Trends of Malaria in the South West Region of Cameroon: Overview, Challenges and Perspectives (SDG3)

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Abstract

Background: The South West Region of Cameroon falls in the large equatorial forest of the south, where malaria parasite transmission is high and perennial. It is one of the two English- Speaking Regions affected by the on-going social crisis with displaced populations which could constitute an enormous challenge to malaria control efforts. If we hope to attain Target 3.3 of the Sustainable Development Goals, then it matters that evidence-based data as the basis for aggressive measures to reduce the burden of malaria in the region be generated. A review of the literature of malaria in the region was done to establish a trend in epidemiological, parasitological and entomological indicators of malaria and identify gaps in knowledge and make proposals for future steps.

Methods: A total of 47 scientific and policy documents were extracted from online bibliographic databases and reviewed. The major findings were noted, the gaps identified and future steps proposed.

Major findings: *Plasmodium falciparum* is the dominant species responsible for malaria infection in the region. Infection in children, pregnant women and adults range from 7.1% to 43.3%, 20.3% to 43% and 5.38% to 25.6%, respectively. The main vector that transmits malaria is the *Anopheles gambiae s.l.* Artemisinin and its derivatives are the drugs for malaria treatment.

Conclusion: All the studies conducted on malaria over the years were sporadic in nature and no trends of malaria transmission in the region could be established.

Perspectives: There is need for longitudinal prospective studies to monitor trends in malaria in the region.

Keywords: South West Region, Malaria, Trends, Epidemiology, Social crisis, Sustainable Development Goal.

Introduction

Malaria is a mosquito-borne disease of humans and other animals caused by parasitic protozoans of the genus *Plasmodium*. It is transmitted through the bite of an infected female *Anopheles* mosquito. The World Health Organization (WHO) reported 229 million malaria cases in 2019 of which an estimated 215 million occurred in the African Region accounting for about 94% of cases.

The majority of malaria cases (82%) and deaths (94%) that were averted occurred in the African Region. Cameroon accounts for 3% of this number (215 million) (World Malaria Report, 2020).

Despite decades of control and prevention efforts, malaria remains one of the greatest causes of morbidity and mortality in Cameroon. According to the National Malaria Control Programme (NMCP) 2008 annual report, malaria accounts for 35% to 43% of all deaths in health units, 50% to 56% of morbidity among children under the age of 5, 40% to 45% of medical consultations and 30% to 47% of hospitalizations. It is also the cause of 26% of absences in the workplace and 40% of the health expenditure of households. Malaria is responsible for 49% consultations and 59% of hospitalizations during pregnancy leading to abortions and premature labour and deliveries as well as low birth weight, all exposing the babies to early deaths and mothers to death during delivery (NMCP Report, 2008; Ngum *et al*., 2010). In 2019, 25,876,387 Cameroonians were at risk of malaria infection, 4,266,684 confirmed cases, 11,233 deaths, 66,071 under five deaths (WHO World Malaria Report, 2020; UNICEF, 2020).

Although malaria is endemic nationwide, the level of endemicity greatly varies from one geographical, ecological and climatic zone to another. The three main epidemiological zones linked to geo-climatic variations are the sudano-sahelian zone (areas of the Far North and North regions), the large savanna area of interior plateau (Adamawa region) and the large equatorial forest of the south (the remaining 7 regions of the southern part of the country). The existing climatic conditions are favorable for the development of the malaria vectors and the parasites. *Plasmodium falciparum* is the most common species of *Plasmodium* (95%), followed by *P. malariae* and *P. ovale* (NMCP Report, 2012; Ngum *et al*., 2010).

The South West Region, which is one of the ten administrative regions of Cameroon, falls in the large equatorial forest of the south, where malaria parasite transmission is high and perennial. The climatic conditions and ecological settings of this region are optimal for continuous transmission throughout the year. The region comprises six administrative Divisions and 31 Sub Divisions. It has a population of 1,553,300 inhabitants covering a surface area of 25,410 km^2. The region has an east-west extension of about 110 km and north-south, it is approximately 190 km. It is located between latitude 3. 80º – 6.70ºN and longitude 8.30º - 10.20º E with altitude ranging from 0 to 4095 m.a.s.l. The region is bordered by the North West Region in the north, the Atlantic Ocean in the south, the Littoral and West Regions in the east and Nigeria in the west. The region is characterized by a succession of vegetation including mangrove at the Atlantic coast through the deep equatorial evergreen forest to the humid savannah in the far north (Akwaya Sub Division) of the region. The climate comprises two seasons, the rainy season from March to October, while the dry season goes from November to February with annual rainfall varying between 1500 mm/ year inland to 4000 mm/year on the sea coast (Suchel, 1998). The region is considered as belonging to a holoendemic stratum with high and perennial malaria parasite transmission but in the highlands, it is seasonal with high transmission observed during the rainy season months (Wanji *et al*., 2012).

