Malaria prevalence and incidence in an isolated, meso-endemic area of Mozambique

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If malaria can be eliminated from anywhere it is from isolated areas such as the 2x7 km peninsula of Linga Linga in southern Mozambique. Currently available control strategies include bed nets impregnated with pyrethroid insecticides (long-lasting insecticidal bed nets; LLINs), artemisinin combination therapy (ACT) for treatment and rapid diagnostic tests (RDTs) for diagnosis. When these became available, they were applied and their effects on malaria prevalence measured over the years 2007 – 2011. Following a census of the population and mapping of 500 households, five annual all age prevalence surveys were conducted over the years 2007 – 2011. Information on LLIN use, house construction, and animal ownership was obtained. Mean prevalence varied from 16% (in 2007) to 65% (in 2009) according to the season in which the surveys were performed. The 5 – 9 year old age group had the highest prevalence rate in the first three surveys (2007 – 2009). A spatially structured generalised additive model indicated that malaria risk was greatest towards the northern end of the peninsula. The effect on the incidence of malaria of a clinic providing RDT's for diagnosis and ACT's for treatment was also monitored from March 2009 to May 2011. Malaria was diagnosed in 31% of the 4321 visits from residents attending the clinic and 72% of those tested were positive. People with confirmed malaria were younger than the median age of people attending the clinic. People with a fever were more likely to have malaria than people without a fever but bednet use did not affect the likelihood of having malaria. People living further away from the health post were less likely to attend. The number of attendees diagnosed with malaria decreased significantly from 35% (399 of 1144 attendees) in 2009 to 24% (271 of 1150 attendees) in 2011 (Chi sq = 19.1, p> 0.0001). In order to reduce malaria prevalence in an area such as Linga Linga further measures of vector control need to be considered if reductions in malaria prevalence are to be achieved.

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Background

If malaria can be eliminated from anywhere, it is from isolated areas such as islands and peninsulas that are surrounded by mosquito-hostile environments, be that sea, desert or uninhabited land, in which there is much less immigration and emigration of vectors (and people) than in more connected environments (Aregawi et al., 2011, Hagmann et al., 2003, Ishengoma et al., 2013, Pinto et al., 2003, Lucas 2010, Lum et al., 2007, Sudomo et al, 2004, Teklehaimanot et al., 2010).

The sandy, low altitude peninsula of Linga Linga, 500 km north of Maputo, is such an area, since apart from a 2 km stretch of uninhabited land at the narrow neck, it is surrounded by saline water making it a virtual ecological island. *Anopheles funestus* is responsible for malaria transmission on the peninsula (Charlwood et al., 2013). During the long dry season, the mosquito may become gonotrophically discordant and individual mosquitoes may survive for long periods taking several blood meals without laying eggs so that, despite low numbers, transmission continues (Charlwood et al., 2013).

In 2007, a project to determine the impact on malaria of introducing currently available control strategies was implemented on the peninsula. Should transmission have been reduced then prevalence and incidence, especially in the most affected age groups should drop and the mean age of maximum prevalence should increase. Annual all age malaria prevalence surveys were therefore undertaken for the years 2007–2011 and incidence from 2009-2011 was monitored in a clinic established by the project. The results are discussed in relation to other potential control techniques that might be applied on the peninsula.

Methods

Linga Linga (23°43'1.29"S, 35°24'15.04"E), which lies 6km to the east across the Morrumbene Bay opposite the district capital Morrumbene, has been described by Charlwood et al., (2013) and Thomsen et al. (2013). People are involved in fishing, the production of copra or the artisanal manufacture of raffia baskets, hats and bags. A number of tourist lodges have been built in recent years or are under construction, employing non-resident and local labour. At the time of the initial survey there was no health centre on the peninsula, the nearest health centres being in the village of Coche, five km to the north of Linga Linga, or in Morrumbene itself (Fig 1). At the start of the project residents were censused, informed of the purpose of the study and consent to participate was obtained; houses were mapped (with Garmin e-Trex hand held global positioning system (GPS) receiver units) numbered and their dimensions noted.

