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Malaria in Complex Emergencies: A Review.

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Summary
Malaria is a life threatening and communicable disease of the tropical and subtropical areas with attendant morbidity and mortality. It is associated with conflict and flourishes in conditions of crisis and population displacement such as in complex emergencies. In complex emergencies, malaria is a significant cause of death and illness. Population movement of non-immune people to endemic areas, lack of access to health care and gaps in medication supply chain and loss of human capital are factors of complex emergencies and contribute to the malaria burden. Vector control and personal protection using indoor residual spray and insecticide treated nets are effective prevention strategies aside using appropriate therapies for malaria management. Effective strategies focusing on communities in complex emergencies to reduce malaria burden can be by way of education, proper information and communication. In any case, complex emergencies deserve special attention to reduce malaria burden. This review provides understanding into complex emergencies and applicable information to reduce malaria burden.

Keywords: Malaria, Complex emergencies, control , population

Introduction

Definition of malaria

Malaria is one of the vital causes of mortality and morbidity during complex emergencies. More than 75% of the countries presently experiencing emergencies are malaria endemic. In displaced populations in Africa greater than 50% of clinical consultations and 33% of all deaths are due to malaria (Webster, 2000; Anderson *et al.,* 2011). Several reports have established that malaria-related deaths are due to anaemia and cerebral malaria.

Malaria is an acute febrile illness caused by plasmodium parasitic species which are spread to people through the bites of infected female anopheles mosquitoes and it is avoidable and curable (WHO, 2023). It is a life-threatening disease essentially found in tropical countries. With prompt diagnosis and treatment, a case of uncomplicated malaria cannot progress to an intense form of the disease which is often fatal. Malaria is not a communicable disease. Transmission is through the bites of female anopheles mosquitoes. Five species of parasites are responsible for malaria in humans and two of these species; *Plasmodium falciparum* and *Plasmodium vivax* present the greatest threat. More than 400 different species of anopheles mosquitoes and about 40 known as vector species can transmit the disease. The risk of infection is greater in some cases than others depending on numerous factors including type of local mosquitoes and may also differ according to the season, the risk being greatest during the rainy season in tropical countries (WHO, 2023).

Malaria Endemicity in Africa

About 70 million persons have been considered to be favorably displaced and 25% of these persons are found in sub-Saharan Africa. Also, a greater part of global deaths associated with malaria occur in sub-Saharan Africa and more than 33% of these are found within complex humanitarian emergency environments (Boete *et*

al., 2020). sub-Saharan Africa climate is favourable to the escalation of malaria every year with attendant deaths. One reason for these deaths is due to the *Plasmodium falciparum*, a malaria parasite that is most likely to cause life threatening illness. Four (4) countries within sub–Sahara African countries were responsible for more than 50% of malaria deaths globally in 2020. That same year, 602,000 deaths were recorded on malaria in the African continent contributing about 96% of the 627,000 malaria deaths globally. With the advent and advancement of climate change, it will be much more favorable for mosquitoes to thrive. Temperatures within certain geographical regions have increased and this becomes an ideal temperature range for malaria parasites and mosquitoes. Most of the persons who suffer malaria deaths are children under the age of five and for sub- Saharan Africa with falciparum malaria infections, the age group with the highest malaria mortality rate are children between 1 and 3 years of age (Stonely, 2023).

Malaria endemicity in Nigeria

Nigeria being a tropical country, malaria deaths and cases are prevalent among persons. Malaria is a leading cause of death and cause for public health concern with 20% mortality rate and more than three (3) episodes of malaria sickness experienced by individuals per annum. Malaria burden is high with the emergence of resistant strains. International intervention programs are not followed as appropriate. Certain individuals, government and environmental factors have been identified for the persistent burden of malaria cases and deaths. Poor living conditions, deficiency of sustainable infrastructures, low budgets to fund health structures, restricted access to medical care, national programs inconsistencies and poor oversight functions have contributed to increase in malaria disease. Political, social and economic structures of the country and unsatisfactory efforts to educate the populace are impediments to malaria control and eradication in Nigeria (Chimezie, 2020; WHO, 2022). About 68 million cases and 194,000 deaths have been attributed to the disease in 2021 according to a report by the world health organization. Nigeria's malaria burden is the highest worldwide with a 27% percentage score. There is a high risk for transmission all over the country and all year round with the northern and north-eastern parts of the country having the highest burden (WHO, 2022). A summary of the progress of malaria incidence recorded a reduction by 26% since 2000 from 413 per 1000 population in 2000 to 306 per 1000 in 2021. Prior covid- 19 pandemic, incident malaria cases was 302 per 1000 population. Other considerations are as detailed in the world health organization summary of results and country profile 2022.