Antonio-Nkondjio and colleagues (2019) reviewed the malaria situation in Cameroon in 2019, including that of the South West Region. However, covering the whole country, some important trends and details for the region might have been left out.

The social crisis affecting the South West region of the country with a displaced population could be affecting malaria epidemiology in the area and this could constitute an enormous challenge that could impede malaria elimination or control efforts in this region. If we hope to attain Target 3.3 of the Sustainable Development Goals (SDGs) by ending epidemics of malaria and ensure healthy lives and promote the well-being of all at all ages by 2030, then it matters that evidence-based data as the basis for aggressive measures to drastically reduce the burden of malaria in the region be generated. This paper attempts a review of the literature of malaria in the South West Region in order to establish a trend in epidemiological, parasitological and entomological indicators of malaria and identify gaps in knowledge and make proposals for perspective and future steps.

Methodology

Data Retrieval

Information on malaria in Cameroon and the South West Region in particular were extracted from online bibliographic databases. PubMed, Google and Google Scholar were used to search for information. Terms used to guide these searches included malaria parasites and transmission, malaria vectors and ecology, malaria incidence and prevalence, morbidity and mortality rates, epidemiology, pathologies, diagnosis, treatment and management, vector control, *Plasmodium*, LLINs, insecticide resistance, Anopheles. Information was also extracted from published reports: WHO, UNICEF, NMCP, Cameroon Demographic Health Surveys (DHS). The search period included 1960 to 2021. The search resulted in 100 articles. Fifty three papers were excluded because they were not reporting data from the South West Region of Cameroon. Scientific publications downloaded were categorized as follows: *Plasmodium* species (4), Epidemiology (11), Genetics (1), Immunology (3), Pathology (7), Diagnosis (4), Treatment and management (4), Vector biology (4), Prevention and control (9).

Results

Situation of Malaria in the South West Region

Plasmodium Species

Very few studies have attempted identification of the *Plasmodium* species circulating in the South West Region. Wanji *et al*. (2008) evaluating the performance and usefulness of the Hexagon Combi rapid diagnostic test in asymptomatic children in the Mount Cameroon region revealed the dominance of *Plasmodium falciparum*. The limitation of the Hexagon rapid test was its inability to detect mixed infections. Kwenti and colleagues in 2017 identifying *Plasmodium* species in five epidemiological strata in Cameroon including the coastal areas of Limbe, by polymerase chain reaction (PCR), concluded that *P. falciparum* was the only species causing clinical malaria in the target population. Kimbi and colleagues in 2005, reported *P. vivax*-like asymptomatic infections in 33.3% of school children (Kimbi *et al*., 2005). However, diagnosis was done by light microscopy and the researchers were not certain about the speciation, especially because of the notion that Africans are refractory to *P. vivax* infection due to lack of the Duffy antigen receptor needed by *P. vivax* to attach and invade red blood cells. As such, there was no follow-up study for proper identification by the researchers.

One of the few studies that employed molecular typing revealed a substantial *Plasmodium vivax* infection of 14.7% (13/87) in asymptomatic adults in a rural community in Buea (Fru-Cho *et al*., 2014). The study also revealed a prevalence of 50% (6/12) Duffy positive individuals. The results of this study provided the first molecular evidence of indigenous *P. vivax* infection in the South West Region and Cameroon at large. Larger studies are needed in order to establish the prevalence of *P. vivax* infection in the region.

Malaria vectors

Although there are 48 *Anopheles* species recorded throughout Cameroon, only 18 are responsible for malaria transmission (Fontenille *et al*., 2004; Antonio-Nkondjio *et al*., 2006; Ayala *et al*., 2009; Sinka et al., 2010). The principal vectors of malaria in Cameroon are *Anopheles gambiae* (*s.s*.), *An. funestus* (*s.s.*), *An. arabiensis*, and *An. coluzzii*. *An. carnevalei*, *An. coustani*, *An. hancocki*, *An. leesoni*, *An. marshallii*, *An. melas*, *An. moucheti, An. nili*, *An. paludis*, *An. pharoensis*, *An. ovengensis*, *An. rivulorum-like*, *An. wellcomei* and *An. ziemanni* play a secondary role (Carnevale *et al*., 1992; Njan *et al*., 1993; Fontenille *et al*., 2000; Antonio-Nkondjio *et al*., 2002).

