

Battling malaria in rural Zambia with modern technology: a qualitative study on the value of cell phones, geographical information systems, asymptomatic carriers and rapid diagnostic tests to identify, treat and control malaria

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Abstract

During the last decade much progress has been made in reducing malaria transmission in Macha, Southern Province, Zambia. Introduction of artemisinin combination therapies as well as mass screenings of asymptomatic carriers is believed to have contributed the most. When an endemic malaria situation is moving towards a non-endemic situation the resident population loses acquired immunity and therefore active case detection and efficient surveillance is crucial to prevent epidemic outbreaks. Our purpose was to evaluate the impact of cell phone surveillance and geographical information systems on malaria control in Macha. Furthermore, it evaluates what screening and treatment of asymptomatic carriers and implementation of rapid diagnostic tests in rural health care has led to. Ten in-depth semi-structured interviews, field observations and data collection were performed at the Macha Research Trust and at surrounding rural health centers. This qualitative method was inspired by rapid assessment procedure. The cell phone surveillance has been easily integrated in health care, and its integration with Geographical Information Systems has provided the ability to follow malaria transmission on a weekly basis. In addition, active case detection of asymptomatic carriers has been fruitful, which is reflected in it soon being applied nationwide. Furthermore, rapid diagnostic tests have provided rural health centers with reliable malaria diagnostics, thereby decreasing excessive malaria treatments and selection for drug resistance. This report reflects the importance of asymptomatic carriers in targeting malaria elimination, as well as development of effective surveillance systems when transmission decreases. Such an approach would be cost-efficient in the long run through positive effects in reduced child mortality and relief in health care.

Introduction

In endemic countries with constant malaria exposure the population above 5 years of age gains a partial immunity. A large number of people can therefore be infected and have a low parasitemia without clinical malaria symptoms.¹⁻³ However, these people can still transfer the infection to others through an *Anopheles* vector. Since these asymptomatic carriers do not seek medical attention, they can serve as an undiscovered reservoir even during the seasonal intercessions of malaria in countries with seasonal transmission.⁴ If properly diagnosed during the dry season, the asymptomatic carriers can be treated. Thereby this malaria reservoir can possibly be eliminated when the parasite and mosquito population is scarce.^{5,6} When approaching malaria elimination an important aspect is that as transmission decreases and countries become less endemic, individuals lose acquired immunity. This changes the focus of symptomatic infections from children under the age of 5 to the population in general. Through active surveillance and early detection the risk of possible rebound effects, *i.e.* epidemic outbreaks affecting entire communities, can be decreased.^{5,7,8}

In Macha, Zambia, work began in 2003 with mass screening of the surrounding communities and treatment of all identified asymptomatic carriers. This occurred at the same time as treatment with the effective and gametocytocidal artemisinin combination therapy (ACT) was introduced. In turn, this led to a decrease of malaria cases³ (Appendix 1: Interviewees 1-3).

In 2008 the malaria situation in Macha had reached a pre-elimination phase. Therefore active case detection of asymptomatic carriers and malaria surveillance were started.⁷ The idea, based on the observation that malaria cases cluster,⁹ was that in a pre-elimination phase, screening could be made more cost effective if the homesteads of all rapid diagnostic test (RDT) confirmed cases of malaria captured by passive case detection during the dry season are selected for targeted screening. Passive case detection is here defined as malaria patients who are seeking health care and active case detection as active screening for asymptomatic carriers in targeted homesteads.^{5,7,10}

In Macha, mobile phones and RDTs have been used respectively to report data and diagnose malaria cases at rural health centers (RHC) since 2008 as a surveillance system. The RHCs involved in the cell phone surveillance are seen on the map (Figure 1). Briefly, staff members at each RHC weekly send a text message with the number of RDT confirmed cases of malaria that week.⁵

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Geographical information systems (GIS) is then used mapping reported malaria cases with geographical features such as altitude and water existence through satellite imaging. On-site factors such as humidity, temperature, wind direction and force are also included to better understand malaria transmission.¹¹ By comparing the GIS-map with local malaria interventions and data on malaria transmission it can be used to help target measures. It can also clarify which interventions that have proven helpful and which geographical areas that have high risk of malaria transmission.^{4,5,11} Hence, the arrival of RDTs and the use of mobile phones to report cases of malaria has created a cost effective method to properly diagnose malaria with RDTs, better distribute interventions through the epidemiological data from the mobile phone reports and thereby prevent malaria outbreaks at the district level.^{5,7,8,12-15}