Overview of complex emergencies.

Complex emergencies are situations negatively impacting large civilian population involving war or civil strife and population displacement with greater mortality and morbidity (USCR, 2000). Of the greater than 35 million people who are displaced from their homes globally, 14 million of these are refugees while 21 million are internally displaced persons (IDP). Complex emergencies progress from the acute to the post-emergency phase (WHO, 2000). The acute phase may be defined as the period where the basic mortality rate is greater than one death per 10,000 per day. The acute phase is characterized by a number of events: population displacement internally (internally displaced persons - IDP) or trans border (refugee) but may affect a stable population or an ethnic group, a change in local or national level authority, a disintegration in infrastructure (health, logistics), diminished and weakened access to food, and increased mortality. The acute phase may progress only a few months. The post-emergency phase commences when mortality rates return to the level of the surrounding population and basic needs are satisfied. Populations disturbed by armed conflict often experience severe public health outcomes due to population displacement, food shortages and crumbling of basic health services . These, therefore, give rise to the term complex humanitarian emergencies (Murray *et al.,* 2002).

Children make up more than fifty percent (50%) of the refugee population and a larger proportion of IDP (Brooks *et al*., 2017). Greater than fifty percent (50%) of world's countries (96 out of 191) are negatively impacted by population displacement giving rise or played host to refugees and /or IDPs. Large portions of this

displacement have been from African countries with Sudan alone accounting for one- ninth of the world's displaced (Elagali *et al*., 2022). The current conflict in Sudan will undoubtedly increase the statistics.

Importance of studying malaria in complex emergencies

Malaria disease can increase rapidly and easily in complex emergencies within short durations. Therefore, the need to deploy control requirements and human resources and experience may be necessary. These will enhance good surveillance activity, increase preventive measures, obtain effective antimalarial drug, provide information to health authorities within the area of conflict and properly and effectively reactivating epidemic preparedness and response committee. The response mechanisms will depend on the extent to which the epidemic is detected but should aim at minimizing transmission and mortality by appropriate treatment of those who are infected and preventing new infections and vector control programs. For surveillance purposes, this will include appropriate legislation for surveillance, surveillance strategy, implementers and stakeholders' network and successful partnerships. These will therefore strengthen and increase case detection, registration and confirmation. It will also strengthen and increase reporting, data examination, analysis and interpretation, epidemic preparedness, response and control feedback.

Malaria transmission in complex emergencies

Human population movement and malaria transmission

Human population is about people and human population movement contribute to malaria mortality and morbidity during complex emergencies. As stated by Martens and Hall (2000), people move for a number of reasons including environmental deterioration, economic needs and necessity, armed conflicts and natural disasters. These factors most likely would negatively impact the poor. Identifying and understanding the influence of these population movements can improve prevention measures and malaria control programs during complex emergencies. At the present time, nearly half of the world has eliminated malaria and eradication is envisioned. Eradicating malaria has been unsuccessful in the past fifty (50) years with human population movement cited as one of the significant reasons (Tam *et al.,* 2021). Often the most immediate conspicuous factor is movement of non- immune populations from areas of no malaria transmission or low transmission to highly endemic areas (Webster, 2000). Children below 5 years and pregnant women are continuously at risk of clinical disease. When non- immune populations move to these highly endemic areas, all age classes will be at risk of malaria and there will be comparatively high proportion of cases of severe malaria (Webster, 2000). The Rwandan genocide experience is exemplary as many of the refugees on their way to the camps had to pass through highly endemic jungle areas.

