Utilization of a local 'Malaria Post' indicates that carers from a village in Mozambique respond appropriately to malaria attacks

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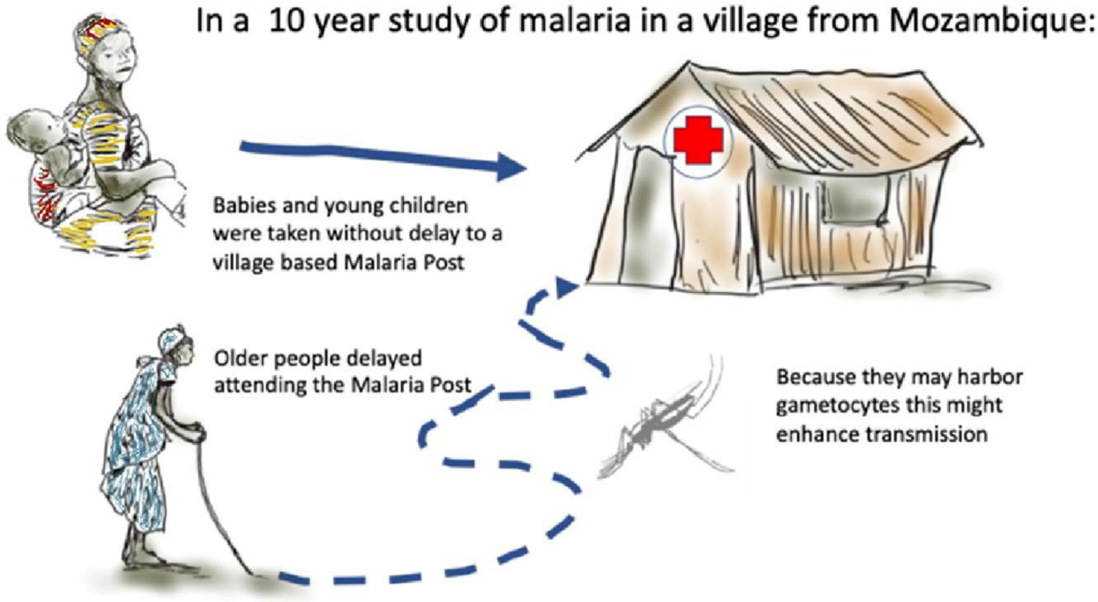
Highlights

- As malaria transmission declines rapid treatment becomes increasingly important.
- This requires an adequate response on behalf of parents of sick children.
- One way of enhancing treatment availability is the establishment of village-based Malaria Posts.
- The utilization of a Malaria Post in a village from Mozambique over a ten-year period is described.
- Children came promptly but adults delayed treatment, which may affect subsequent transmission.

Graphical Abstract



Abstract

As malaria elimination becomes a possibility the focus of interventions changes from vector control to disease control. It is important that treatment occurs early during an infection, in order for it to be efficacious, especially at the population level. The time between the onset of symptoms and treatment seeking is, therefore, crucial. Following a census and an oral autopsy survey of the inhabitants of Furvela, a village in southern Mozambique, a malaria post (MP) where malaria was diagnosed and treated was established in 2001. The time between the onset of symptoms and attendance at the MP was determined and compared to the severity of disease. A cross-sectional survey was also conducted, in 2007, to determine prevalence among 235 children aged between 6 months and 15 years of age. Malaria was hyperendemic in the village. It was responsible for most deaths reported from the two years prior to the start of the project. In the prevalence survey 74% of two-to-four-year-old children had malaria parasites. The likelihood of being parasite positive was significantly higher in children living in houses with roofs made of traditional materials compared to those living in houses with tin roofs. At the start of the project only 12% of residents owned or used a mosquito net, most of which were not treated with insecticide. However, even before any formal intervention, malaria declined in the village between 2001 and 2007, but there was a rebound in later years. Nevertheless, the relative proportion of patients who had to be referred to the hospital declined significantly in the latter years of the project, and the incidence of both *Plasmodium ovale* and *P. malariae* also decreased significantly. Overall 4911 patients, the majority of which were under one year of age, attended the MP between 2001-2010. The proportion of patients with a positive slide for *P. falciparum* remained relatively constant throughout the study (mean 0.66 std. dev. 0.3) Most of the patients came from the village of Furvela, or its environs, but some came from the nearby town, ostensibly because of the good treatment they received. Infection rates increased up to the first three years of life to a peak incidence of 92% at 31 months. Children with fever had higher parasite densities than those without fever. Mothers generally bought their children to the MP on the second day of symptoms but on the first day if they had fever. Older patients, with lower density infections, delayed in coming for treatment. These patients may harbour sub-microscopic gametocytes which would help maintain transmission in the village. Mothers acted appropriately in their treatment seeking behaviour. The establishment of village-based MPs are an effective way of providing adequate diagnosis and treatment in villages such as Furvela.

Key words

Treatment seeking behaviour; Malaria rebound; malaria incidence.

