knowledge and treatment seeking behavior among pregnant women in Onit-sha, Anambra State, Nigeria. American Journal of Epide-miology and Infectious Disease, 7(1), 1-6. https://doi.org/10.12691/ajeid-7-1-123.

Nworie, K. M., Aluh, D. O., Eze, J., Opurum, C. A., Ndubuisi, L., et al (2018). Assessment of self-medication practic-es for treatment of illnesses among school-children in southeast, Nigeria. Matters of Behaviour, 3(4), 15-25.

Olasope, M. A., Ojuromi, O. T., Ajibaye, O., & Ibidapo, C. A. (2023). Antiplasmodial Potential of Thaumatococcus danielli Extracts (Benth.) against Plasmodium berghei Infected Mice. Tropical Journal of Natural Products Research Onosakponome, EO Malaria Prevalence in COVID-19 Patients by Blood Group Classification

Olowookere, S. A., Adekanle, D. A., Fola-Adebayo, Y. Y., Adeleke, G. E. (2017). Assessment of knowledge and up-take of intermittent preventive treatment in pregnancy in Oke-Oyi community, Ilorin, Nigeria. Journal of Basic and Clinical Reproductive Sciences, 6(1), 29-35.6.

Omole, O & Ezirim, Edmund & Abali, Isaiah & Akwuruoha, E & Airaodion, Augustine. (2024). Prevalence, Knowledge and Prevention of Malaria among Preg-nant Women Attending Antenatal Care at a Teaching Hospital in Southern Nigeria. 1-11.

Paaijmans, K. P., & Huijben, S. (2020). Taking the "I" out of LLINs: Using insecticides on vector control tools in addition to long-lasting bed nets to combat malaria. Malaria Journal, 19(1), 1-6. https://doi.org/10.1186/s12936-020-3151-x

Panda, Amaresh & Mohapatra, Sanjay. (2024). Research Design. 10.1108/978-1-83549-140-920241004.

Sangho, Oumar & Tounkara, Moctar & Collins, Lillian & Beebe, Madeleine & Winch, Peter & Doumbia, Seydou. (2021). Determinants of intermittent preventive treatment with sulfadoxine–pyrimethamine in pregnant women (IPTp-SP) in Mali, a household survey. Malaria Journal. 20. 10.1186/s12936-021-03764-5.

Sano, Aicha & Sivaratnam, Dhashani & Ahmad, Norliza & Camara, Alioune & Daliwa, Yempapou & Lim, Poh Ying. (2024). Effectiveness of malaria education program based on Health Belief Model on improving Knowledge, Attitude and Practice of Malaria Prevention among university students in Conakry, Guinea. 10.21203/rs.3.rs-3919657/v1.

Sarfo JO, Amoadu M, Kordorwu PY, Adams AK, Gyan TB, Osman AG, Asiedu I, Ansah EW. Malaria among children under five years in sub-Saharan Africa: a scoping review of prevalence, risk factors and prevention interventions. European Journal of Medical Research. 2023 Dec;28(1)

Tairou, Fassiatou & Diallo, Abdoulaye & Sy, O. & Kone, Aminatou & Manga, Isaac & Sylla, Khadim & Lelo, Souleye & Fall, Cheikh & Sow, Doudou & Ndiaye, Magatte & Faye, Babacar & Tine, Roger. (2022). Malaria-associated risk factors among adolescents living in areas with persistent transmission in Senegal: a case–control study. Malaria Journal. 21. 10.1186/s12936-022-04212-8.

Tong, Michael & Hansen, Alana & Hanson‐Easey, Scott & Cameron, Scott & Xiang, Jianjun & Liu, Qi Yong & Liu, Xiao-Bo & Sun, Ye-Huan & Weinstein, Philip & Han, Gil-Soo & Williams, Craig & Bi, Peng. (2017). Perceptions of malaria control and prevention in an era of climate change: a cross-sectional survey among CDC staff in China. Malaria Journal. 16. 10.1186/s12936-017-1790-3.

Uduma, V. U., Ijioma, C. E., Ekeleme, N. C., Abali, I. O., Ejik-em, P. I., et al (2023). Respiratory symptoms and ventilation patients receiving antiretroviral therapy in Edo State, Nigeria. Merit Research Journal of Medicine and Medical Sciences, 11(9), 214-224

World Health Organization. World malaria report 2020: 20 years of global progress & challenges. Geneva, World Health Organization; 2021. https:// www. who. int/ publi catio ns‑ detail‑ redir ect/ 97892 40015 791

**Questionnaire**

PLEASE KINDLY TICK CORRECTLY IN THE BOXES PROVIDED

**Demographic distribution**

**Age Range**

|  |  |
| --- | --- |
| 17–29 |  |
| 30–49 |  |
| 50–69 |  |
| 70–95 |  |
| **Gender** |  |
| Male |  |
| Female |  |

**Religious distribution of respondents**

|  |  |
| --- | --- |
| Christian |  |
| Muslim |  |

**Educational status**

|  |  |
| --- | --- |
| None |  |
| Primary school |  |
| Secondary school or above |  |

**Occupational status**

|  |  |
| --- | --- |
| Crop farming |  |
| Pastoralist/mixed farming |  |
| Business owner/employee |  |
| Other |  |

**Community Knowledge on Malaria, Mosquito Ecology, and the Environment**

**Table 4.2. Methods used to Reduce Mosquito Populations in the Community**

|  |  |  |
| --- | --- | --- |
| Methods | Yes | No |
| Clean environment around home |  |  |
| Use bednets |  |  |
| Clear vegetation around home |  |  |
| Drain stagnant water around home |  |  |
| Spray insecticides inside home |  |  |
| Spray insecticides outside of home |  |  |
| Use larvicides |  |  |
| Drain rice fields |  |  |
| I don’t know |  |  |

**Environmental Management Practices for Malaria Control**

What can you do to protect yourself from malaria?

|  |  |  |
| --- | --- | --- |
| Practices to prevent malaria | Yes | No |
| Use a bednet |  |  |
| Clean residential surroundings |  |  |
| Clear grass/bushes around the home |  |  |
| Drain stagnant water |  |  |
| Spray insecticides inside or outside home |  |  |
| Take anti-malarial drugs intermittently |  |  |
| Use mosquito coils |  |  |
| Burn local herbs/plants |  |  |
| I don’t know |  |  |