Factors contributing to malaria outbreaks in complex emergencies

Transmission intensity, periodicity and geographical distribution of malaria are affected by environmental factors (Castro, 2017). These with the human, vector and parasite make up the malaria system and this triad interacting with the environment produce a variety of local patterns of malaria transmission giving rise to specific and different definitions such as forest malaria, urban malaria and frontier malaria. However, factors may be fluid but could transform and adapt to pressure or new local conditions bringing about new difficulties for malaria control. Environmental factors are in two categories, the natural and human made environment. Climate based factors, temperature and precipitation are the essential environmental determinants of malaria in the natural environment with temperature influencing vector and parasite development and thus a limitation on geographical suitability to malaria. Human made transformations of the natural environment serve many major usefulness and could result in the decrease or increase in malaria transmissions. Development projects such as population resettlement lead to social and environmental impacts with a resultant negative effect on physical, mental and social wellbeing of the people. Housing quality may also play a crucial role in the human made environment and to a great extent offers a barrier against the malaria vector (Castro, 2017). In the years gone by, reference standard used to reporting malaria

transmission intensity is the entomological inoculation rate (EIR). This defines the number of infectious bites for a person per year (Pothin *et al*., 2016). The sporozoites rate is estimated by catching mosquitoes usually using light traps and dissecting it to determine the rate. This procedure is costly, lacks precision and it is time consuming particularly in low endemic areas. The alternative requirement to the entomological inoculation rate is the parasite prevalence (PrP) and could be done using microscopy which is the gold standard in malaria diagnostics, rapid diagnostic test or nucleic acid determination method to detect infection in the individual (Pothin *et al*., 2016). Seasonal variations, the peak and trough may affect the parasite prevalence estimations. An estimated 30% variation rate between the peak and trough has been reported in elevated seasonal areas in west Africa (Oduro *et al*., 2013; Pothin *et al*., 2016). This rate is disturbed by antimalarial therapy status, availability of skilled human capital for microscopy and nucleic acid determination method and the lack of specificity in low endemic areas.

Serological data are also utilized for reporting malaria transmission intensity. It is an antibody and antigen reaction. It is an alternative method to evaluate malaria infection in retrospect and this was properly deployed during the global malaria eradication program and after to keep track of changes in transmission (Voller and Bruce –Chwatt, 1968; Bruce –Chwatt *et al*., 1973; Ambroise –thomas *et al*., 1976; Voller *et al*., 1980; Voller and Drapper, 1982). Enzyme linked immunosorbent assay (ELISA) , a type of serological assay is quick , simple and inexpensive to deploy. In any case, the serological procedure has a limitation which is to distinguish between seropositives and seronegatives. Sera from European volunteers are utilized to fix a cut-off.

Periodicity of weather and climate are essentially significant factors in the life cycle of the parasite and the vector mosquitoes involved in transmission (Ibrahim and Denes, 2021). The roles of temperature changes have been explained by Mordecai *et al*. (2013) in the spread of malaria. Several other works have also analyzed the effect of weather on mosquito populations and the transmission of malaria (Mordecai *et al*., 2013; Ibrahim and Denes, 2021).

A study by Millogo (2022) identified geographical variables affecting malaria transmission to include annual temperature, vegetation density, percentage of clay soil, total amount of rainfall and distance from nearest body water. Correlating the findings, higher vegetation is linked with lower malaria transmission and higher temperature is linked with low prevalence of malaria. High rainfall is linked with lower malaria transmission and larger distances from bodies of water is linked with lower malaria prevalence.

Challenges in controlling malaria in complex emergencies.

Access to health care

Access to health care involves assisting populations command relevant health care resources for the improvement and preservation of their health (Gulliford *et al.*, 2002). Diagnosis, treatment and management of diseases are critical elements in providing access to health care. Not having access to health care is a public policy concern. Many barriers have continually prevented persons from having access to health and one of such is attributable to complex emergencies. Therefore, access to health care by the refugees and host population will be reduced (Webster, 2000). The likely reason being that available health services department are overwhelmed by the large number of persons. Recently in Sudan, since fighting began April 15, 2023, the violence has impacted health workers, hospitals, ambulances and patients. In the least, 13 hospitals in Khartoum became dysfunctional and those that are operating are running low on supplies and struggling with utilities (Hemmeda *et al.,* 2023).