1 Introduction

With the decline in malaria, even in highly endemic areas, the behaviour of the human host becomes more significant than that of the parasite or vector in the dynamics of the disease. In particular, three factors are important: whether people sleep under a mosquito net (with, if possible, an effective insecticide incorporated into the fabric); how much time they spend outside in the early evenings and before dawn (potentially exposing them to exophagic vectors); and how they respond to an episode of illness, either in themselves or in a child for whom they are responsible (WHO, 2015). As pointed out by Battle et al., (2016), prompt diagnosis and treatment of clinical malaria is the mainstay of all control or elimination programs, and information regarding the treatment-seeking behaviours of fever cases in malaria endemic countries is essential to assessing the feasibility of success.

As transmission of *Plasmodium falciparum* decreases it becomes even more vital to treat an infection early, prior to the development of gametocytes (so preventing transmission to the vector). Seeking treatment at the early onset of disease is recommended by the WHO as a cornerstone of malaria elimination (WHO, 2015). In remote areas, this is an important consideration. For example, in the Democratic Republic of Congo (DRC), patients may have to walk 12 kms to a health post, which means a 24km round trip (Corey Le Clair, 2017, personal communication). Although a delay in seeking treatment under such circumstances is understandable, it is not certain that even when access to treatment is available delays do not occur Kassile.et al 2014 Early treatment depends upon prompt recognition of symptoms and signs of malaria in the household, which is usually the domain of mothers. Cultural practices, such as whether or not people use traditional healers, and the role of the father in decision making, are also important in relation to the perception and response to malaria and will probably affect treatment-seeking behaviour (Falade *et al.* 2006, Comoro et al. Ahorlu et al., 1997). Early treatment also requires that appropriate health services and medication are accessible and used (Tanner and Vlassoff, 1998, Hopkins et al., 2007).

One way of assessing people's response to illness is to determine how long they have been ill before seeking treatment, and what symptoms they might have had. What they might do before attending a clinic for treatment is also important. Assessing people's responses to illness should enable health personnel to improve their services and tailor a response that is efficacious.

Malaria, in Mozambique, remains a serious problem. In 2015 it accounted for 4% of global cases and deaths (www.severemalaria.org/countries/mozambique) and was responsible for 29% of all hospital deaths among the general population and 42% of deaths in children under five years of age (National Malaria Control Programme of Mozambique, 2016). In order to better understand the dynamics of transmission in a highly endemic area of the country the Mozambican-Danish rural malaria initiative (MOZDAN) was established, in a village close to the coast in the southern part of the country. In addition to examining entomological aspects of transmission, information on the human side of the disease was studied. The impact of malaria on the population was assessed by oral autopsy and prevalence in children up to 15 years of age determined. A malaria post (MP), which provided diagnosis and access to free treatment for malaria was established in the village in 2001, and information on health seeking behaviour during an episode of malaria determined. The results indicate that such MPs are a useful tool for the treatment of malaria in rural areas of Mozambique.

2 Material and Methods

2.1 Description of study site

The village of Furvela in Inhambane Province, which has been described by Charlwood, (2011, 2017), Charlwood and Bragança (2012) and Kampango *et al*., (2013), is situated 8kms to the south of Morrumbene, the district capital, and 25 kms north of Maxixe (a larger town on the landward side of the provincial capital, Inhambane). At the time of the study both Morrumbene and Maxixe had hospitals but access from Furvela by '*chapa*' (public minibus) was neither easy (they often did not stop in Furvela preferring to take passengers between the urban centres only), cheap (urban-to-urban fares were often demanded from people travelling to and from Furvela), nor frequent (waiting times for an hour or more for transport were not uncommon). Most of the villagers live by subsistence farming, growing maize, manioc, peanuts and beans. Cashew nut trees and coconut palm are also common. A single rainy season occurs from October to March, when approximately 1,200 mm of rain falls, mostly in February and March. Daily mean temperatures vary between 18°C in July and 30°C in December.

The village is bordered on two sides by the alluvial plain of two rivers, the Furvela and the Inhanombe. There are a number of irrigation canals radiating from the Furvela River in a 2km wide valley to the north of the village (Fig 1). These provide a large, and relatively stable, number of water bodies that provide suitable habitat for *Anopheles funestus*, the primary vector in the village. The Inhanombe River valley to the east contains reeds, used for house construction, and sugar cane, used in the production of local alcohol. Unlike the Furvela River, it is not used for washing or bathing.

