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RESEARCH ARTICLE

The Role of Rural Health Centres in the Detection and Management of Malaria Outbreaks in a Low Transmission Setting of Choma District, Zambia

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ABSTRACT
The Southern Province of Zambia has been afflicted with malaria for many years, but in recent times, with the success of the national malaria control programme, malaria transmission has declined significantly and is now at low ebb. This success has been attributed to the effective use of indoor residual spraying, proper use of insecticide-treated mosquito nets provided to the people, as well as the use of artemisinin combination therapies in all rural health centres (RHCs) to treat clinical malaria cases at health facilities as well as in the communities by trained community health workers (CHWs). Despite this success and in trying to understand the epidemiology and control of malaria in rural areas of sub-Saharan Africa, it has been clear that local elimination is most unlikely due many challenges such as lack of incentives for CHWs who are the first link of the community to the health care system, inability of the officially approved rapid diagnostic tests to detect low level parasitemia in asymptomatic individuals, and anti-malaria stock-outs in RHCs, especially during the rainy season when most areas are unreachable due to impassable roads. This paper discusses the role of RHCs in the detection and management of malaria outbreaks in low transmission settings and the challenges of achieving elimination in Choma District, Southern Province, Zambia. These challenges could adversely impact malaria elimination if they remain unanswered.

List of Acronyms

IRS Indoor Residual Spraying
ACT Artemisinin Combination Therapy
RHC Rural Health Centre
MoH Ministry of Health
NMEC National Malaria Elimination Centre
RDT Rapid Diagnostic Test
MRT Macha Research Trust
SMS Short Message Service
NMESP National Malaria Elimination Strategic Plan
CHW Community Health Worker
DHIS2 District Health Information System 2
HFCA Health Facility Catchment Area
MCI Malaria Case Investigation
ICEMR International Centre of Excellence for Malaria Research
ITN Insecticide Treated Net
LLIN Long Lasting Insecticidal Net
MDA Mass Drug Administration
OPD Out-patient Department

Introduction

The Southern Province of Zambia has been afflicted with malaria for many years, but in recent times, with the success of the national malaria control programme, malaria transmission has declined significantly and is now at low ebb [1–3]. This success has been attributed to the effective use of indoor residual spraying (IRS), proper use of insecticide-treated mosquito nets provided to the people, as well as the use of artemisinin combination therapies (ACTs) in all rural health centres (RHCs) to treat clinical malaria cases. These interventions have been monitored and encouraged by the National Malaria Elimination Centre (NMEC), formerly the National Malaria Control Centre under the Ministry of Health (MoH), and embraced by the residents themselves, who see the benefits of the programmes [4]. The malaria parasite rate now stands at 0.7% in children under five years [3], although in-depth entomological research [5] has shown that several anopheles species other than *Anopheles (An.) arabiensis,* the primary vector, may be involved in malaria transmission and may alter the current transmission level. This causes concern because asymptomatic malaria does occur over the area, and it is difficult to detect because the officially approved rapid diagnostic tests (RDTs) available in the RHCs are not sufficiently sensitive to very low parasitemia [2].

Over the years, and in trying to understand the epidemiology and control of malaria in rural areas of Africa, it has been clear that local elimination is most unlikely [6,1,3] and it is best first to manage malaria in the endemic areas. This form of management needs the full attention of the MoH and has to be incorporated into the local policies. Zambia has approached this effectively by strengthening the services of local clinics, particularly the RHCs, and providing them with effective diagnostics in the form of RDTs and effective ACT drugs. The government has also set up the NMEC, which is science-based, focussed on malaria elimination, well supported, and complemented by other stakeholders [4].

Starting as a research project, the Macha Research Trust (MRT) staff requested 14 local RHCs within the Macha Mission Hospital catchment area to report weekly malaria testing results by RDT to MRT via the mobile phone Short Message Service (SMS). The weekly report included the number and age of all positive and negative results as well as anti-malaria stock levels in the facilities. This malaria reporting system was started in 2008 [7,1], and it is now a national malaria surveillance programme under the MoH [8]. The malaria surveillance system is able to capture, in near real-time, local malaria outbreaks. These data are reported weekly to the provincial and district medical officers, as well as the malaria programme officers [9]. This system enables the affected District Medical Office to look into the outbreak and, if necessary, deal with it by employing local interventional measures such as targeted IRS or focal mass drug administration in the exposed community or seeking help from the NMEC [3,10]. This process and reporting system will help keep malaria transmission at bay, reduce local transmission, and inform local management of the disease until research provides an effective and affordable vaccine [11] or other intervention [12].