Information on the age and number of residents, the number of animals kept by householders, bednet ownership, the duration of residency, sources of drinking and washing water, and details on the construction of the houses were noted. Roof and wall categories were based on whether the material in which they were constructed was made of ‘natural’ materials (reed, palm leaf, grass, palm frond) or ‘man-made’ materials such as corrugated iron, bricks or tiles. Water sources were separated into ‘in the house’, ‘from a well’ or ‘neighbours’.

In 2007, 130 blue double Long Lasting Impregnated Nets (LLINs) impregnated with Deltamethrin were given to the households with the greatest number of children below 10 years of age recorded in the census. In 2008, two days prior to the prevalence survey, a further 100 pink, 200 green and 100 blue LLINs were distributed. Householders were invited to a central distribution point and were given the opportunity to choose their nets. When distributing the nets, names were called out and people came up and chose their net. We attempted to make sure that all three colours were always available and equally easy to pick. The colour of the net chosen was recorded until that particular colour was exhausted.

Prevalence surveys

Following the initial census, an all age baseline malaria prevalence survey was performed in February 2007. Subsequent prevalence surveys were conducted in February 2008, March 2009, April 2010 and June 2011, coincident with increments in the distribution of interventions

Seven locations were chosen as survey field sites. Local residents were informed the day prior to the survey that it would be taking place, and requested to come to the site location to be surveyed. In addition, a survey was undertaken at the school to collect data of school-aged children who had not been previously screened. During the surveys, residents were asked if they have experienced malaria since the start of the year and where they went for treatment. In the initial survey (2007), information on absence from the peninsula (duration, location, means of transport and whether they had used a net when away) was also collected. In subsequent surveys, people were asked: 1. How long have you lived in your present house? 2. Where did you come from? 3. Do you have a mosquito bednet? 4. Did you sleep under it last night? 5. Where did you obtain your net? Thus, the parasitology datasets contained information on the individual's house number, name, age, sex, whether or not they tested positive for malaria, and whether or not they used a bednet the previous night.

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 Instituto Nacional de Saude (INS) reference laboratory for the presence of parasites. Slides were read twice and numbers of parasites per 500 leucocytes were counted and converted to densities per micro-litre of blood, assuming a density of 8000 leucocytes per micro-litre (Bruce-Chwatt, 1985). Parasite density per micro-litre of blood was determined according to the formula:

Density = ([P.f Count] * [8000])/ [White Blood Cell Count]

People's temperature was also taken. In surveys from 2008 onwards, an RDT (OptiMal ®) for malaria was given to anyone with a fever (defined as an axillary temperature of >37.5 °C). Those that tested positive by RDT were treated with Coartem® (artesunate and lumefantrine) according to national guidelines.

Incidence data

A clinic was established in March 2009 in an unused cement house in a central location (Fig 1). The clinic was open from Monday to Friday in the mornings, with a resident nurse also available for emergency consultations at other times. It provided curative care for general ailments using the UNICEF Kit B stock of medicines. The age, sex and house number of attendees was recorded over the period March 2009 – May 2011. Attendees were asked how long they had had their symptoms, including headache and fever, defined as an axillary temperature of 37.5°C or above, and whether they had slept under a bednet the previous night.

RDTs were used to determine the likelihood of patients reporting with a headache or fever having malaria. At the same time (also when RDTs were not available), a blood slide was taken and subsequently read for parasite confirmation. Thick and thin blood films were prepared of diagnosed cases and subsequently read by a microscopist in Morrumbene. In the absence of RDT's treatment was, therefore, based on clinical diagnosis, which was subsequently checked by microscopy. People with parasites confirmed by

RDT, or presumptively diagnosed with malaria when RDTs were not available, were treated with artemether –lumefantrine (Coartem®).