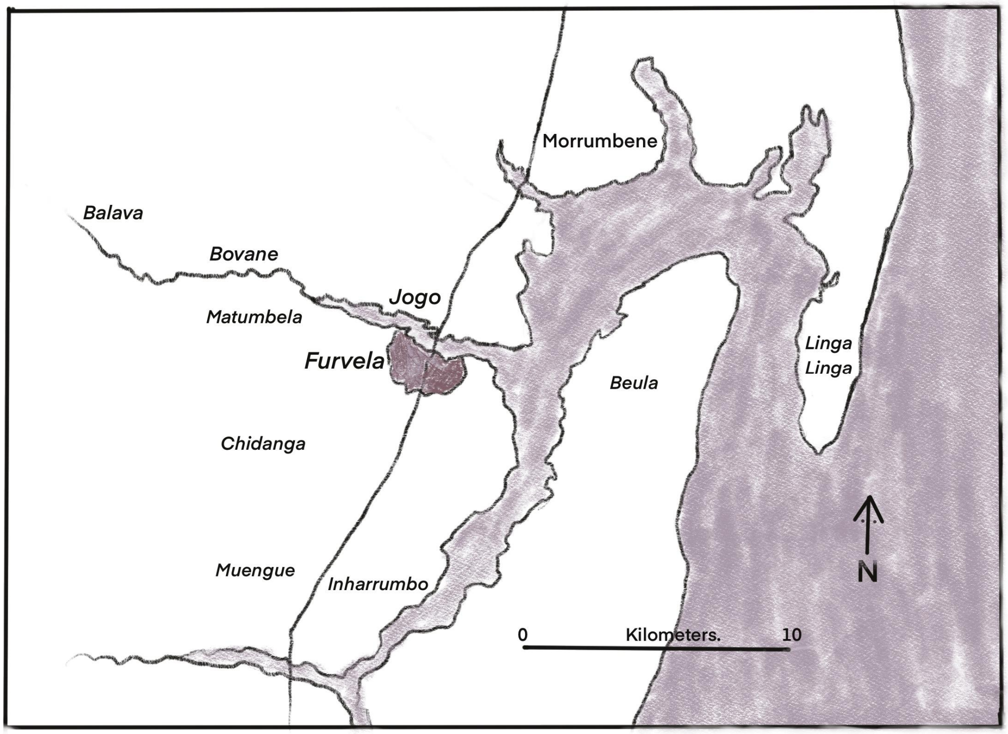


Figure 1 *Map of Furvela and the surrounding hamlets*

At the start of the project the village was mapped using hand-held GPS units (Garmin Etrex) (Fig 1), and a census of the inhabitants undertaken. During the census information on deaths in the household over the previous two years was obtained (by oral autopsy), as was information on mosquito net ownership and use. The survey also included information on the material that the house was made of (whether organic 'green' or non-organic 'artificial' material), numbers and kinds of animals owned, and any methods used for mosquito bite prevention.

2.2 Malaria Post

From May 2001 until 2007 the project was responsible for a Malaria Post (MP) in the village. In 2007 this was incorporated, and continues to function, within the District Health System (DHS). From Mondays to Fridays, during a morning consultation, a clinician took blood slides, axial temperature (with a digital thermometer) and a case history (including place of residence, age, sex, duration of illness, whether the patient had had a fever the previous night, and whether the patient had slept under a mosquito net the previous night). People with a temperature greater than, or equal to, 37.5^{o}C were considered to have a fever. Patients needing immediate, more dedicated treatment, were transferred to the hospital in Morrumbene. Finger-prick blood was used in the preparation of thick and thin blood-films. Films were stained with 5% Giemsa for 20 minutes and examined at the District Hospital, in the afternoon, for the presence of parasites. Slides were considered to be negative if no parasites were seen after examining 200 thick films. Parasitaemia was classified into five levels including F1 (< 50 parasites/µl blood), F2 (50–499 parasites/µl), F3 (500–4999 parasites/µl), F4 (5000–49,999 parasites/µl) and F5 (≥ 50,000 parasites/µl). Treatment, which was free, followed government guidelines. From 2001-2003 chloroquine was the first line treatment. From 2004 to 2007 it was Sulphadoxine-Pyramethamine (S-P) and from 2008-2009 was Artesunate. From 2010 until the present Artemether/lumefantrine (coartem) was the primary treatment. During clinic hours regular triage of waiting patients was conducted, so that very sick late arrivals could 'jump the queue' and be dealt with immediately.

Daily incidence data for the years 2003, 2004, 2008 and 2009, was entered into an Excel database. For other years the monthly summary of cases was used. Monthly data was provided to the District Health Office.

In order to determine how well the clinic was used, and how well it was known in the community, a survey of random households, located at different distances away from the MP, was undertaken in 2005. Householders were asked what they did when they, or a family member, had malaria, whether they had heard of the Furvela Malaria Post and whether they had used it.

2.3 Measurement of prevalence

A survey for determination of prevalence by age group was conducted in 2007. A random set of households, based on the census data, were chosen for inclusion in the survey. Houses were grouped into three strata (up to 150m from the Furvela River valley; over 150m from the valley edge and on the Inhanombe River side of the village on the far side of the EN1 road that bisected the village). A dummy cardinal variable was included in the database and the numbers randomised using a random number generator in Microsoft Excel.

Householders were informed of the purpose of the survey and informed consent obtained. All children up the age of 15years of age from the selected households were included in the survey. In addition to slides, which were prepared and read in the usual way, filter paper samples for subsequent PCR analysis were taken. The *msp -1* and *msp-2* gene of *P. falciparum* was genotyped by PCR-RFLP from a sample of the positive blood-slides from the cross-sectional survey, according to the protocols outlined in Felger et al. (1999). Restriction digests of the PCR products were performed with *Hinf* I and *Dde*I, and the restriction fragments separated by gel electrophoresis.