Therefore, this paper discusses the role of RHCs in the detection, reporting, and management of malaria outbreaks in low transmission settings, as well as challenges for achieving elimination in Choma District, southern Zambia.

Strategic Approaches to Malaria Control and Elimination

After years of the Roll Back Malaria campaigns, which mainly focussed on malaria control and burden reduction, the Zambian MoH shifted its strategy from control to elimination by developing a multipronged approach against the disease anchored on focal malaria epidemiology, vector abundance, and malaria intervention mix in its five year National Malaria Elimination Strategic Plan (NMESP), 2017 - 2021 [4]. The goal of the NMESP was to eliminate malaria by the year 2021. This was based on stratifying the country's malaria epidemiology and intervention responses into four components, namely, A, B, C, and D. Component A,

for high malaria transmission settings, was based on ensuring universal access to malaria prevention activities, diagnosis, and treatment by enhancing and optimizing vector control as well as malaria case management. Component B, for moderate transmission settings, was focused on transforming malaria surveillance into a core intervention. This entailed increasing the sensitivity and specificity of surveillance systems to detect, characterize and monitor all local malaria cases. Community Health Workers (CHWs), members of the community who volunteered to be the first community contacts for malaria testing and detection, were trained in RDT usage and administering ACTs to RDT-positive malaria patients. The CHWs were also responsible for compiling monthly community malaria reports and sending them to NMEC. Accelerating efforts towards elimination and attainment of malaria-free status was the pillar for Component C, suited for a low transmission setting, with population-wide parasite clearance and additional or other new interventions. Lastly, Component D was for very low malaria transmission settings. This component was focused on Investigating and detecting individual malaria cases, managing foci, and following up on reported malaria cases for active screening of the surrounding households within a 140 metres radius [4,13].

Despite this multipronged approach towards ending malaria, Zambia missed its 2021 elimination target just like several other countries which experienced a resurgence in malaria cases in 2020 after earlier steady declines [14]. The country's malaria burden has remained similar to what it had been over a decade ago, with a north-to-south disease gradient such that regions in the north and north-east of Zambia experience high malaria prevalence every year with little change regardless of the interventions compared to the prevalence in the southern part of the country [15].

Community Health Workers and Challenges in Malaria Case Management

In Southern Province, a low malaria transmission setting, Community Health Workers (CHWs) are expected to play a critical role in strengthening malaria surveillance by being key community malaria testing and treatment personnel, as well as driving the implementation of targeted malaria interventions in the communities [9]. However, many challenges in the malaria elimination agenda remain. Since the CHWs are mainly volunteers, it is important to have them well equipped for effective detection and management of malaria outbreaks in view of the low parasitemia but sustained low-level transmission.

The CHWs are drawn from communities in which they have a basic understanding of the sociocultural, economic, and public health challenges. They generally can read, write, and use a mobile phone for communication. The CHWs are trusted and connected to members of the community who depend on them as the first contacts to the health care system [16]. Being volunteers in community malaria programmes, the availability of their own resources dictate the extent to which they can go in carrying out these activities. One of the key challenges is mobility. It is a daunting task for CHWs to go around villages under their care carrying out malaria programmes without proper transport. The most reliable transport to get around these rural communities is the use of bicycles and motorbikes. During the rainy season, most of the rural communities are cut off from the rest due to flooding and impassable roads. This leads to critical antimalarial commodity stock-outs amongst many CHWs. Without owning any bike, the work of CHWs becomes significantly hampered such that community malaria screening becomes almost impossible.

Most rural communities depend on farming as their main source of livelihood. Oftentimes, CHWs have to divide their time and effort between volunteering in malaria programmes and engaging in farming activities to support their families. Monthly incentives enabling them to provide basic needs for their families can help them to be more focused on fulfilling their roles as community malaria agents, especially during the farming season, which also coincides with high malaria transmission. Due to this dilemma of fulling their community obligations and cultivating their fields, most malaria cases in the community are missed or not followed up by CHWs during the rainy season.

Before becoming community malaria agents, CHWs undergo training about testing and treating malaria cases within the community and refer only those cases of complicated malaria to the nearest health facilities [17]. However, due to the voluntary nature of their jobs, CHWs easily quit and go for greener pastures when better opportunities arise. It takes a long time of learning and practice for CHWs to become effective community malaria agents [16]. The high turnover of CHWs at health facilities leaves communities more vulnerable to the malaria burden, a detriment to the elimination efforts by the government. Related to this is the effectiveness of CHWs in carrying out malaria surveillance and reporting in the communities. Any missed or misreported malaria cases give a false picture of the malaria situation in the community, especially since these data are important for devising

community malaria interventions by MoH. As cases continue to decline and elimination efforts are heightened, surveillance and ownership of malaria data become very critical for policy decision-making [18]. In the current malaria surveillance system, CHWs send monthly community malaria reports to the NMEC. These reports or data are not usually summarised into useful information for CHWs to appreciate the burden of malaria from their communities to enable them to assess how successful their efforts or interventions against the disease have been. This is exacerbated by limited resources which make it difficult to effectively meet targets and satisfy needy areas when community malaria interventions are carried out.