By using only clinical examination it can be hard to differentiate malaria from other forms of fever diseases.¹⁶ In rural areas in Zambia other diagnostics such as direct microscopy and polymerase chain reaction (PCR) are diffi-

cult to obtain. These are also time consuming, expensive and require technical expertise. Therefore, the advent of RDT has revolutionized the ability to more accurately diagnosing malaria in rural health centers. Luckily they also require little training and can easily be used in addition to the clinical examination. The RDTs in use in Zambia (ICT®) (IC Diagnostics, Cape Town, South Africa) have a high sensitivity for *P. falciparum* but are less sensitive than PCR to low degrees of parasitemia.^{7,17,18}

This study evaluates the impact of cell phone surveillance and GIS on malaria control. In addition it reflects on the importance of screening and treatment of asymptomatic carriers and what the arrival of RDTs in health care has led to in Macha, Zambia.

Materials and Methods

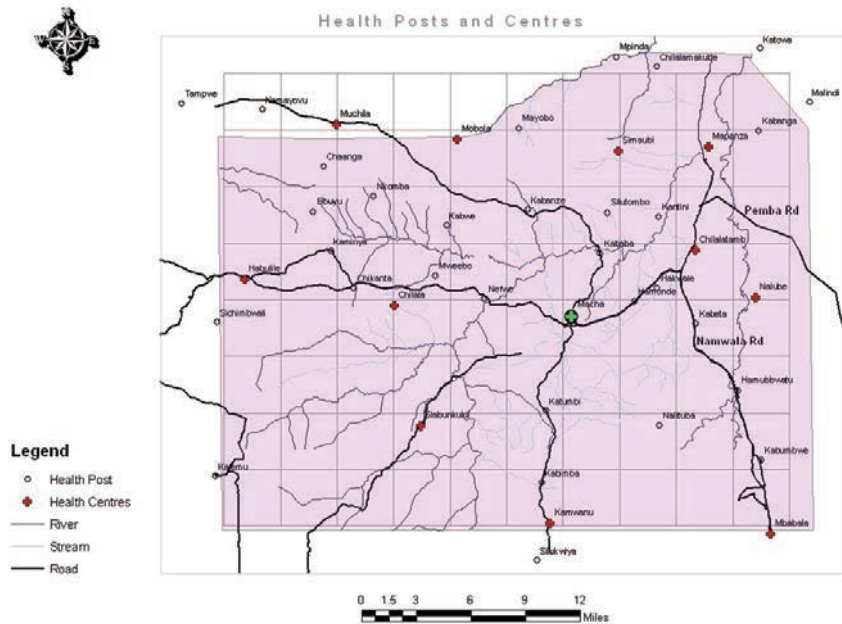
Our report is built on information gathered at the Macha Research Trust and surrounding RHCs in Choma district, Zambia. The majority of the people here live in homesteads, a group of buildings located in proximity to the family's farmland. Some homesteads are close together while others are isolated. This region experiences highly seasonal transmission of *P. falciparum*, with peak transmission occurring during the rainy season from November through May. The information gathered was obtained through field observations and semi-structured interviews with staff at different levels involved in the cell phone surveillance and the screening for asymptomatic carriers.

Qualitative methodology

In our analysis of the work done at Macha Research Trust we used in-depth interviews, data collection and unstructured observations while participating in field work. In addition we analyzed changes seen in malaria case history in Choma District, Zambia. This method was inspired by rapid assessment procedure as presented by Utarini *et al.*^{19,20}

Personal communication

Ten semi-structured in-depth interviews were performed at RHCs in Chilala, Chilalantambo, Chitongo, Habulile, Mapanza, Nalube, Sianbunkululu and at the Molecular Research Lab at Macha Research Trust. These were based upon seven main topics as seen in Appendix 3. We used a mixture of open, closed, and hypothetical questions in order to get both qualitative and quantitative data. These topics were chosen to highlight the results achieved or not achieved. They were further complemented by related questions in order to obtain general information on malaria treatment in



Prepared by: The Malaria Institute at Macha

Figure 1. Map showing Health Posts and Health Centres in the Macha Region in the Southern Province of Zambia involved in the cell phone surveillance. Permission for image reproduction retrieved from Macha Research Trust.