It has also been reported by Webster (2000) that an estimated 500,000 and 800,000 Rwandans fled to the North Kivu region of the democratic republic of Congo (DRC). The response capacity by local and international agencies was inadequate to deal with the number of people arriving within a short period and death rates were high (34 – 54 deaths per 10, 000 per day). Similar findings were reported in Angola, and this impacted negatively on the already weakened health services, thereby increasing the exposure and negative outcome of these population inclusive of IDP. It is worthy of note

that health services are a critical component of any population activity and reduction during emergencies may be due to destruction of these facilities. Health services are also symbol of state and are likely targets for destruction during armed conflicts and such were the case during the Congo –Brazzaville war 1998 to 1999. In Sierra-Leone, greater than fifty (50%) percent of first level contact health or community health units were non- functional due to armed conflicts. Other possible causes of health facilities not functioning are lack of staff, drugs, equipment, critical supplies and gaps in the medication supply chain. Human capital is also adversely affected.in emergency situations due to staff being among the displaced populations. Patient outcome inevitably becomes bad with children also missing out on important malaria drugs. These concerns therefore negatively affect malaria control in emergencies including vector control programs which can lead to an increase in vector numbers (Webster, 2000). Even when there are opportunities for treatment, rising malaria cases among the displaced population can be overwhelming.

Sundry challenges

Implementing an improved malaria control program requires coordination, communication and organization due to the number of agencies involved, the instability surrounding change of emergency situations, the lean consensus often seen among agencies regarding a plan of action for malaria control, and the absence of a single clearly identified organizing agency or committee to lead the effort (Williams and Bloland, 2003). However, these may be lacking in managing malaria in complex emergencies.

Impact of malaria in complex emergencies

The impact of malaria in complex emergencies is huge. The consequences have implications for health, economic and social significance. Access to water, sanitation and hygiene are inadequate in complex emergencies alongside poor drainage and waste management mechanisms. These lead to increased levels of vector population and increased malaria transmission (Messenger *et al.*, 2023). The diminished, disrupted, and overburdened national malaria control programs and health services lead to reduced access to treatment and control measures, with poor health outcomes made worse by associated infectious diseases, malnutrition, security concerns, anaemia and trauma. In any case, the prime concern for malaria control should be prompt, efficient and effective diagnosis and treatment. These will lead to good health outcomes. The value of malaria can be measured by lives lost, ill health with associated fever, and in economic terms. Money spent on managing malaria, the loss of wages, school absenteeism, and loss of man hours caring for sick persons, build on at the personal level. The public sector is equally affected as large expenditures are made on malaria management. On the macroeconomic level, substantial national burden of malaria dampens economic development extensively (Gelband *et al*., 2004).

Malaria control strategies in complex emergencies

During emergencies, a vital priority is to prevent as many deaths as possible. Hence, access to quick, early and effective diagnosis and treatment becomes necessary and an essential part of malaria control. Malaria as a disease does not segregate or treat persons differently based on political or military associations (Ahmed *et al*., 2021). In complex emergencies, humanitarian aids and health care services are inaccessible in unprotected or defenseless environments. This impacts the vulnerable especially children accessing health services. Control and prevention strategies includes vector control , chemo prevention , health education and promotion while treatment strategies include case management, mass drug administration and integrated community case management. As identified in the roll back malaria program control strategies, major attributes are a commencing analysis and evaluation, which gives priority local concerns and capabilities. Other key considerations are in disease management, prevention and surveillance and response to an epidemic. It also presents the issue of training and the roles played by policy makers, health program officers and clinical experts in handling emergency needs inclusive of future needs.

As for treatment, expectations are that resistance of plasmodium species to antimalarials will be heightened as a result of treatment of symptomatic malaria becoming reduced effectively. It should be stated during complex emergencies, with local health

infrastructures destroyed, malaria diagnosis and therapy, promoted and provided by non-governmental organization (NGO) and other associated agencies such as UNICEF and UNHCR. When and where valid reasonings arise for not adopting the nationally approved guidelines of treatment, agencies should collaborate with the supervising ministry of health as much as possible and with each other to determine on the most standard treatment policy guidelines for the affected persons (Webster, 2000). Reasons that have been adduced for this approach is to avoid confusions of both health providers and patients for optimum therapy and drug compliance. Debates have been put forward for changing drug policy in complex emergencies in regions of known drug resistance. In any case, national authorities recommend first line treatment for uncomplicated malaria. Chemoprophylaxis in complex emergencies as documented should be available to pregnant women, special teams such as the military, and technical staff. Medicines in this category are chloroquine, mefloquine, doxycycline, pyrimethamine and associated drugs (WHO, 2000).