In the early years of the 21st Century, rural telephone connection was limited, meaning that most rural health centres were not easily connected to the health infrastructure or research centres such as the one at MRT. However, by 2008, wireless connections were available but expensive to use. At this time, scientists at MRT developed close connections with 14 rural health centres (RHCs), which were supplied with point-of-care malaria rapid diagnostic tests (RDTs) and were required to use them to test malaria prior to administering treatment. The weekly data recorded and reported by this system provided information on where and when cases were detected at operational clinics. Personnel were requested to text information each Monday with the number of cases under or over 5 years of age diagnosed as well as anti-malarial stock levels in the past week. These data were checked every quarter of the year and were found to be accurate overall, and errors detected were corrected. The RHC staffs are reimbursed for their cell phone expenses after sending the weekly malaria reports every Monday. These data are still being collected from the original 14 RHC to Macha Research Trust as local information and simultaneously sent to the NMEC database to add to the national data set in the District Health Information System 2 (DHIS2). Following a local conference that formulated a directive, the Ministry of Health inaugurated the process nationwide to all rural health centres to send weekly reports of malaria data to the NMEC. These data, collected in near-real time, have been used appropriately by the NMEC to drive the elimination agenda since April 2012.

Malaria Case Reporting and Management in Rural Health Centres

The collection of malaria data from rural health centres in Zambia now follows the MRT collection strategy described prior. Each RHC starts with reports being sent to the Malaria Data Surveillance Officer weekly. The malaria data then enables MRT or malaria programme officers from the MoH to observe weekly disease trends in near real-time and be able to detect outbreaks early enough to alert the respective RHC malaria focal point persons for possible targeted interventions. However, challenges arise when the personal mobile phones used by CHWs or RHC staff get damaged or stolen, as there are no programme-specific mobile phones provided by research projects. The other challenge stems from high CHW turnover in some facilities who find better occupations than the voluntary services they offer in reporting weekly malaria cases at both facilities and the communities. These challenges are hindrance to achieve elimination as they lead to inadequate malaria surveillance and reporting systems, resulting in several community malaria cases missing or lagging from being reported into the DHIS2.

With MRT implementing a study employing the 1-3-7 strategy in which a case is reported within a day of diagnosis, classified within three days, and interventions done within seven days, malaria transmission is expected to decrease further. This strategy is similar to the activities under component D, however, data is only collected and reported through the facilities where the research is ongoing, and the District is unable to monitor this data adequately. Mobile phones were provided to all CHWs in the study for enhanced reporting so that index cases are followed up and interventions completed within seven days of a case being diagnosed.

The Health Facility Catchment Area (HFCA), being the malaria elimination unit, lacks a robust feedback reporting system to enable the RHC to appreciate the malaria situation in their own catchments after sending the malaria data to the district and national programmes. The health centre-level malaria surveillance system is a critical component of the elimination agenda. However, most community health workers are unpaid and face many challenges ranging from very low to non-existent motivation, lack of transport which is compounded by long distances and other mobility challenges, and inadequate anti-malarial supplies. Additionally, current malaria rapid diagnostic tests (RDTs) are not sensitive enough to detect malaria parasites that are less than 100 parasites per microlitre (µm) of blood. With a constantly low malaria prevalence of about 1% in Southern Province in the last decade, there is no doubt that many malaria cases are being missed by RDT and that they have the potential to contribute to

sustaining low-level transmission whenever a potent malaria vector emerges.

Despite these difficulties, weekly malaria data collected from clinics in rural areas can provide the national malaria programme with data to identify areas of potential outbreaks. These are seen in the weekly incidence of diagnosed malaria using current on-site diagnostic equipment and observing any increase in transmission [19]. These data are currently obtained and managed by the NMEC, from which they can be accessed via the DHIS2 database.