3 Statistical analysis

We applied chi-squared tests to determine association between nominal variables, such as the material used in house construction, sleeping under a bed net, and malaria positivity. Logistic regression was used to determine the distribution of malaria risk according to age. To account for the longitudinal data (in which observations might have been made on the same subjects) the variable 'year' was considered a random factor. Segmented regression analysis was applied to investigate changes in the trajectory of malaria cases during the study period. Multinomial regression analysis was applied to determine the probability of patient delay, according to age, in seeking malaria treatment. Statistical analyses were implemented using R software (v. 4.0.2) R Core Team, 2020.

3.1 Ethics

The study was conducted under the aegis of the joint Instituto Nacional de Saúde (INS)–DBL Centre for Health Research and Development project 'Turning houses into traps for mosquitoes', which obtained ethical clearance from the National Bioethics Committee of Mozambique on 2 April 2001 (ref: 056/CNBS/01). Householders were informed about the purpose of the study and could decline to accept without prejudice.

4 Results

4.1 Census data

There were 1072 houses recorded in the census. Most (80%) of the houses were traditional 'green' buildings with palm thatched roofs and reed walls. The remainder had corrugated iron or 'Lusalite' (a cement compound with 10 to 15% asbestos fiber) roofs, and either reed or cement block walls. Only 306 (12%) households had a mosquito net and only 54 (17%), among the 267 respondents who knew whether the net had been impregnated with insecticide, replied in the affirmative. Other anti-mosquito measures, such as burning pungent leaves, were also occasionally adopted. Domestic animals, that might act as alternative hosts to humans, were also uncommon in the village (Table 1).

Table 1 *Numbers of animals by household in Furvela village, 2006.*

	Cows	Pigs	Goats	Chickens	Ducks	Turkeys	Dogs	Cats
Households with animals (% of total households)	79 (4.7)	492 (27)	212 (12)	523 (30)	269 (15)	22 (1)	76 (4)	223 (12)
Number of animals	255	998	498	4086	1543	129	87	320

A total of 2632 people were recorded in the census. Sixty-one people were reported to have died in the two years before the census, the age of three of these people was not recorded (one of whom was reported to have died from malaria, one from anaemia and one from a stroke). Seventeen (29%) of the remaining 58 deaths occurred in children below the age of two years. Five of these children died from unknown causes. Malaria was considered to be responsible for 10 of the remaining deaths while one baby had apparently died from malnutrition and one had been murdered. Malaria was also given as the cause of death in five (29%) of the 17 deaths registered among over 50-year-olds, but was less common in intermediate age groups (Table 2).

Table 2 *Cause and age of death among the 58 deaths among residents of known age reported to have occurred in the years 2003-2006, Furvela, Mozambique.*

	Age (Years)						
Cause of death	>2	2-9	10-19	20-29	30-49	<50	Total
Accident	0	0	1	0	1	0	2
Anaemia	0	0	0	0	3	1	4
Asthma	0	0	0	0	0	1	1
Burns	0	0	0	0	1	0	1
Cancer	0	0	0	0	0	1	1
Epilepsy	0	0	1	0	0	0	1
Gangrene	0	0	0	0	0	1	1
Birth	0	0	0	2	1	0	3
Blood pressure	0	0	0	0	0	1	1
Malnutrition	1	0	0	0	0	0	1
Malaria	4	7	0	2	3	5	21
Military operation	0	0	0	1	0	0	1
Murdered	1	0	0	0	1	0	2
'Nerves'	0	0	0	0	0	1	1
Stomach	0	0	1	1	1	0	3
Stroke	0	0	0	1	1	2	4
Infection	0	0	0	0	0	1	1
Unknown	3	2	0	0	1	3	9
Total deaths	9	9	3	7	13	17	58

4.2 Prevalence data

During the prevalence survey children from 122 houses were examined for malaria parasites. 53 houses had a single child, 37 houses had two children, 22 three children, nine had four children and in one house there were six children tested. Prevalence by age group among the 235 children surveyed in 2007 is shown in Table 3.

Table 3 *Prevalence of* Plasmodium falciparum *among children from 6 months to 15 years of age, Furvela village 2007.*

Age group (years)	Prevalence (%)	Number surveyed
<1	40.0	10
1-2	71.4	49
2-4	74.0	50
4-6	66.0	47
6-8	57.1	49
8-10	46.7	30
Total	63.4	235

PCR-RFLP typing of the *msp*-2 and *msp*-1 genes of *P. falciparum* from 89 children positive for a blood slide found a mean of 3.54 parasite genotypes per infected person, with little age dependence in this multiplicity (Table 4).

Table 4 *Frequency distribution of multiplicity of infection*

Multiplicity	Frequency
1	7
2	14
3	30
4	13
5	14
6	9
7	2

Children from houses in which the roof was made from local ‘green’ material (palm thatch) were more likely to be positive for malaria parasites than children from houses in which the roofs were made from man-made material (corrugated iron or Lusalite) (Yates corrected χ^2 (1, N = 235) =5.15, $p = 0.023$). Prevalence was significantly lower in children on the side of the village to the east of the highway N1 (close to the Inhanhombe River) (Yates corrected χ^2 (1, N = 235) = 4.33, p = 0.037) but was not different in houses at a distance from the Furvela River compared to those nearer the valley edge (Yates corrected χ^2 (1, N = 184) = 1.54, p = 0.21). There was also no difference in prevalence between children who had slept under a mosquito net the night before the survey and those who had not (Yates corrected χ^2 (1, N = 235) =3.70, p= 0.054).