Data analysis

Data was entered into MS Excel spreadsheets and analysed with the software R (R Core Team, 2013). Summaries of the 2007 census data were produced, including the age distribution of the population and bednet ownership by sex. LLIN colour preferences, and subsequent information on their reported use were also summarised. Prevalence surveys (2007-2011) were matched with the census data using the unique household ID number (additional file 1) which enabled overall annual malaria prevalence to be tabulated, and household-level malaria prevalence to be mapped using the software ArcGIS. Annual prevalence and the geometric mean parasite density by age group (<2, 2-4, 5-9, 10-19, 20-29, >29) were calculated to assess whether there was any evidence of a change in the age distribution of cases. An individual-level multiple logistic regression model was fitted to the prevalence data, with potential predictors under consideration including age group, bednet usage and household characteristics (roof type, door type, distance to the health post, number of people, water and sanitation access). A backwards stepwise model selection approach based on minimising the Akaike Information Criterion (AIC) was used to determine which variables to include in the final model. A generalised additive model (GAM) was then fitted to the data by adding a spatially smooth term to the final model to account for any possible residual spatial dependency in the data, and a map of this term was produced.

The straight-line distance between households and the health post was calculated using ArcGIS and the correlation between the number of visits per person per household and distance to the health post was calculated to assess whether or not those living further away were less likely to seek treatment. Summaries of the percentage of health post attendees who were diagnosed with, or tested for malaria were calculated by age group, sex, resident status (resident or non-resident), reporting year, and bednet usage and chi-squared tests were performed in order to elucidate whether there was an association between malaria risk and these variables.

Ethics

The project received ethical clearance from the National Bioethics Committee of Mozambique (reference 123/CNBS/06) on the 2nd of August 2006.

Results

Population composition

There were 467 households recorded in the census of 2007. A further 33 houses were recorded early in 2008 giving a total of 500. The locations of the households are presented in Figure 1.

In 2007 5.7% of the population was between 55 and 64 years of age and 9.1% was over 65 years of age (compared to a national average of 3.5% and 2.9% respectively derived from www.theodora.com, z test p <0.05). Of the 195 households recorded with resident children less than 15 years of age 118 had only one child, 46 had two children, 21 had three children, nine had four and one house had five children. Only 183 (19%) of the 975 people recorded used a bednet. Bednet use was equally divided amongst the 447 males and 528 females. Half the households had a radio, 16% per cent owned a mobile phone and a small number owned fishing boats. Only three households owned a bicycle. Of the 410 people who completed the baseline prevalence survey, 163 (40%) had been out of Linga Linga in the previous year. Of these, 146 had left by boat (Fig 2), five had gone by foot and only three had travelled by car. The majority of people who reported that they had been absent from the peninsula in the previous year had only spent one or two nights away.

Net distribution

The villagers preferred pink nets; nets of this colour being taken at twice the rate of the others Those villagers who took a green or a blue net at the start of the distribution process (i.e. when all three colours were still available) said that that they were acting on behalf of their neighbours and that therefore the colour 'did not matter'.

In the 2009 survey 96 pink, 39 blue, 50 green and 10 white nets were reported to be in use whilst in the 2010 survey 93 pink, 118 blue, 43 green and 27 white nets were reported to be in use. In the 2009 survey 16 of 282 net owners did not use their net the night before the survey. The reasons given for non-use included that the net was 'too hot'; that there were no mosquitoes; that they were ill or that they just didn't like it.

Prevalence and density of malaria parasites 2007-2011

An overview of the parasitology datasets, including the number of individuals per survey, and the number of individuals that matched the 2007 census data, is presented in Table 1. Prevalence of malaria varied from one year to the next with a marked increase in prevalence in the 2009 survey (Fig 3). This was an exceptionally wet year whilst 2007, the year with the lowest prevalence, was an exceptionally dry one. The number of people who did not have an associated house number in the years following the initial census increased with each survey indicating that there was a considerable movement of people into (and perhaps out of) Linga Linga. There was, however, no significant difference in the use of nets between previously registered householders and new arrivals (i.e. people not registered in the original census).