In Nigeria, so far the approved initial and important antimalaria medicine for uncomplicated malaria cases is artemisinin based combination therapy (ACT). This is because of the invariable remarkable resistance to single drugs or monotherapies when utilized for malaria treatment, hence the adoption of the artemisinin-based combination therapy. The ACT should be able to resist varying surrounding conditions in the country's distribution value chain and should be provided with appropriate length of time for use. As an example, capsules and tablets have a durable shelf life in the current ambient temperature and humidity than mixtures, elixir and syrups. Besides, the Nigeria national emergency management agency (NEMA) is equipped to handle national emergency response program. Therefore, malaria emergencies will be mainstreamed in the process of planning and response in order to address current inadequacies as it were (National Malaria Policy, 2014).

During complex emergencies, quick and early access to accurate diagnosis of malaria following presentation of symptoms is principal to effective and reasonable treatment. Microscopy is the operational gold principle for malaria diagnostics. The reason for this is that it is cost effective, and can differentiate species, quantify the parasite load and also relevant and beneficial in the management of other disease. A well-equipped medical laboratory and presence of skilled staff are crucial for maintenance of quality microscopic diagnosis. According to WHO (2000), microscopic identifications may not be attainable in the acute phase of an emergency or where the health system is weak. If microscopic identification is not attainable, diagnosis must be dependent on clinical symptoms and knowledge of risks of malaria recognizing that this is inaccurate (WHO, 2000). The rapid diagnostic tests (RDT) depend on detecting parasite antigens or the parasite by-products. Histidine rich protein (HRP 2) based RDT that is quality assured is approved for the diagnosing malaria in all age categories. This is because of its sensitivity and stable status over a wide range of variation in surrounding temperatures.

The other concerns in malaria management in complex emergencies as described in the Sri Lankan efforts towards malaria eradication are:

1. Co-operation in disease eradication irrespective of opposing political or military interest. The reason adduced is to help sustain operations of the health care systems in conflict zones. This would ensure conflict affected individuals have access to care for malaria and also benefit from preventive plans.
2. Consolidated leadership by the federal government ensures and deepens strong national malaria policy and does not allow redundancies in the job carried out by non - governmental participants while a decentralized program activity ensures national policy guideline is adaptable to suit various challenges encountered by respective regions.
3. Non-profit / or private stakeholders can assist close up gaps in the health care systems caused by conflict as it is often seen as unbiased parties and can therefore navigate areas that may be otherwise confined (Ahmed *et al.,* 2021).

Prevention

Preventing further malaria infections is an effective and efficient control strategy in

endemic areas. Besides, it adds to the diagnosis and treatment. Vector control and personal protection methods can be used to stop further infections. Insecticide treated nets (ITN) and indoor residual spraying (IRS) are utilized to stop malaria transmission. Both interventions use insecticides to kill mosquitoes that bite and rest elsewhere. The addition of IRS to ITN may ameliorate or maximize malaria control due to the fact that two interventions can be better than one (Pryce *et al.,* 2000). Worldwide, the incidence of mosquito resistance to one insecticide exists in no less than sixty- four malaria endemic countries. In Africa, Latin America and South-east Asia, mosquito resistance concerns continue unabated. To minimize the threat, a global plan was developed in 2012 was developed by the World Health Organization (Guyant, 2015).