Confirmed Malaria cases compared to other diagnoses at the Pediatric Ward at Macha Mission Hospital

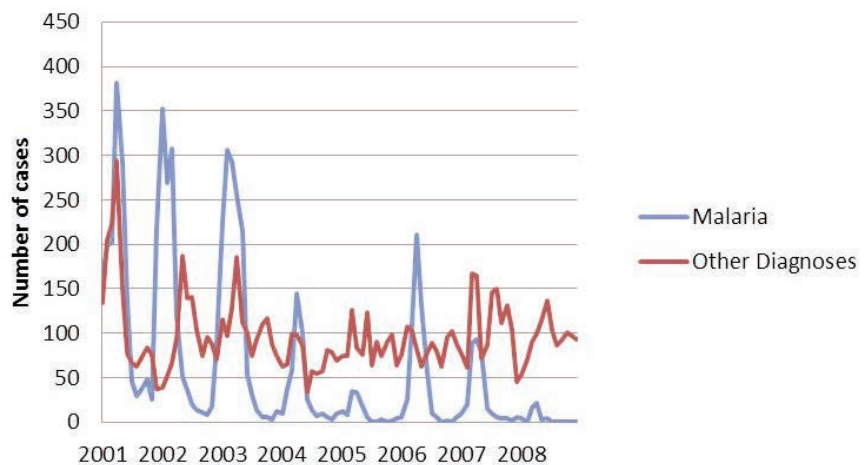


Figure 2. Monthly amount of confirmed malaria cases compared to all other diagnoses at the Pediatric Ward at Macha Mission Hospital, Choma District, Zambia, from 2001 until 2008.

the region. We decided to record our interviews, which provided us with the opportunity to listen through the interviews several times. Informed consent was acquired from all interviewees and all contacted chose to participate. All interviews were performed between April 28th and May 6th 2011.

To cover all aspects of the project we chose interviewees at both Macha Research Trust and at the RHCs. At Macha Research Trust we decided to interview Interviewee 1 and Interviewee 2, those in charge of the cell phone surveillance and screening for asymptomatic carriers, as well as Interviewee 3, senior scientific advisor at Macha Research Trust. At the RHCs we interviewed those in charge of the cell phone reports. This was undertaken to recognize differences in opinions at different levels of the organization.

Data analysis

Answers in our interviews were stratified according to topic and summarized. The answers regarding the local malaria situation were then cross referenced with data collected from the cell phone surveillance, screening of asymptomatic carriers and Macha Mission Hospital. We chose the most consistent data for our analysis, *i.e.* RHCs with the least stock-outs of RDT, the least absence of reports and with data solely involving properly diagnosed malaria cases, meaning cases that were diagnosed through RDT, microscopy or PCR. Data from the Pediatrics ward at Macha Mission Hospital were chosen because it exclusively contains proper diagnoses. Data concerning malaria in Zambia were retrieved from the latest WHO-publications.¹⁷

Results

At the Pediatrics ward at Macha Mission Hospital malaria cases have decreased by 97% between 2001-2008, as seen in Figure 2. The dip from 2003-2005 is related to the introduction of ACT in 2003 and the spike in 2006 is related to a national stock out of ACT (Appendix 1: Interviewees 2,3). If interventions nationally would continue to upscale and malaria on a national level would decrease, the perception is that nationwide cell phone surveillance and active case detection possibly could lead to malaria elimination in Zambia (Appendix 1: Interviewees 1,2).

Since the start of the cell phone surveillance and screening for asymptomatic carriers through active case detection in 2008, 7 out of 8 contacted rural health centers in the Macha region have seen a reduction in malaria cases (Figure 3). This has also been accompanied by local decreases in malaria mortality, especially among children under 5 years of age (Chilala,

Chilalantambo, Habulile, Mapanza, Nalube, Sianbunkululu, Appendix 1: Interviewees 1-3).