In 2007, 24.4% (11 of 45) of the malaria positive individuals were children less than five years old whilst in 2011, only 8.9% (5 of 56) of the malaria positive individuals were children less than five years old. In both 2007 and 2011 the majority of cases (55.5% in 2007 and 66.1% in 2011) were individuals aged 5 – 19 years old. Thus there was a tendency towards the older age groups being positive for malaria parasites in the later years of the study.

From all the surveys, the 2 – 4 year age group had a significantly higher geometric mean parasite density of 19983 (95% C.I. 12444) compared to all the other age groups that had a mean of 2147 (95% C.I. 699)(t-test p < 0.0001). Parasite densities were also higher in the 2010 and 2011 surveys combined compared to the previous years (i.e. 2007 – 2009) combined (Fig 4). *Plasmodium malariae* was recorded in two slides from the surveys of 2008, four from the survey of 2009 and from two slides in 2010. Blood stage parasites were not seen in five of the 21 gametocyte carriers identified in 2009, in seven of 14 identified in 2010 nor in eight of 21 identified in 2011. In all years the majority (67%) of gametocyte carriers were under 15 years of age although they were seen in all age groups.

In the 2010 survey from 31 rapid tests that were negative 29 were slide negative and two were slide positive whilst from the 27 rapid tests that were positive seven were slide negative. This results in a sensitivity of 90.91% (95% C.I. = 70.08% to 98.62%) and a specificity of 80.56% (95% C.I. = 63.97%-91.77%) in the RDT (assuming that the slide reading was 100% accurate).

A multiple logistic regression model was fitted to the data from the 618 surveyed people for which matching covariate data was available from the census. A significant relationship was observed between being infected with malaria and year of survey, age group, roof category, door category, number of people per household, water source category, washing water category and whether or not the surveyed person slept under a bed net on the previous night. Thus after adjusting for other risk factors, people who lived in houses having a roof made of thatch or other ‘Green’ material had an increased risk of having parasites than those who lived in houses with a roof of corrugated iron or other man-made material. The number of people living in the house was also a risk as was age.

Using a backwards, stepwise model selection approach, the final fitted model included year, age group, number of people in the house and roof category (Table 2). A generalised additive model (GAM), i.e. a logistic regression model with a smooth term for spatial location, was fitted to the individual-level data to determine whether there was any spatial pattern in malaria prevalence after accounting for observed risk factors (see the supplementary information). The fitted GAM indicated that there was an area of lower risk in the southeast of the study region, and an area of higher risk in the north and west of the study area (Fig 5).

Incidence data

In the 28 months that the clinic was operational there were 4949 visits to the Health Post, with 4321 (87%) of attendees residing in Linga Linga. Hence, despite its isolation 628 (13%) of the people attending were non-residents. Among the residents only, 31% (1345/4321) were clinically diagnosed with malaria and 870 (65%) of these were tested by blood slide and/or RDT, resulting in 623 (72%) who tested positive for *P. falciparum*. A similar proportion (34%; 213/628) of non-residents were clinically diagnosed with malaria. Among these 142 (67%) were tested by microscopy and/or RDT and 79 (56%) were positive. Among non-residents, 84 of the diagnosed cases came from urban areas (where transmission is low or absent) and 117 (58%) came from nearby rural areas (where autochthonous transmission is likely to occur). There was no significant difference in the likelihood of urban and rural non-residents having a confirmed case of malaria (two tailed Fishers exact test p = 0.217).

People diagnosed with malaria were slightly younger than people attending the clinic for other ailments (median age: 20 years Interquartile range (IQR) 6 – 38 and median age: 23 years IQR 7 – 44, respectively). The median age of those confirmed to have malaria was younger still (12 years, IQR 4 – 30). The majority (80%) of attendees had used a bed net the previous night. People using a net the night before reporting ill were, however, as likely to have malaria as those who did not. Of the 820 people who reported using a net that were diagnosed and tested for malaria, 506 (62%) were positive, whilst of the 194 tested who did not use a net, 120 (62%) were positive for malaria.