In the South West Region of Cameroon, a few studies have identified the malaria vectors implicated in the transmission of malaria. Wanji *et al*. (2003) investigated the biting habits, feeding behaviour and entomological inoculation rates of different *Anopheles* species during the dry and rainy season in the Mount Cameroon region. Five *Anopheles* species were identified: *Anopheles gambiae s.l*., *An. funestus*, *An. hancocki*, *An. moucheti* and *An. nili*. *An. gambiae*, *An. funestus* and *An. hancocki*, recorded during both seasons, were the main vectors of malaria in the region. *An. gambiae s.s*. was the only member of the *An. gambiae* (Giles) complex. These three species had their peak activity between 1 and 2 am. The sporozoite rate, for all vectors together, was significantly higher in the rainy season (9.4%) than in the dry season (4.2%) with all the species infected by *Plasmodium falciparum*. The average inoculation rate was 0.44 infective bites per man per night, which adds up to 161 infective bites per year in this study area. No malaria vector was caught at 1200 m a.s.l.

Bigoga *et al*. (2007) studied malaria vectors and transmission dynamics in coastal south western Cameroon and reported *Anopheles gambiae* (78.2%), *Anopheles funestus* (17.4%), *Anopheles nili* (7.4%) as the dominant species. *Anopheles gambiae* accounted for 72.7% of transmission, *Anopheles funestus* (23%) and *Anopheles nili* (4.3%). The entomological inoculation rate of 287, 160 and 149 infective bites/person/year was recorded for Tiko, Limbe and Idinau, respectively.

Amvongo-Adjia *et al*. (2018) investigated the bionomics and vectorial role of anophelines in wetlands along the volcanic chain of Cameroon with Tiko, Meanja, Kumba and Mamfe (all in the South West Region) as part of the study sites. Eight malaria vectors: *Anopheles arabiensis*, *An. coluzzii*, *An. funestus* (*s.s.*), *An. gambiae*, *An. hancocki*, *An. melas*, *An. nili* and *An. ziemanni*, were found biting humans. Anophelines were more exophagic (73.6%) than endophagic (26.4%), showing a marked nocturnal activity (22:00–4:00 h) for *An. coluzzii* and *An. gambiae* while *An. funestus* (*s.s.*) was mostly caught between 1:00 and 6:00 h and *An. ziemanni* having an early evening biting behaviour (18:00-00:00 h). The transmission level was low with entomological inoculation rates estimated to 0.7 infected bites per person per month (ib/p/mth) in Tiko and 1.4 ib/p/mth in Mamfe.

Boussougou-Sambe *et al*. (2018) assessed the susceptibility of *Anopheles gambiae* (*s.l.*) mosquitoes from South-West Cameroon to deltamethrin, permethrin and malathion identified two species of the *An. gambiae* (*s.l.*) complex, *An. coluzzii* and *An. gambiae* (*s.s.*) in all three study locations with high proportions of *An. coluzzii* in Limbe (84.06%) and Tiko (92.2%), while in Buea, *An. coluzzii* (55.6%) and *An. gambiae* (*s.s.*) (44.4%) occurred almost in the same proportions.

Epidemiology

In changing climatic and environmental conditions coupled with different malaria prevention and control measures put in place by the government, the epidemiology of malaria in the region cannot be expected to remain the same over the years. Temperature, precipitation, vegetation and altitude are important predictors of the geographical distribution of malaria in Cameroon (Massoda *et al*., 2015). During the last two decades, an increase in temperature of 0.4 °C and decrease in rainfall of 10% – 20% have been reported, compared to the period 1951–1980 (Sighomnou, 2004). Most of the studies that have been conducted on malaria in the region have focused on the incidence and prevalence in vulnerable populations (children and pregnant women). Ikome *et al*., (2002), reported a prevalence of 50.9% uncomplicated malaria and 7.1% cerebral malaria in children below 15 years of age in Limbe. Between 2008 and 2019, varied prevalence of malaria parasitaemia were reported in children below 15 years in the Mount Cameroon area ranging from 24.8% to 43.3% (Wanji *et al*., 2008; Nyasa et al., 2015; Kimbi *et al.*, 2013; Sumbele *et al*., 2015; Bate *et al*., 2016; Eposi *et al*., 2019). The highest prevalence (43.3%) was recorded in 2019, after many years of free subsidized treatment for children and free Long-Lasting Insecticide-Treated bed nets (LLINs). Outside the Mount Cameroon area, Fokam *et al*. (2016) and Nyasa *et al.* (2021) reported prevalence in children of 40.7% and 21.35% in the Tombel and Nguti areas of the Kupe Muanengouba Division respectively. Asoba *et al*. (2009) and Fokam *et al*. (2016) reported prevalence of 43.2% and 20.3% in pregnant women in the Mount Cameroon area (Buea, Muea and Mutengene) and Tombel Health District respectively. Studies in adult populations recorded prevalence of 25.6%, 32.3%, 26.5% and 5.38% in the Mount Cameroon area (Ebako *et al*., 2010; Fru-Cho *et al*., 2014; Nyasa *et al*., 2015; Nyasa *et al*., 2021) and Kupe Muanengouba Division. The least prevalence (5.38%) was in Kupe Muanengouba.