4.3 Clinic data

The clinic was well attended from its opening to the end of the project (when it continued to function as part of the District Health System). During the assessment of perceptions and utilization of the MP in 2005 all respondents, from 35 households in a 7km radius away from the MP, knew about it and went there for malaria treatment if needed. Fever and vomiting were the most common symptoms described by parents of sick children, although lack of appetite, and especially failure to breast feed in young babies were also considered as signs of malaria.

Overall there were 16698 patients recorded from the years 2001-2010. There were 4911 patients from the years in which the daily cases were entered into the database. Most of these patients came from Furvela itself, although people from neighbouring villages and hamlets also comprised a large proportion of the patients (Fig 1, Table 5)

Table 5 *Place of residence of patients attending the malaria post 2001-2010, number of attendees, proportion positive and means of transport to the clinic.*

Village	Number of attendees	Proportion positive	Means of transport to the MP
Furvela	2454	0.65	Foot
Jogo	1357	0.64	Foot
Matumbela	438	0.67	Foot
Balavala	117	0.59	Foot
Bovane	89	0.73	Foot
Muengue	75	0.49	Foot
Inharrumbo	61	0.77	Chapa
Chidanga	40	0.70	Foot
Beula	20	0.75	Foot
Morrumbene	29	0.65	Chapa
Other	231	0.66	

Given that many of the localities were close to the main village of Furvela, some patients from adjoining areas may have described themselves as coming from ‘Furvela’. Some patients even came from the main population centres of Maxixe and Morrumbene. The reason these patients gave for attendance was that they had heard of the quality of treatment provided by the MP compared to that available in the town’s hospitals.

Overall, almost two thirds of attendees had a positive blood slide (mean proportion±SD being 0.621± 0.065). This proportion remained relatively constant throughout the study. The monthly number of positive cases during the period when the post was operated by the project is shown in Fig 2A.

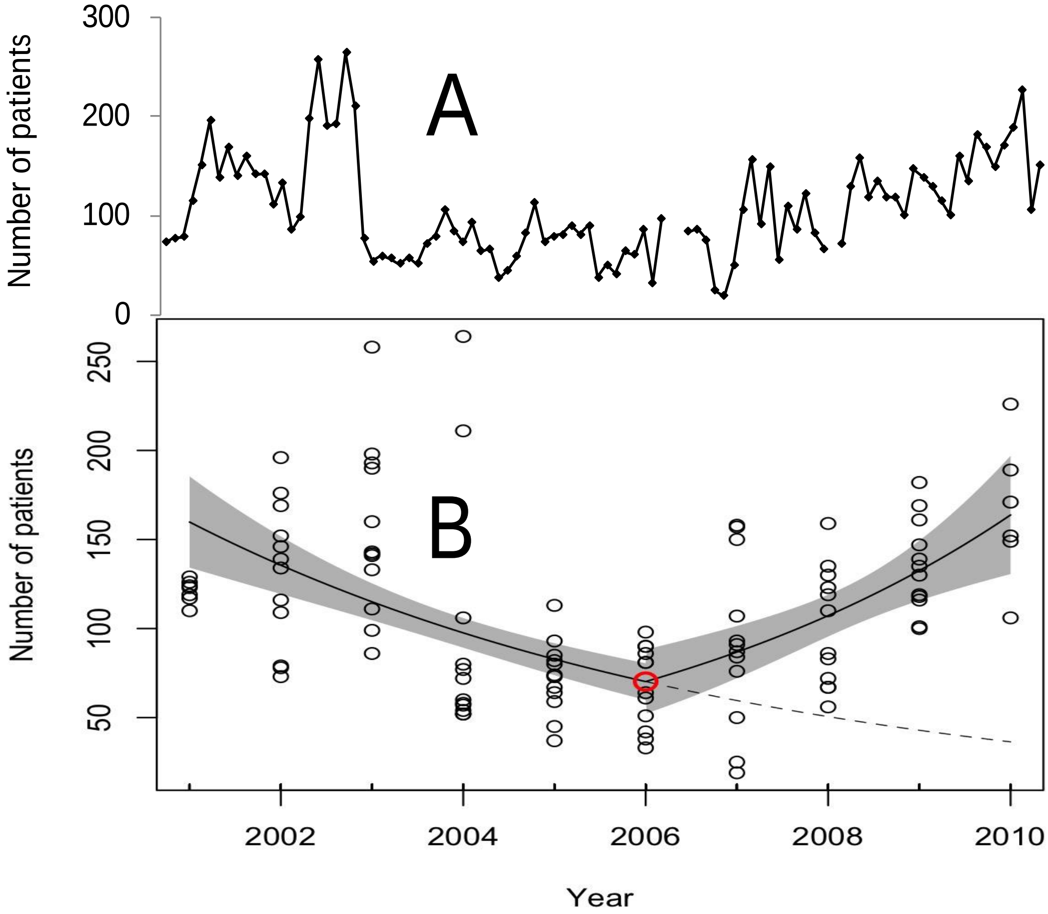


Figure 2*A Number of* P. falciparum *positive patients attending the malaria post (MP)by month and year Furvela village. 2B segmented (break-point) regression analysis of the number of malaria patients attending the MP. Dashed line indicates predicted trajectory of malaria prevalence if there was not a break-point in 2006*

The number of cases was lowest in 2007. Segmented (break-point) regression analysis, however, indicated that the rebound in malaria incidence was initiated in 2006, a year earlier (Fig 2B). Rates continued to rise in subsequent years. This pattern was also seen in the proportion of mosquitoes positive for sporozoites in the ELISA (Kampango *et al*., unpublished data).