1). Indoor Residual spraying

The most effective method of vector control is mostly through insecticide spraying campaigns in acute emergencies (Webster, 2000). This is accomplished by indoor residual spraying of the interiors and other structures. Tents may also be sprayed if it houses refugees (Webster, 2000). In 2008, forty-four (44) countries adopted indoor residual spraying as a control strategy (WHO, 2008). IRS may ameliorate malaria control where ITN fails as a result of insecticide resistance. It has been observed IRS decreases incidents of anaemia and also decreases malaria incidence on aggregate. Few studies have compared the productive value of IRS with other methods of malaria control. Repeating IRS in chronic emergencies comes with a big budget alongside trained sprayers and tools. Before the highest transmission period, walls should be sprayed for maximum effects. For the IRS effects, a minimum of 80% of homes and barns in a given area should be sprayed(WHO, 2006). It has been noted that spray programs can be jeopardized if residents refuse spraying. Factors such as smells and stains have been identified as the reason why residents can refuse spraying. However, stains can make an easy identification for room or tents that have been sprayed. Pyrethroid insecticides have been reported to be satisfactory since no noticeable residues are found on the walls (Curtis ,2007). IRS effectiveness demands a large percentage of sprayable surfaces within each dwelling should be accessible, vectors (mosquitoes) feed and rest indoors, and identified vectors should not be resistant to the insecticides being sprayed (WHO, 2006). The majority of the insecticides approved by the World Health Organization; the length of successful action is 60 days to 180 days with DDT being more than 180 days. However, data provided on genetic, pharmacological and toxicological activity on DDT and pyrethroids insecticides have established voltage gated sodium channel as a principal target (Zhorof and Dong, 2017). Other methods of vector control that have been identified are the use of larvicides , identifying and destroying breeding sites.

2). Insecticide treated mosquito nets(ITN)

ITN is required for personal protection against malaria and a validated aspect of the roll back malaria program of the World Health Organization. Available evidence on the effectiveness of ITN in acute emergencies is absent despite being found to provide protection against malaria in numerous African countries in various trials (Webster, 2000). However, evidence exist in chronic emergencies such as in afghan refugee camps of Pakistan where ITN have been effective (Webster, 2000). A meta analysis by Messenger *et al*. (2023) reported insecticide treated nets accounted for a decrease of *Plasmodium falciparum and plasmodium vivax incidence* with increased certainty but reported a low certainty that for indoor residual spraying for *Plasmodium falciparum and Plasmodium vivax.* Tropical repellents had a moderate certainty linked with a decrease in malaria infection and a low certainty was observed using insecticide treated clothing. Long lasting insecticide treated nets (LLIN) and conventional bed nets treated with insecticides are the available ITNs. Approvals and validations by the world Health Organization advocates LLIN for use compared to ITN. The reason adduced for this is that LLIN has an effective level of insecticide for 36months (Khan and Bhutta, 2017). LLIN has been identified as a significant control strategy of applicable programs globally (Wang *et al*., 2014). In Nigeria, the type of camp site predicted the use of LLIN as reported by Ejembi *et al*. (2018). Technical and operational issues regarding

treatment of malaria has been observed and have to be addressed. Detailed coordination between agencies is vital to achieve understanding by the communities of the essence of the net and insecticide. Educational promotional activity is a necessity especially for naïve communities without experience of ITNs. Without educating the community, distributed ITNs may not be valued or used correctly.

Challenges of implementing malaria control in complex emergencies

Complex emergencies as a diverse international concern has challenges that are content specific, and this requires adaptation, practicability, quick deployment and implementing operational requirement easily (Boete, 2023). Some of the challenges that have been identified spans security, infrastructure, logistics, funding, coordination and collaboration. To mitigate these challenges, the World Health Organization alongside other integrated organizations produced an interagency field handbook for an efficient response mechanism in emergencies. The revised 2013 edition document changes in international best practices, current trends in technologies, access to new tools and edited versions to world health organization approvals (Atta *et al*., 2016). In emergencies, international fund inflow and coordination are huge and pivotal. More or less, post –conflict international assistance are inadequately addressed, especially at the early planning stage. Surveillance is no less important in specific interventions during emergencies. Affected persons with malaria should receive diagnostic and therapeutic care in post conflict period. This approach will reduce severity and deaths.

Conclusion

Complex emergencies and chronic humanitarian crisis have compounded malaria treatment and prevention programs. Access to health care and protection could improve malaria prevention and control programs. Effective strategies for malaria control in complex can be by using suitable information, proper education and communication . Efforts should be geared towards protecting children and pregnant women since they are the most vulnerable in complex emergencies.

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