Diagnosis

Early diagnosis and treatment of malaria remains critical to preventing death, reducing the disease and its transmission (WHO, 2015; World malaria report, 2020). Current malaria management guidelines recommend prompt parasitological confirmation of all suspected malaria patients by microscopy and/or rapid diagnostic test (RDT) prior to antimalarial treatment (WHO, 2015). Some communities in malaria-endemic areas lack healthcare facilities, and diagnosis of malaria relies predominantly on its clinical presentation which is nonspecific. Although presumptive diagnosis of malaria is less expensive (Ansah *et al*., 2013), the accompanying prescription could lead to the treatment of patients without malaria (Perkins et al., 2008), over prescription of antimalarial drugs (Rafael *et al.*, 2006), thus contributing to antimalarial drug resistance (White, 2004). It is worth noting that WHO recommends parasite-based diagnosis first for older children, adults and all suspected cases of malaria regardless of patient age (Bell *et al*., 2018). The examination of Giemsa-stained blood smears for the detection of malaria parasites using light microscopy therefore remains the gold standard for malaria diagnosis, as it provides information on both parasite species and density (Moody, 2002). However, microscopy requires basic laboratory infrastructure, quality equipment and reagents and is labour intensive and needs a trained technician. In order to overcome the deficiencies of light microscopy, RDTs have thus been designed as alternatives. RDTs require little training, produce rapid as well as prompt results after 15 to 30 minutes, require no laboratory infrastructure and therefore allow them to be used in the most remote settings. RDTs are vastly sensitive and specific compared with microscopy and also compare favourably with the polymerase chain reaction (PCR) (Moyeh *et al*., 2019; Berry *et al*., 2008). However, RDTs are limited mainly by their inability to detect infections at low parasitaemia. In addition, false positive or negative results may be reported due to the persistence of target antigen even after successful treatment or deletions in the PfHRP2 gene, respectively (Haditsch, 2004; Gamboa *et al*., 2010). Nevertheless, they are affordable, easy-to-perform, fast, reliable and effective diagnostic point-of-care tools for malaria case management especially in endemic rural settings and areas with limited laboratory facilities (WHO, 2011).

It is worth noting that newer diagnostic techniques such as amplification of parasite DNA with polymerase chain reaction are specific and can detect low concentrations of parasites but take time and requires specialised equipment and are thus not suitable in most field settings. The use of malaria RDT has expanded both in endemic and non-endemic settings, with over 60 different RDT brands and more than 200 developed products (Bell, 2011). Yet, results from field trials suggested highly variable field performance. Procuring excellent quality RDTs does not necessarily guarantee good field performance because factors such as shipping, handling and storage could affect the RDT accuracy (Bell, 2011).