The overall malaria case reduction diagnosed by RDTs and reported via cell phone surveillance in the Choma and Namwala districts surrounding Macha Hospital was 47% from 2009 to 2010, as seen in Figure 3. Rural health workers and Macha Research Trust staff accredited this reduction mainly to effective treatment with ACT and active case detection of asymptomatic carriers, even if the mosquito population also has declined spectacularly locally. Several health workers were also of the opinion that RDTs, distribution of insecticide treated nets (ITN) to pregnant women and children under 5 years of age has contributed to the decrease. Occasional stock-outs of RDT occurred at most RHCs, which have decreased the total number of reported malaria cases diagnosed through RDT during both 2009 and 2010. Clear reasons why Macha, Chilalantambo and Nalube have not followed the same pattern as the other RHCs are unidentified.

Health workers at the involved RHCs throughout the Macha area state that they have received education in the use and interpretation of RDTs. Since guidelines have been established that require positive RDT result before ACT-treatment and the RDTs themselves have demonstrated their reliability, they are now looked upon as a valuable tool to decrease excessive treatment and prevent

drug resistance (Appendix 1: Interviewee 2, Chilala, Chilalantambo, Chitongo, Habulile, Mapanza, Nalube, Sianbunkululu).

Although it is intended, the surveillance has not yet provided a significant change in distribution of resources in relation to malaria incidence (Appendix 1: Interviewee 1). Other advantages of the program to the rural health centers are that when stock-outs occurred supplies of RDTs and ACT were provided by Macha Research Trust. Advice and education on malaria as well as occasional provision of ITN have also been given during screening for asymptomatic carriers (Appendix 1: Interviewee 1). The workload at the RHCs is considered to have been relieved through the treatment of the asymptomatic carriers, thereby decreasing malaria burden. It has also shed light on the stock situation at the RHC to the District Health Offices (Appendix 1: Interviewee 2).

The staff at all contacted RHCs considers the cell phone surveillance to be very time efficient and easy to use. Therefore education of RHC workers has not been a problem (Appendix 1: Interviewees 1,2). Some minor difficulties have occurred with the surveillance system and the data collected, although they were simple in nature. These were problems such as small and extensive stock-outs of RDT and lack of reports due to change and absence of the personnel sending the data as well as possible slight data entry errors. Apart from

Annual RDT-positive cases at the Rural Health Centers 2009-2010

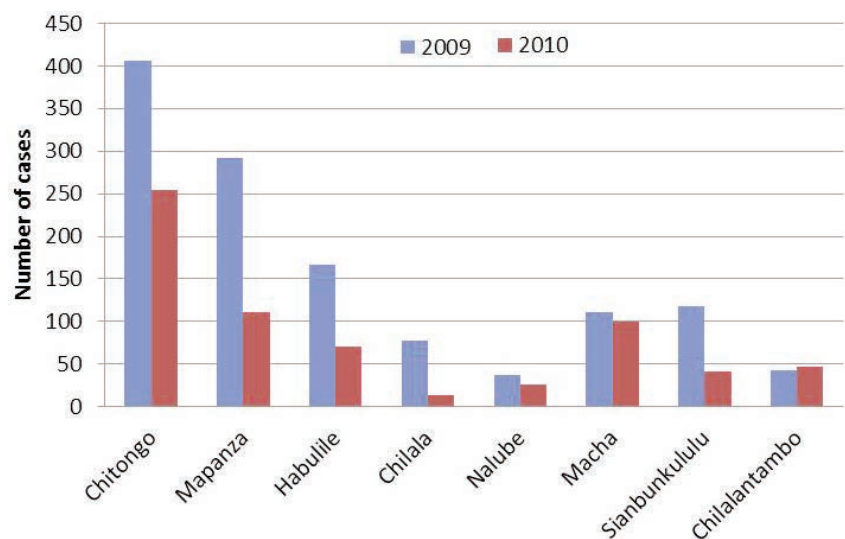


Figure 3. Number of rapid diagnostic test-confirmed malaria cases in 2009 compared to 2010 at 8 rural health centers involved in the cell phone surveillance in a section of the Choma and Namwala Districts, in the Southern Province of Zambia.

these trifles the surveillance has so far been running without technical difficulties (Appendix 1: Interviewees 1,2). To enhance participation and adherence in the cell phone surveillance at the RHC, talk-time has been given as incentive to the health worker providing the data. This has in addition to the perception that the malaria projects have led to an improved health situation helped to easily integrate it in the daily work at the RHCs (Appendix 1: Interviewees 1,2).