During the first years of the project, children presenting with multiple earlier treatments of chloroquine and who showed little subsequent weight gain, were treated with second line medication at their presentation. These underweight children, with chronic malaria, were no longer a problem in the later years of the project. In

2003+2004, 6% of attendees (181 of 2870 attendees) were transferred to the hospital in Morrumbene, but in 2008+2009 only 3% were considered to need to be transferred (59 of 1942 attendees). This was equivalent to 9.5% and 5.0% of the attendees with malaria (χ^2 (1, N=3267)= 51.2 p<0.0001). The proportion of attendees with a high-grade infection (Grade 4 or 5) was, however, similar in both periods (χ^2(1, 3015) 0.275, p =0.60). At the same time the number of *P. ovale* and *P. malariae* positive patients, among attendees, decreased from 66 and 93 cases in 2003+2004 (3.4% and 4.8% of positive cases) to 7 and 17 (0.6% and 1.4% of positive cases) in 2008+2009, as did the number of attendees recorded with *P. falciparum* gametocytes (from 36 to 1).

The majority of patients attending the clinic were below three years of age. A high proportion of babies had a high-density infection even though they comprised only a small proportion of cases. Patients with a fever were almost three times more likely to have malaria than people without a fever (O.R = 2.97, 95% C.I = 2.37-3.72 $p < 0.0001$) and, amongst the positive cases, more had a high-density infection (χ^2 (4, N= 1692) = 84.2449, $p < 0.00001$).

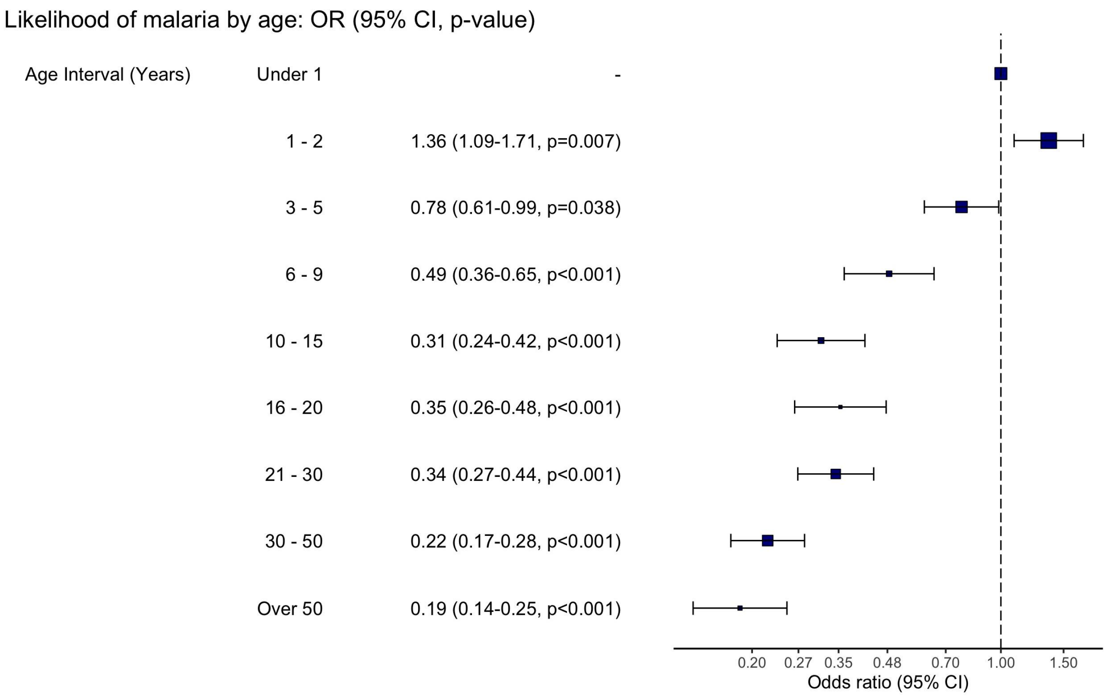


Figure 3 *Likelihood of a patient having a positive blood slide by age, Furvela MP, Mozambique*

The likelihood of having a negative blood slide increased with age (Fig 3). Most mothers bought their sick infants to the clinic on the second day of illness. Older children and, especially, adults would delay 3 to 9 days before attending the MP (Fig 4).