Despite persistent high malaria prevalence, and the continuous influx of RDTs into our markets, the surveillance of RDTs in Cameroon and the South West Region in particular seems virtually ignored. Between 2008 and 2021, a number of studies evaluated the validity and usefulness of different brands of RDTs in the South West Region. Wanji *et a*l. (2008) evaluated the performance of the Hexagon Combi™ Rapid Diagnostic Test in children with asymptomatic malaria in the Mount Cameroon area and obtained 85.33%, 95.05% and 91.40% for sensitivity, specificity and accuracy respectively. They also noted that sensitivity and specificity increased with increase parasitaemia. It was concluded that the Hexagon Combi™ Rapid Diagnostic Test can be used in mass surveillance programmes. Teh *et al*. (2019) investigated the concurrence of CareStart™ Malaria HRP2 RDT with microscopy in a population screening for *Plasmodium falciparum* infection in the same area. Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and accuracy were 82.4%, 76.6%, 57.4%, 91.9% and 78.2%, respectively. Sensitivity depended on parasitaemia and reached 96.1% at densities ≥200 parasites/μL of blood. The overall concurrence of CareStart™ Malaria HRP2 pf Ag RDT with microscopy in the detection of *P. falciparum* infection was moderate and most useful at parasitaemia ≥200 parasites/μL of blood. The conclusion drawn from this study was that the RDT could be effective as a diagnostic test for confirmation of clinical cases of malaria, but its applications in population screening with a higher proportion of asymptomatic cases are limited. Moyeh *et al*. (2019) compared the accuracy of four malaria diagnostic methods in a high transmission setting in coastal Cameroon and observed that SD Bioline can be an addition to or alternative to light microscopy in the diagnosis of malaria in the South West Region of Cameroon. With a diagnostic sensitivity that is above 90% as required for confident diagnosis of malaria, SD Bioline could replace light microscopy in remote areas with difficult access to reagents and electricity. Apinjoh *et al*. (2021) evaluated and compared the diagnostic performance of a PfHRP2/pLDH-based malaria rapid diagnostic test (mRDT) on patients' blood, saliva and urine relative to conventional light microscopy and nested PCR at outpatient clinics in the Buea and Tiko Health Districts of southwestern Cameroon. The sensitivity and specificity of presumptive diagnosis, light microscopy and mRDT on blood, saliva and urine were 86.9% and 19.7%, 77.8% and 96.1%, 75.8% and 96.6%, 74.5% and 93.1%, and 70.7% and 81.8%, respectively. They concluded that the agreement between mRDT on saliva (k = 0.696) and microscopy (k = 0.766) compared to PCR was good.

HRP2 is the most widely used antigen in mRDTs either alone or in combination with other antigens, due to its abundance, specificity for *P. falciparum* infection, and high sensitivity and thermal stability (WHO, 2012). However, large numbers of genetic deletions of *pfhrp2* and/or *pfhrp3* genes in natural populations of *P. falciparum* have been reported in parasite populations in Peru and subsequently in many countries including Africa (Gamboa *et al*, 2010; Maltha *et al.,* 2012; Koita *et al*., 2012; Berhane *et al*., 2018).

In Africa, where malaria is endemic and the use of RDTs is widespread, there is scarce information on *pfhrp2/3* deletions, although a few surveillance studies have reported on their existence. Systematic reviews by Agaba *et al*., in 2019 (Figure 1), and Kojom and Singh in 2020 provided unequivocal evidence of the existence and occurrence of *pfhrp2* and *pfhrp3* gene deletion.

