Human malaria infection is one of the leading parasitic diseases which is transmitted in 108 countries consisting of approximately 3 billion people; in 2019, statistical analysis showed that 229 million human malaria infections were recorded of which an approximately 409,000 deaths were reported (WHO, 2021). About eighty per cent and ninety per cent of cases and deaths were reported in sub-Saharan Africa respectively, especially among children younger than 5 years who accounted for approximately sixty-seven per cent of all malaria deaths worldwide (WHO, 2021). Malaria is a protozoan transmitted infection that is spread by Anopheles mosquitoes. Five species of Plasmodium are implicated in human malarial infection, with the most caused by either Plasmodium (P) falciparum or P vivax, although P ovale, P malariae, and P knowlesi are also implicated in malaria infection (Kantele & Jokiranta, 2011). Most of the mortalities associated with malaria are caused by falciparum malaria (Kantele & Jokiranta, 2011). Malaria was earlier prevalent around the globe but was eliminated from the USA, Canada, Russia, Europe, El-Salvador, Algeria, Argentina, Paraguay, and Uzbekistan (Feacham et al, 2010; WHO, 2021) and the latest data from the World Health Organization showed that China has also eliminated malaria from the country as a result of 70 years of sustained effort (WHO, 2021). Sub-Saharan Africa (SSA) has the highest burden of human malaria infection, and it was estimated that in 2019, the region accounted for ninety-four per cent of the global morbidity and mortality burdens of malaria (WHO, 2020). In 2019, six countries from Africa were associated with half of the global mortalities. The countries are Burkina Faso, Democratic Republic of Congo (DRC), Congo, Mozambique, Niger, Nigeria, and Tanzania (WHO, 2020). Although there has been a significant effort to curb malaria, it is still a public health issue across SSA which means more attention should be directed to it (WHO, 2020).

This review would make a critical analysis of human malaria prevention and control techniques. From the public health point of view, the focus of this review will be on human malaria infection (HMI) in Nigeria. A literature search was conducted using relevant databases such as PubMed, Google Scholar, Cochrane Review, and NLM using the following keywords which were used in combinations: “Human Malaria”, “parasites diseases”, “prevention”, “control”, “Nigeria”. Relevant articles were identified and used.

Introduction

Human malaria infection is among the leading global parasitic diseases which have substantial effect on all facets of human life. A series of measures have been devised to prevent and control malaria infection, including vaccines and prophylaxis. Nigeria, the most populous country in Sub Saharan Africa, is burden by effect of malaria infection. A literature search was performed using relevant key words. This review critical analysis various preventive and control measures employed in malaria infection with a focus on Nigeria.
for example, the financial loss as a result of malaria on an annual basis is estimated at 132 billion naira (Federal Ministry of Health, 2011). The important risk factors associated with the acquisition of malaria include socioeconomic and environmental factors respectively (Federal Ministry of Health, 2011). Age and sex are some of the demographic factors that play a role in the transmission of the parasite while wood land, trees, and plantation are some examples of environmental factors associated with malaria transmission. In addition, some climate elements that impact mosquito breeding while climatic factors that impact the transmission of malaria include temperature, humidity, and rainfall (Kelly-Hope et al, 2009)). Finally, socioeconomic factors include education, occupation and social status that might directly impact human exposure and treatment patterns (Awosolu et al, 2019). Awosolu et al (2021) in a study added another factor, migration, as they reported that cases of malaria were more frequent in their study as travelling was implicated in the transmission of the parasite among study subjects who travelled from the countryside to cities and another way round. The clinical manifestations of human malaria include increased body temperature, shaking, chills, and headache, tiredness, and muscle pains. In some cases, nausea, vomiting, and diarrhea have been reported (CDC Online Resource). Malaria has been associated with anaemia and jaundice due to the loss of red blood cells (CDC Online Resource). Malaria can be detected by analysing the patient’s blood using a microscope or rapid detection test (RDT) for the presence of the malaria or antibody respectively (CDC Online Resource). The current drugs used in treating malaria infection include Artemisinin drugs, Atovaquone, Chloroquine, Doxycycline, Mefloquine, and Quinine (CDC Online Resource). Although there are no efficient vaccines for malaria, recent data provide some hope.