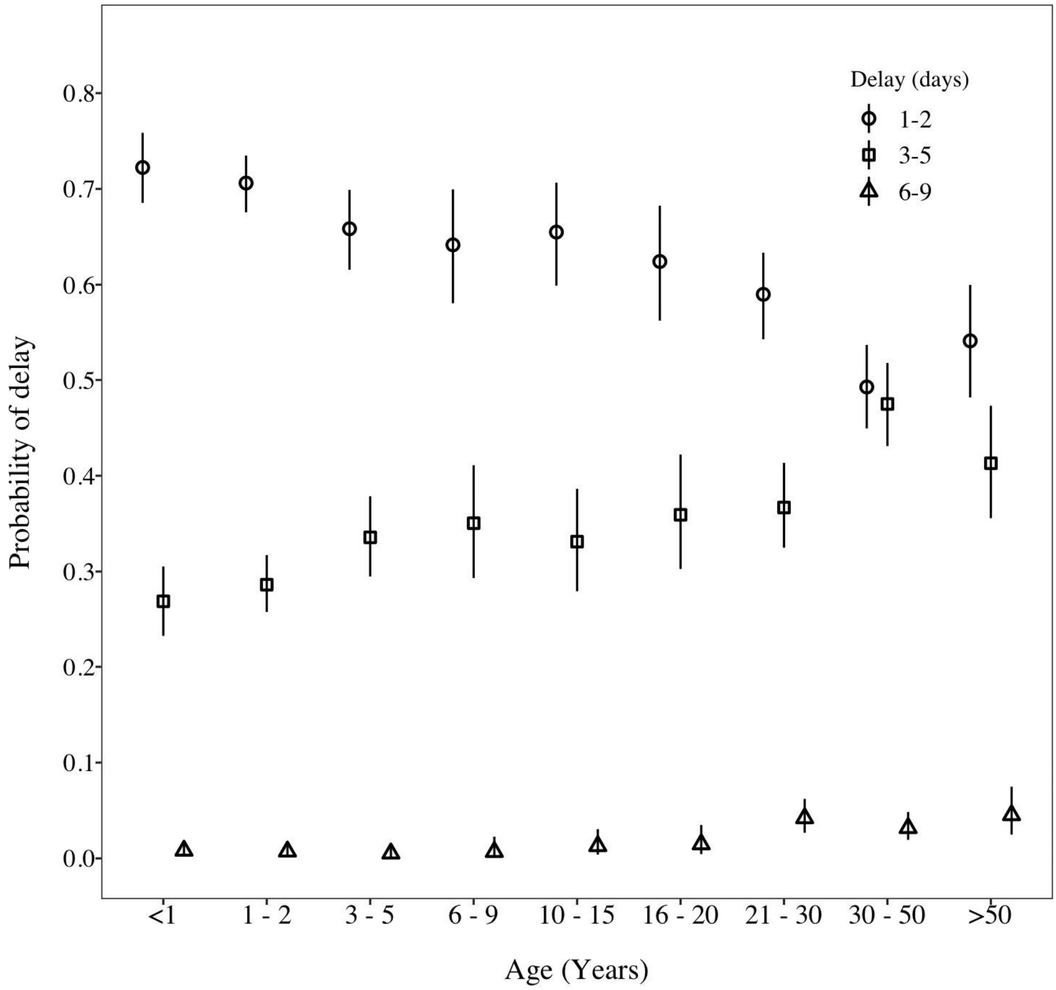


Figure 4 *Predicted probability of delay in seeking treatment at the Furvela MP by age of patient. Error bars represent 95% confidence intervals.*

5 Discussion

There have been a number of studies assessing the impact of Community Workers, as well as other community-delivered models and their impact on malaria-metric indices (Win Han et al, 2019). Results from these studies suggest that evidence for context-specific solutions is required. Here we provide information on the establishment of a Malaria Post (MP) in an area of intense transmission, run (in a hands-off way) initially by a research project, which was subsequently integrated into, and continues to function, as part of the District Health system, now as a Health Post treating a wider variety of diseases rather than just a Malaria Post. The very high prevalence of malaria among young children, and the high level of multiplicity of infections, was an indication of intense, perennial transmission and, as might be expected from such an area, most of the patients attending the MP were children under three years of age, and most of these had malaria. It is not known what diseases people with a negative blood-slide were suffering from. The lower proportion of adults with positive blood slides is an indication that they, as would be expected in a highly endemic region, were at least semi-immune to the disease (Warrell & Gillies, 2002, Wernsdorfer & McGregor, 1988). Although dengue was present in the village (one of the authors had an attack that was serologically confirmed in Denmark) how prevalent it, and other arboviruses, were in the village remains unknown. Indeed, the prevalence of other fever causing illnesses are also unknown in the village, but malaria, especially in young babies and children, was obviously the most important.