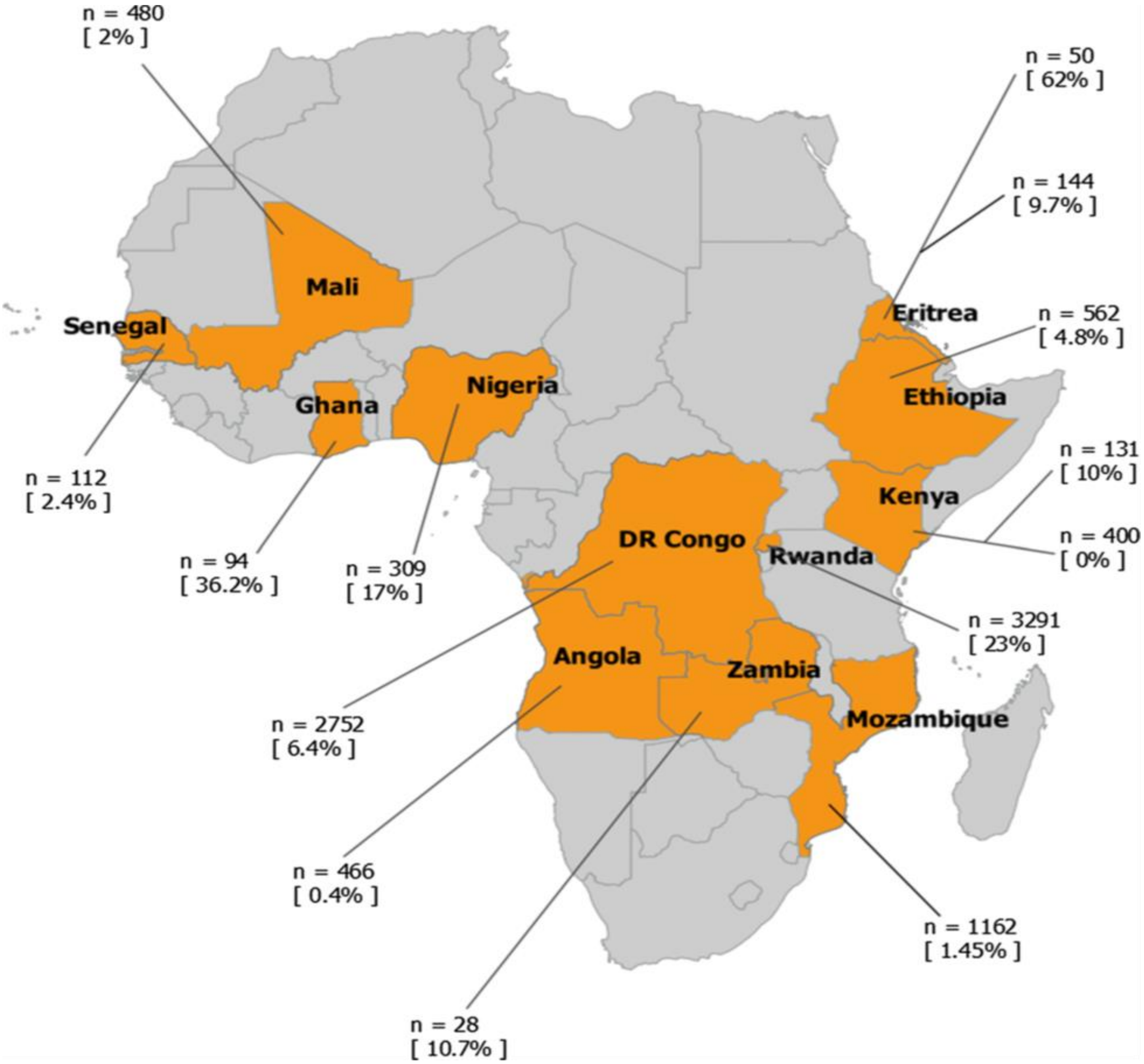

Figure 1: Distribution of *pfhrp2/3* gene deletion across Africa (Agaba *et al*., 2019)

So far, there are no data available for *pfhrp2* and *pfhrp3* gene deletion in Cameroon. Determining the existence and prevalence of deletion is crucial for accurate malaria diagnosis which may help in curbing the disease. Esum *et al*. (*in press*) recently concluded an investigation on this phenomenon in febrile patients in Buea and Limbe Health Districts of the South West Region and may provide the first evidence of *pfhrp/pfhrp3* gene deletions in the region and Cameroon.

Prevention and Control

The main strategies for malaria prevention in Cameroon are intermittent preventive treatment (IPT) for pregnant women and vector control through the use of LLINS, especially for pregnant women and under-five children (Ntonifor & Veyufambom, 2016). The WHO in 2004 recommended a package of intermittent preventive treatment in pregnancy (IPTp) with sulfadoxine-pyrimethamine (SP) and use of insecticide-treated nets (ITNs), together with effective case management of clinical malaria and anaemia. During the period 2010–2017, 1.45 billion artemisinin-based combination therapy (ACT) treatment courses were delivered by NMPs, of which 1.42 billion (98%) were in the WHO African Region.

In Cameroon, this policy was adopted and implemented by the Ministry of Public Health in 2004 immediately after WHO recommendations and consisted of at least three free SP doses between the 16th and the 36th weeks of pregnancy alongside the use of ITNs. These interventions are commonly delivered in antenatal clinics (ANC) through the collaboration between malaria and reproductive health programmes (World Malaria Report, 2015). According to the World Malaria Report in 2011, in most malaria endemic countries in Africa, 40 % of pregnant women sleep under ITNs. In Cameroon, data on coverage on malaria control interventions show that only 13.1 % of children belowr five years sleep under insecticide-treated mosquito nets, 37% of pregnant women receive the second dose of Sulfadoxine-Pyrimethamine and only 58% of complicated cases of malaria are promptly and properly managed. In a recent study in Obala Health District (Cameroon Coalition Against Malaria: Obala Malaria Campaign Baseline Survey, Feb 2010), the coverage was as follows: 15.1% for ACTs, 41% for LLINs, 67% for IPT2.

Treatment and Case Management

WHO recommends artemisinin-based combination therapies (ACTs) for the treatment of uncomplicated malaria caused by *P. falciparum* (WHO, 2015). By combining two active ingredients with different mechanisms of action, ACTs are the most effective antimalarial medicines available today. WHO currently recommends five ACTs for use against *P. falciparum* malaria. The choice of ACT should be based on the results of therapeutic efficacy studies against local strains of the parasite.