Malaria Control in Nigeria

Malaria control in Nigeria is among the oldest control programs in Nigeria as it began somewhere in 1948 (cited in Mokuolu, 2016). It has passed through different transitions beginning with the National Malaria Service to National Malaria Elimination Program in 2013 with the ambition of eliminating malaria. The Ministry of Health hosts the National Malaria Elimination Program and the various states’ elimination-activities (Mokuolu, 2016). The National Malaria Strategic Plans (NMSP) provides a blueprint required for aims and targets of malaria control in the country (Federal Republic of Nigeria, 2014). Since its inception in 2014, four NMSP strategies have being implemented with the latest NSMP’s goal been to decrease the burden associated with malaria to the level of the planned targeted elimination period and reduce malaria-associated deaths to zero via strategies as highlighted in the seven planned goals (Federal Republic of Nigeria, 2014). Nigeria malaria control is based on the NMSP strategy which is made of five important interventions. These include global access to Long-Lasting Insecticide-treated nets (LLINs), indoor residual spraying (IRS), larval Source Management (LSM), providing Intermittent Preventive Treatment of malaria in pregnancy (IPTp) to pregnant women attending antenatal clinics by targeting communities, the surveillance of vectors, devised resistance monitoring that should include antimalarial drugs and vectors, and quality assurance of malaria-related products (Federal Republic of Nigeria, 2014). A study by Adaji and Gabriel to evaluate access and usage of LLINS among women of childbearing age and individuals below the age of 5 years in rural communities in Benue State found that ninety-three per cent of the respondents used LLIN which means access to bed net was high, but the study highlighted the fact that regular use among women was low (Adaji & Gabriel, 2019). LLINS is one of the most important malaria prevention and control strategies especially in SSA (National Malaria Elimination Programme, 2016; Mokuolu, 2016). By 2015, net ownership in Nigeria was approximately six per cent. This was a massive increase from two percent in 2003. Between 2009 and 2015, there was the distribution of over 103.8 million LLINS across Nigeria in which net ownership was higher in the countryside in comparison to towns (National Malaria Elimination Programme, 2016; Mokuolu, 2016). When the regional distribution is taken into consideration, the north-west has the highest than the south-west (National Malaria Elimination Programme, 2016; Mokuolu, 2016). Net utilization is not yet up to the extent of net ownership. However, over a couple of years, net utilization rates have seen some increase; for example, among children of 5 years or less, net utilization increased from one per cent to thirty-nine per cent in 2003 and 2015 respectively and five per cent to four three percent from 2003 to 2015 respectively among women who were pregnant (National Malaria Elimination Programme, 2016; Mokuolu, 2016). Chukwu et al (2021) in their study to evaluate the dissimilarity in utilizing LLIN and occasional prevention of malaria among pregnant women across geopolitical zones of Nigeria reported that the prevalence of LLIN was approximately eighty-eight per cent and the differential rates were approximately ninety per cent for North Central, ninety-two per cent for North East, ninety per cent for North West, seventy-seven per cent for South East, eighty-one per cent for South-South, and seventy per cent for South-West respectively. The utilization of LLIN was high. However, full coverage of LLIN was not fully achieved. Effective health education, as well as intensive mass media campaign programs, would facilitate and coverage gaps. Despite the significance of LLINS in malaria control, some challenges seem to be impeding the overall net ownership and utilization. In recent times, there has been a massive increase in social mobilization campaigns in Nigeria. However, despite these efforts, the number of Nigerians sleeping under net is worryingly very low. Socioeconomic and sociocultural barriers can be implicated. These include irregular power supply, the beliefs that itching, colour, change of odour, and heat production mitigate net use. LLIN production should take a national dimension as only one indigenous company is linked with LLIN production (Chukwu et al, 2021). This means there is the need to assist local LLIN indigenous producers, developing effective networking involving the community- groups and -based institutions, etc. to increase the awareness of demand for LLIN and its subsequent use. IRS is another effective intervention that can lead to a facilitation in malaria transmission (World Health Organization, 2017). In 2015 for example, 106 million people globally were protected by IRS (cited in World Health Organization, 2017). However, as of 2010, the percentage of people who were at risk and protected by IRS reduced from approximately six per cent around the globe to three per cent in 2015 while in SSA, it reduced from approximately eleven per cent to six per cent (World Health Organization, 2017). The Nigeria Malaria Indicator Survey (MIS) of 2015 reported that approximately one per cent of the study population received IRS within the previous year (Federal Ministry of Health, 2015). Dimas et al (2019) found in the study aimed at evaluating the scope of IRS usage and determined the component that impacts its acceptability in Nasarawa State, Nigeria, that coverage for IRS was approximately ninety-nine per cent; however, only approximately eighty-two per cent of those who earlier accepted IRS were ready to accept it again. The reason implicated in this includes the high cost of IRS campaigns, lack of vector maps to assist in the discharge of planned strategies, and the increasing emergence of resistance to phrethroids and other products that have cidal effects on insects. To solve these challenges, there is a need to put more effort to address the challenges of insecticide resistance.