Distribution of Malaria Cases in Choma District, the Current Reality in Zambia

Choma district had a population of 266,916 in 2022 [20], with a total of 44 health facilities inclusive of the public, private, and mission facilities. Only 14 of these facilities within the vicinity of Macha Research Trust are covered by malaria research activities, mainly in the north-western part of the district, while those in the Southern and Eastern parts entirely depend on the Ministry of Health programmes and are not covered by any malaria research programme. Of great concern are three facilities bordering Pemba and Sinazongwe districts that are proximal to Lake Kariba with a very high malaria incidence per 1000 population of 119.4 for Sikalongo, 43 for Masuku Mission, and 40 for Masuku Terminal. These three RHCs are the known malaria hotspots in Choma District in which the current malaria interventions have yielded very minimal impact.

The overall 2022 incidence of malaria for Choma District was 16.1 per 1000 population, with a 94% reporting rate (Figure 1). Of this incidence, a total of 4,104 were confirmed passive cases recorded in facility RDT registers, while 1,472 were reported by CHWs through the community RDT registers. These figures show that 35.9% of all cases in 2022 were detected at the community level by CHWs and 64.1% of cases at health facilities. These data shows that the majority of the population directly sought treatment at health facilities, bypassing CHWs in their communities. This poses a problem as more people seek malaria tests and treatment from the health facilities than the CHWs in their communities, a situation which should be reversed in order to provide health services as close to the household as possible in line with the NMESP. From the community case follow-ups, a total of 522 cases were recorded via reactive case detection by CHWs. The challenge of having a low number of active case detection is clearly evident, arising from factors discussed earlier. Efforts are continuously being made with responsive IRS on top of the scheduled interventions, which include LLNs distribution, to curb the recurring surges of cases in what are considered as malaria hot spots in the district.

The overall provincial picture of malaria incidence shows that Choma District, despite having some hotspot facilities, does not appear among the top eight districts with high incidence. With more than 60% of the health facility catchment areas (HFCAs) being in the low malaria transmission settings (Component D), there is a need to establish strong case-based surveillance systems to ensure that every confirmed case is tracked and timely interventions are done. However, the district is not yet implementing the Malaria Cases Investigation (MCI) strategy like districts within the province, and as such, chances of missing cases due to the low RDT sensitivity are high.

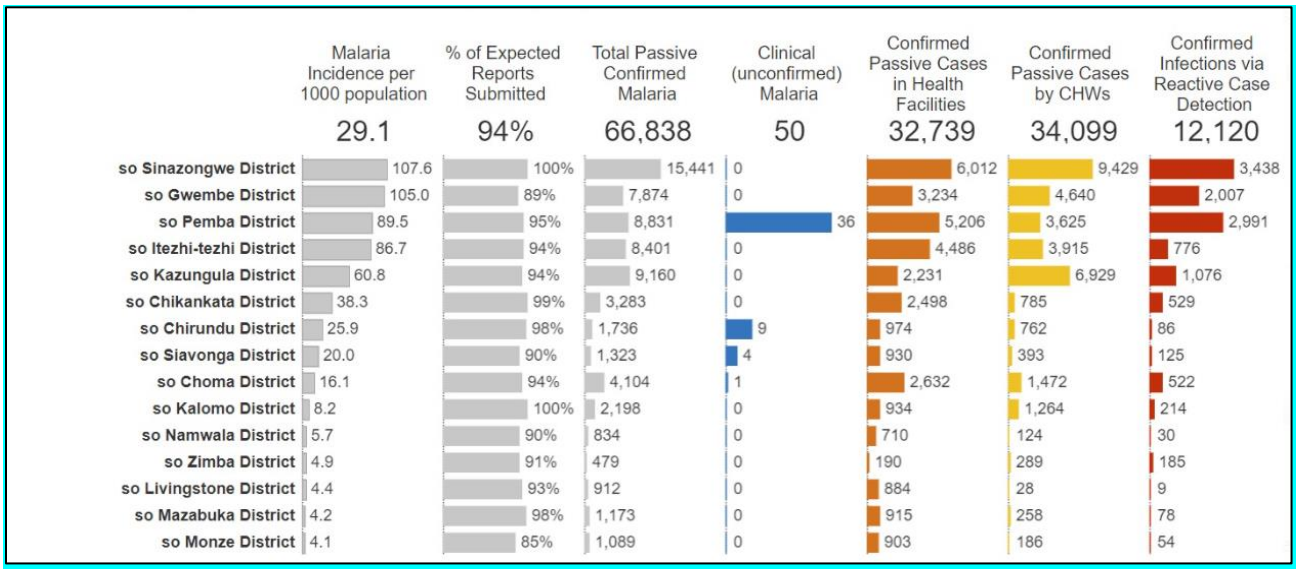

Figure 1: Southern Provincial Malaria Incidence by district, 2022 (Source: Tableau)