The Cameroon government launched the policy of free malaria treatment which was adopted in Cameroon in 2011 and 2014, for the treatment of simple and severe malaria respectively (MINSANTE,PNLP, 2014; Sieleunou *et al*., 2015). The free malaria treatment is a package that includes subsidized diagnosis of malaria and treatment for under five children and pregnant women for severe and simple malaria provided in all health facilities (Khun *et al*., 2008; O'Meara *et al*., 2010; MINSANTE, PNLP, 2014; Sieleunou *et al*., 2015).

After the introduction of the malaria prevention and control policy in Cameroon, few studies in the South West region have evaluated the effectiveness of the measures adopted. Fokam *et al*. (2016) assessed the usage and effectiveness of intermittent preventive treatment and insecticide-treated nets on the indicators of malaria among pregnant women attending antenatal care in the Buea Health District. They reported coverage of ITN as 32.4 % while that of ITPp was 63.2 %. Malaria prevalence was least (7.2 %) amongst women using both IPTp- SP and ITN, while those with no intervention had the highest malaria prevalence of 18.6 %, and concluded that repeated doses of SP in combination with ITN use are effective in reducing malaria parasitaemia and improving haemoglobin level of pregnant women. Kimbi *et al*. (2012) assessed the efficacy and tolerability of Malartin and Sulphadoxine-Pyrimethamine combination against uncomplicated falciparum malaria in Dibanda, south west Cameroon. They administered malartin for 3 days and SP as a single dose on day 0 and observed an overall success rate of 92.53% of the drug combination. The prevalence of anaemia decreased from 22.99% at enrolment to 9.77% on day 14. The study concluded that malartin and SP are effective and safe against uncomplicated falciparum malaria and suggested that this drug combination is a better alternative for the patients that react to malartin/amodiaquine combination in Cameroon.

Anchang-Kimbi *et al*. (2020) evaluated the coverage and effectiveness of intermittent preventive treatment in pregnancy with sulfadoxine–pyrimethamine (IPTp-SP) on adverse pregnancy outcomes in the Mount Cameroon area, South West Cameroon. The prevalence of falciparum malaria was 18.5% where uptake of SP was ≥ 3 doses and three or more dosing was associated with increased falciparum malaria density notably among women from semi-urban areas. The prevalence of low birth weight infants was 7.3% and was generally observed in anaemic and semi-rural women. They concluded that, reported uptake of IPTp with ≥ 3 SP doses in the Mount Cameroon area did not provide observable prophylactic benefits and suggested that SP resistance efficacy studies are necessary.

The Demographic Health Survey of 2018 (DHS Report, 2018) reported that the household population of the South West Region with access to ITN was 46%.

Drug Resistance

Since early 60s the sensitivity of the plasmodium parasites to chloroquine, the best and most widely used drug for treating malaria, has been on the decline. Newer antimalarials were discovered in an effort to tackle this problem, but all these drugs are either expensive or have undesirable side effects. Moreover after a variable length of time, the parasites, especially the falciparum species, have started showing resistance to these drugs also. The Asia Pacific region has traditionally been the focus of resistance to antimalarial drugs and now we have artemisinin resistance primarily on the Thai-Cambodian border. (WHO :Drug Resistance.http://www.who.int/tdr/research/progress9900/methods/malaria-resistance.htm: Accessed December10, 2021) If it is not contained, it can have global implications and the most serious effect would be in Africa which has a high disease burden and the highest mortality rates. The best way to prolong the use of the drug would be to use it in combination with other anti-malarial drugs (Whegang *et al*., 2010).

In Cameroon, resistance to anti-malarial drugs has been reported (David et al., 2009). Chloroquine, which was most accessible and used as the first line treatment for uncomplicated malaria, developed resistance, which was depicted for the first time in 1985 in the Limbe Township of the South West Region and later in other localities in the country with high rates of therapeutic failures observed. Confronted with this situation, other molecules (Amodiaquine, Sulfadoxine - pyrimethamine as well as more recent artemisinine associated therapies) were proposed for use in chloroquine resistant areas (Whegang *et al*., 2010). However, therapeutic failures to Artemisinine Combination Therapies (ACT) are now being registered in some towns in Cameroon including Limbe, where a therapeutic failure rate of 14% related to combination of Atesunuate and amodiaquine + sulfadoxine-pyrimethamine was reported between 2004 and 2006 (NMCP Strategic Plan, 2007 - 2010).