Preventive Techniques

One of the preventive strategies is supplying drugs as Intermittent Preventive Treatment for pregnant women (IPTp) and infants (IPT-i) and provision of periodic chemoprevention (SMC) for individuals under the age of five (Federal Ministry of Health, 2015). IPTp consists of administering three or more doses of sulphadoxine-pyrimethamine (SP) as a directly observed treatment (DOTS) which should be given a month apart (Yaro, 2014). The uptake of three doses of IPTp in Nigeria is low (nineteen per cent), however, the uptake of two-doses was reported to be around thirty-seven per cent in 2015 (Federal Ministry of Health, 2015).
Poor implementation and lack of sufficient knowledge and receiving three or more doses were implicated for both figures (Federal Ministry of Health, 2015). The National Malaria Policy identifies the impact of IPTi and seasonal malaria chemotherapy, the method of execution is unacceptable. SMC is underutilized as an alternative method for the prevention of transmission in parts of Sahel areas of Nigeria. This intervention could play a significant role in achieving zero death from malaria. Already the target of zero targets by 2020 has not been achieved as more deaths are now reported than before (Federal Ministry of Health, 2015).

Another control measure is complementary vector control which consists of larval source management (LSM) and the use of personal protection. LSM is an important measure for the control of breeding sites in areas where larval breeding sites are minimal. LSM has been utilized in Rivers and Lagos States but it has still not had any meaningful effects probably due to certain challenges such as logistics (Federal Ministry of Health, 2015). Further studies are required to explore a better understanding of this vector control strategy (Yaro, 2014).

Early diagnosis and treatment of malaria is a control strategy that is of importance (Yaro, 2014). In Nigeria, early diagnosis and treatment are among malaria control strategies. The National Malaria Policy states “All suspected cases of malaria should have parasite-based confirmation before the institution of antimalarial treatment at all levels of healthcare delivery in the country, except in the extraordinary circumstances where the diagnostic facility is not available” (National Malaria Control Programme, 2009). This is a firm statement about national activities which highlighted the need for all individuals suspected of having malaria to acquire care consisting of a rapid diagnostic test (RDT) or blood film by the year 2020 (National Malaria Control Programme, 2009). This therefore completely removes unconfirmed diagnosis as an ideal strategy. Based on this, the rate of testing with rapid diagnostic testing and a blood film analysis has increased significantly (Mokuolu, 2016).

A study showed that seventy to ninety per cent of persons who reported to various health facilities with fever were tested for malaria (Mokuolu, 2016). RDTs utilization for malaria started in Nigeria in 2010 (Ezeoke et al, 2012; Uzochukwu et al, 2011). Although RDTs have been recognized as an important tool for parasitic-based diagnosis of malaria, it has been afflicted with some challenges. The capability of RDTs to detect low levels of parasitemia is a challenge. Another challenge is the issue of reading the test. This sometimes leads to the rejection of RDT results and subsequent delaying the initiation of treatment (Ezeoke et al, 2012; Uzochukwu et al, 2010). Novel techniques such as ‘Deki reader’ increase the accuracy of RDT and provide a platform for real-time capturing of the data (Yaro, 2014).

What are the novel strategies for future malaria control and prevention in Nigeria? First, there is the need to develop a strategy that would develop strategies on how to avert and hinder the acquisition of malaria and the idea of ‘track, test, and treat’ should be strengthened. Novel techniques that can be used for diagnosing human malaria infection such as identifying malaria parasites in urine should be improved for mass production and distribution at affordable prices (Oguonu et al, 2014). In addition, the sensitivity and specificity of current RDTs should be improved through the utilization of automated RDT readers (Fio Corporation online). Finally, the world needs a malaria vaccine. There are several malaria vaccine candidates which are in different phases of clinical studies (Yaro, 2014). Among the candidates, RTS, S vaccine is the most advanced with the latest data reporting of its partial protection against P falciparum (Yaro, 2014). The vaccine was shown to provide partial protection in children in clinical trials (WHO, 2017). Pilot implementation is currently underway in Malawi, Ghana, and Kenya (Adepoju, 2019). Although RTS, S vaccine has been shown to possess some effectiveness, it should be regarded as another armamentarium for the control of malaria due to its low to modest efficiency (Arora et al, 2021).

Conclusion
The World Global Technical objective is that by 2030, more than 35 countries should have eliminated malaria. This is just few years away. Can Nigeria be part of the history makers? Well, the answer to this question depends on our capability of providing homemade solutions to overcome challenges associated with malaria control and prevention; for example, further studies are required to explore a better understanding of vector control strategies. Of importance are economic and social strategies for the effective application of National Malaria Policy. The issue of drug resistance is now a global problem that would have a significant negative impact on the goal of the WHO Global Technical plan. We need to also have an attitude of developing sustainable implementation of malaria prevention programs in terms of building a robust and resilient health systems, etc. Only then can we be able to develop meaningful control and prevention strategies.

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