Before the cell phone surveillance, it took up to 6 months for case data on paper from RHCs to reach the national health office, these reports are now sent on a weekly basis through cell phone surveillance and Internet (Appendix 1: Interviewee 1). Health workers believe that no benefits would come out of reporting the data more often than weekly, as is the present procedure and the general perception at RHCs and Macha Research Trust is that the cell phone surveillance should expand nationwide, and a national program is now in the making (Appendix 1: Interviewees 1,2, Chilala, Chilalantambo, Habulile, Mapanza, Nalube, Sianbunkululu).

Discussion

Macha has seen a much more prominent reduction than Zambia in general and when comparing interventions the major difference is the focus on asymptomatic carriers in Macha.¹⁷ These have been identified through mass-screenings started in 2003 as well as randomized cross-sectional and longitudinal studies that started in 2006. This was followed by the evaluated active case detection that started in 2008. Without the arrival of ACT effective treatment of the asymptomatic carriers would not have been possible.^{7,21} Also worth mentioning is that the decrease in parts can be due to a decrease in mosquito population in Macha, as during the extended drought in 2004-2005 as reported by Kent *et al.*²²

Macha Mission Hospital staff has been involved in community-based health care for several decades and this extensive fieldwork has possibly led to a higher degree of participation and adherence (Appendix 1: Interviewee 3). New approaches involving diagnosis of malaria through less invasive procedures such as testing saliva, instead of blood, could also help enhancing participation.²³ Asymptomatic carriers can also often suffer from anemia, fatigue, poor pregnancy outcomes and reduced cognitive function.³ Highlighting this during screening could also be important to enhance adherence. Worth mentioning is also that when health interventions are funded by non-governmental organizations and research projects it is also rele-

vant to integrate national or local authorities at an early stage, so that programmes can be economically sustainable even when external funds no longer are available.

Actively identifying asymptomatic carriers consumes both time and money. However, it can be argued that such an approach could decrease hospital admissions due to malaria. In addition, treating patients in the hospital is often far more expensive than treating asymptomatic carriers in the field. In the long run the onetime expense of mass screening could be outweighed by predicted reductions in socioeconomic effects of malaria.^{3,24}

At the moment a nationwide cell phone surveillance system is in the making. A possible obstacle in this is the sheer amount of data. To interpret this data in a time efficient manner more trained epidemiologists will be required in Zambia. Another issue is poor cell phone reception in some remote rural areas, but currently the cell phone network is expanding (Appendix 1: Interviewee 2).

The integration of cell phone surveillance with GIS helps us to better understand malaria transmission and provides reliable real-time epidemiological data. If implementing this data in prevention it might lower costs and better focus interventions in relation to the heterogeneous malaria situation in Zambia.

Initially mistrust towards the RDT's reliability was common. Therefore education in its use and interpretation is important.¹⁸ Despite the initial reluctance, RDTs eventually prove their reliability and value through their correct diagnosis. Guidelines of acquired RDT-diagnosis before treatment could also help in decreasing unnecessary prescription of ACT, thereby decreasing the risk of resistance development (Appendix 1: Interviewee 2).

The studied setup of active case detection in Macha manages to detect higher amounts of asymptomatic carriers, when using PCR, compared to randomized screenings. However, significant results could not be shown when using RDTs as diagnostics in the screening due to low statistical power.⁷ There are those who suggest that a molecular-based assay is needed in order to identify these low degrees of parasitemia,² while others suggest that RDT-based screenings would identify and lower the parasite reservoir enough to disrupt malaria transmission.³ It is hard to completely specify what impact active case detection has had in the Macha area, but the perception at the rural health centers is positive and the malaria transmission is still decreasing in the areas included in the project.

To conclude, an approach of identifying asymptomatic carriers in order to reduce burden of malaria has proven successful in Macha, Zambia. The arrival of cell phones and RDTs is considered valuable and in combination with GIS, creates an opportunity to pro-

vide inexpensive real-time surveillance maps for possible use in national health programmes. Mass screening and active case detection has the potential to reduce malaria mortality and transmission and thereby ease the health care workload. If the expansion of similar programs in the rest of Zambia will be equally successful, it should also be worth trying in other sub-Saharan African countries.

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