Entomological Surveillance in Choma District

Much of the initial entomological studies in Choma District were conducted by the Southern and Central African International Centre of Excellence for Malaria Research (ICEMR) in collaboration with the Macha Research Trust in the year 2010. At this point, the primary recognised malaria vector around the Macha Chiefdom and surrounding areas was *Anopheles (An.) arabiensis* [3]. The beginning of entomology studies by the ICEMR demonstrated that this species of mosquitoes was mainly anthropophilic and endophagic, which indicated a preference for indoor human blood feeding. Over the years and with the intensification of intervention against malaria mosquitoes, such as indoor residual spraying campaigns and ITN distribution, *An. arabiensis* has adapted its feeding and host-seeking behaviours by becoming more of an opportunistic feeder, biting both indoors on humans and outdoors on other hosts such as goats, contributing to both indoor and outdoor malaria transmission [21].

Although *An. arabiensis* is the primary malaria vector in Choma District, other secondary vectors, such as *An. squamosas* and *An. rufipes*, have been caught especially from outdoor traps, and found to have been infected with sporozoites [22,23,5]. The emergence of these secondary and understudied malaria vectors poses another challenge in realising the malaria elimination agenda in this setting due to inadequate interventions in the current IRS and long-lasting Insecticide nets (LLINs) distribution methods which do not target the exophilic and opportunistic feeders. Despite this threat from new and under-studied malaria vectors, the RHCs have been key in increasing coverage of ITN distributions during mass campaigns as well as through routine antenatal visits. In this case, additional interventions such as Mass Drug Administration (MDA) may support response in the presence of these uncommon exophagic species.

Utilisation of Malaria Data by the District Malaria Programme

Malaria data are generated at community and facility levels through routine data collection tools. This includes tests done by RDTs or microscopy where it applies. Commonly used registers include RDT and the outpatient department (OPD) from which reporting is done weekly under malaria rapid reporting and monthly through the routine health impact assessment 1 and 2, and entered into the DHIS2 system. These data are visualised in platforms such as DHIS2 and Tableau for specific institutional or individual decision-making requirements. The information can be used to generate malaria trend graphs that can help determine when and where the problem is and the extent thereof for targeted management action. At the same time, intervention efficacy can be studied based on outcomes per given periods of implementation.

The study revealed that malaria case-based surveillance has become critical for districts such as Choma that have very low transmission, with a positivity rate influenced by limitations where rapid diagnostic testing is the predominant method of confirmation. Where active reporting and robust surveillance systems are in place, there is potential to detect the lowest number of cases and determine responsive measures. Furthermore, the use of microscopic diagnosis becomes more effective where RDTs cannot detect low parasitemia. The reduced incidences in most parts of Choma can be attributed to continued IRS and active community-based interventions such as those under Component D. However, with scientific evidence of more exophilic and exophagic mosquito species, it is not clear yet the impact of these species on the overall disease burden, whereas the application of exclusive interventions such as MDA may help accelerate the reduction of population parasitaemia. Research and new scientific information remain critical in determining vector densities and species as well as transmissibility. Macha Research Trust remains the provincial and national pivot for malariology, epidemiology, and evidence-based statistics that are cardinal to timely and appropriate decisions. There is also a need to extend the MCI strategy to other HFCAs within the district with low incidence, to increase the detection index and responsive action.

Conclusion

Rural health centres have played a very critical role in detecting and managing malaria cases in Zambia. In Choma District, the use of mobile phones to report weekly malaria cases and anti-malaria stoke levels contributed to policy changes that enabled the government to adopt country-wide weekly malaria surveillance and reporting system, which now feeds into the DHIS2. These data have been the basis for monitoring malaria trends across the country and assessing the impacts of the various interventions by the NMEC as well as formulations of country-wide elimination strategies. Community health workers are a critical component to the carder of health personnel that enable the timely detection and treatment of malaria cases in rural Zambia and contribute to further interruptions of malaria transmission. However, there is a need to incorporate them into the mainstream MoH programmes with proper budgets and incentives

secured to sustain their role as first community contacts for health facility services, actualising the vision of the NMESP of bringing health services closer to the people. Therefore, CHWs, RHCs, and research institutions such as MRT play a significant role in complementing the national malaria programme in the detection and management of malaria cases and possible outbreaks, especially when robust data transmission systems are consistently in place and effective.

Competing interests

The authors declare that they have no conflicts of interest.

Authors' contributions

ML conceived and prepared the manuscript with the help of CS, and JM, CS, EM, RM, TM, LS, MM, EM, and PT contributed to developing the concepts presented in this paper and provided valuable insight during the preparation, revision and editing stages. All authors read and approved the final manuscript.

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