Moyeh *et al*. (2018) investigated the effects of Drug Policy Changes on evolution of molecular markers of *Plasmodium falciparum* resistance to chloroquine, amodiaquine, and sulphadoxine-pyrimethamine in the South West Region of Cameroon. They reported that the Pfcrt 76T mutation was observed in 91.7% (211/230) of samples while the mutant 86Y, 184F, and 1246Y of the Pfmdr1 gene were observed in 58.8% (133/226), 82.1% (183/223),and1.3% (3/226), respectively. The study showed that the evolution of treatment policies in Cameroon had led to the gradual return of the sensitive genotype of the 4-aminoquinoline resistance markers. The gradual return to the CQ-sensitive genotype showed that return to its clinical efficacy can be anticipated as was the case in Malawi.

Insecticide Resistance

The prevention of malaria in Cameroon is based essentially on vector control through use of Insecticide Treated Mosquito Nets (ITN) and Indoor Residual Spray (IRS) (David *et al*., 2009). The efficacy of IRS and ITNs depends, among other things, on the proportion of vectors resting on the sprayed surface and the susceptibility of the vectors to the insecticide used. It is therefore important to monitor development and extent of insecticide resistance in the particular vector population. A number of insecticide sensitivity studies have been carried out by the NMCP as well by other research institutions in different parts of the country. The results derived through these studies show that there is optimum sensitivity of *An. gambiae s. I.* to carbamates and organophosphates. However, *An. gambiae* is more resistant to DDT than is *An. arabiensis* in the tropical zone. No vector resistance, what so ever, has been noticed in Maga and Tiko for all insecticides tested. (NMCP Strategic Plan, 2007 – 2010)

Boussougou-Sambe *et al.* (2018) investigated the insecticide susceptibility status of *Anopheles gambiae* (*s.l.*) in South-West Cameroon four years after long-lasting insecticidal net mass distribution. Two species of the *An. gambiae* (*s.l.*) complex, *An. coluzzii* and *An. gambiae* (*s.s.*) were identified in all three study locations with high proportions of *An. coluzzii* in Limbe (84.06%) and Tiko (92.2%), while in Buea, *An. coluzzii* (55.6%) and *An. gambiae* (*s.s*.) (44.4%) occurred almost in the same proportions. Tested samples were found resistant to pyrethroids (deltamethrin and permethrin) in all locations (< 90% mortality), with > 3-fold increase of KDT50 values compared with the Kisumu susceptible reference strain of *An. gambiae* (*s.s*.). However, the mosquito populations from Limbe and Buea were fully susceptible to malathion. The L1014F kdr was found in both *An. coluzzii* and *An. gambiae* (*s.s*.) with the highest frequencies found in *An. gambiae* (*s.l.*) populations from Tiko (94%) and Buea (90%) compared with the Limbe population (66%). No kdr L1014S was observed in analyzed samples. Their findings indicate ongoing development of *An. gambiae* (*s.l.*) resistance to pyrethroids used in impregnating LLINs and suggest the use of malathion as an alternative insecticide for IRS in complementarity with LLINs.

Conclusion

All the studies conducted on malaria in the region over the years were sporadic in nature and no trends of malaria transmission in the region could be established. About 95% of the research on malaria in the region was conducted in the Mount Cameroon area (Fako Division) and very little is known in the other areas. It is therefore difficult to determine whether malaria control efforts will produce the desired results in the region by 2030.

Challenges

Insecurity due to the ongoing social crisis affecting the South West Region of the country may present an uncondusive environment for research and handicap accessibility to remote health districts, health areas and communities.

Environmental Sanitation is a very weak component of malaria vector control efforts in the South West Region. This warrants a change in the mentality of the population through tailored sensitization messages adapted to the socio-cultural context of the region.

Perspectives

There is need to use molecular biology techniques to identify *Plasmodium* and *Anopheles species* circulating in the region in order to adopt appropriate control strategies. A multi-disciplinary approach to design and conduct longitudinal prospective studies to monitor trends in malaria epidemiology, parasitology and entomology in the region in the next eight years is paramount. These are long-term studies carried out regularly, e.g. monthly or half-yearly, for the purpose of evaluating the impact of control measures. They provide up to date information on incidence, prevalence, morbidity and mortality rates as well as changes in vector density, infection rates, behaviour, and susceptibility of vectors to insecticides.

Quality assurance procedures and structures are needed to monitor the performance and guarantee the quality of the RDTs used in the region.

Collaborative studies are envisaged between the University of Buea and the National Malaria Control Programme and Municipal councils. Funds for these studies will be solicited from national and international bodies through competitive research grants.

Acknowledgements

We are grateful to the University of Buea SDG, Review and Technical Committees for their coordination and scientific inputs. We thank the Vice Chancellor of the University of Buea for supervising this paper.

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