There was a clear difference in the delay between presentation at the MP and the age of the patient. Very young babies, who may have had a fever, were brought in as soon as feasible. This was a good practice, since a higher than expected proportion of them had a high-grade infection. Older children (who constituted the majority of patients) were brought to the MP on the second day of illness. These were generally children, or infants, who had perhaps had a slight fever on Day 1 and the parents had waited to see if it resolved itself before coming to the post on Day 2. Older patients tended to delay in coming. Although this may have been due to the lower intensity of their illness, it has implications for the maintenance of transmission in the village. Gametocytes are present in most malaria infections at highly variable densities (Bousema and Drakeley, 2016). A relatively higher concentration of gametocytes has been observed in individuals with low-density infections when compared to those with high-density infections (Drakeley et al. 2006). These adults and older children, because they have a higher body surface area (Port et al., 1980), attract more mosquitoes than infants and are, therefore, likely to increase their contribution to the infectious reservoir of parasites in the human population. As pointed out by Bousema and Drakeley (2016), more needs to be known about low density gametocyte carriage and its role in transmission. Although there is likely to be an inherent bias in the kind of data reported in this paper, this is more likely to enhance the relevance of our conclusions than diminish them. Given the difficulties of transport to the local towns, and the response of everyone interviewed during the survey of MP use, all young children were likely to be brought to the MP, but whether all adults with symptoms did so is less certain. Non-attendance by adults would enhance rather than reduce transmission.

The catchment area of the MP extended for at least 5kms. Indeed, during its operation, the occasional patient from the town of Maxixe, 25kms from Furvela, came to the clinic, largely because they had heard of the good treatment received there. The decline in the incidence of malaria in the early years of the project, even in the absence of any control measures, was similar to that observed elsewhere in East Africa (Ishengoma et al., 2013; Meyrowitsch et al., 2011 O'Loughlin et al., 2016), the main difference being that the principal vector in Furvela was *An. funestus* rather than *An. gambiae* found elsewhere. Why this occurred we do not know. Despite the lowest incidence being observed in 2007, segmented (break-point) regression analysis indicated that the rebound in malaria incidence was initiated in 2006. In subsequent years the incidence of malaria continued to increase, and even exceeded the rate observed in earlier years. Nevertheless, the proportion of patients who required hospital treatment decreased significantly during the study, and the disappearance of malnourished infants with chronic malaria indicates that it was having a positive effect on people's health.

Given that the MP, although highly appreciated by the villagers, by itself did not reduce transmission some consideration of what might be needed is relevant. There were very few mosquito nets or other anti-vector measures in use in the village at the start of the project, and distribution and use of Long-Lasting-Insecticide-treated Nets (LLINs) is the most obvious technique. Fortunately, villagers received these as part of the National Distribution campaign in 2009, but there was no immediate effect on incidence seen in 2010. Having a net does not necessarily mean that you use it Adebayo et al. 2015 Awosan2013. Not everyone knows how to set up a net and, of those that do, not everyone has string to do so. Once a net develops holes, which reduces their effectiveness, they rarely get mended. This is in part because rust-proof needles are not always available. Making needles and (permanently impregnated) thread widely available would help in reducing exposure (Charlwood, 2002). Establishing local 'Re-treat and repair' services (even for LLINs) might be a cost saving intervention that improves malaria control. At the present time, and under present environmental conditions, a net in Inhambane is expected to last for three years (Abílio *et al*., 2020). Extending the life of a net should reduce costs, especially if they can be retreated.

Our results indicate that, as was the case in Linga Linga eight kilometres from Furvela, across the Morrumbene Bay, children living in traditional 'green' houses had a higher prevalence of malaria than those in which the roofs were made of corrugated iron or Lusalite (Charlwood et al ., 2015). Although, as pointed out by Theroux (1971) such roofs make houses hotter replacing the palm thatch roofs of houses with corrugated iron would reduce transmission by reducing survival in the mosquitoes that enter and rest in them. Changing the walls to brick or cement is unnecessary and environmentally harmful (Gates, 2021).

Additional measures might include covering the openings between the walls and the roof of the houses with netting, which was shown to be effective in reducing mosquito entry in the village (Kampango et al., 2013). These measures are likely to be particularly effective against a vector like *An. funestus*, which is especially anthropophagic and endophilic (Charlwood, 2011). Environmental management, that acts to control the flow of the Furvela River, might also be useful in reducing mosquito numbers, although this would require a more specialised intervention. A further anti-malaria measure would be the provision of at least 3 doses of intermittent preventive therapy during pregnancy, at each scheduled antenatal care visit in the second and third trimester (Kayentao et al, 2013). This is not only an effective strategy that targets the most affected groups in the population, but is something that could be done through the auspices of the MP.

Conclusions

The establishment of village-based MPs are an effective way of providing adequate diagnosis and treatment in villages such as Furvela. Our results show that mothers/carers recognized the symptoms of malaria in their children and acted accordingly and appropriately. Furvela is typical of many villages in Africa. Facilitating treatment by the establishment of such MPs elsewhere would enable mothers to access treatment at the early onset of disease and would help in attaining the goals of the WHO.

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Author contributions

Jacques D Charlwood designed the study, established the MP ran the project and wrote the paper

Erzelia V E Tomás assisted in running the MP interviewed mothers and commented on the manuscript

Sonia Enosse supervised and assisted in the prevalence survey and wrote the paper

Sara P Saija conducted the prevalence survey and undertook the PCR analysis

Jannick Sanholdt conducted the field survey assessing care givers responses to the MP

Lourenço Filemon ran the MP, read the slides and was responsible for treatment

Ayubo Kampango helped supervise the running of the MP, analysed the data and wrote the paper

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