In the 25 – 40 and the 41 – 64 years of age groups, more females than males were diagnosed or tested for malaria but the majority of these tests were negative (Fig 6). Significantly more of the attendees with fever were malaria positive than those without fever (Chi square for diagnosis = 131.9 $p < 0.0001$, positivity among those tested Chi square = 12.6 $p = 0.0004$). Of the 656 people who had, or reported having had, a fever when attending the health post, 390 (59.5%) were diagnosed with malaria and of the 233 tested, 188 (80.7%) were positive. From the 2788 people recorded attending without a history of fever, 807 (28.9%) were clinically diagnosed with malaria out of which, 479 of these patients were tested (either microscopically or with RDT) and 246 (51.3%) were positive.

There was no significant clustering of cases attending the health post, although by mapping the number of visits per household and weighting these values by number of people in the household (obtained from the census data), there was evidence that those living away from the health post were less likely to attend (Spearman correlation co-efficient between distance to health post and number of visits per person per household = -0.1492, $p = 0.0031$) (Fig 7).

The number of resident patients diagnosed with malaria decreased from 35% of all attendees in 2009 (399 of 1144 attendees) to 24% in 2011 (271 of 1150 attendees) (Chi square = 19.1, $p < 0.0001$) (Fig 8).

Discussion

In Mozambique, malaria represents around 45% of all cases in outpatient visits, approximately 56% of inpatient at paediatric clinics and around 26% of all hospital deaths (WHO, 2013). In Linga Linga too it was a leading cause of attendance at the clinic. The proportion of visits attributable to malaria, however, decreased significantly during the years that the clinic was running. Hence the widespread use of LLINs and the availability of ACTs (that have an anti-gametocidal effect, Okell et al., 2008) may have resulted in a decrease in transmission and incidence.

Malaria prevalence, however, was not reduced by an enhanced availability of bednets (even pink ones) or the clinic. Net ownership and ACTs for treatment are not likely to be sufficient to reduce overall prevalence in a setting like Linga Linga where transmission is maintained by a low-density, long-lived, insecticide resistant, anthropophilic vector like *An. funestus* (Charlwood et al., 2013).

Most of the malaria infections detected in all but the 2 – 4 year age group in the prevalence surveys were low density ones (below 300/µl) they are, therefore, likely to be chronic asymptomatic ones. People with chronic asymptomatic infections are less likely to seek treatment especially when, as at the start of the study, available health centres are a considerable distance away. They may continue to have parasites for long periods and so prevalence among these people may be unaffected by vector control measures such as LLINs. Although gametocyte carriage was apparently lower in these age groups than in 2 – 4 year olds, it is possible that gametocytes were present sub-microscopically. This may lead to a relatively large infectious reservoir and a rapid rise in transmission following rainfall with the associated increase in numbers of *An. funestus* (Charlwood et al., 2013). The exceptional rainfall in December 2008 and January 2009 may have been the cause of the high prevalence observed in 2009.

Although not quite statistically significant (due perhaps to the small sample size) the potential peak shift in prevalence rates from 1-4 year olds to older age groups and the reduction in the proportion of people attending the clinic diagnosed with malaria implies that, as was observed in Papua New Guinea (Smith et al., 2001) there may have been some effect on transmission rates.

The type of roof that a house had was associated with an enhanced malaria risk. *Anopheles funestus* may be more likely to rest inside houses that have thatch rather than iron roofs. Should the mosquito, due to the lack of suitable oviposition sites, have an extended gonotrophic cycle, as postulated by Charlwood et al., [2013] then occupants of thatched roofed houses may be at greater risk of transmission than those in iron roofed ones (Kirby et al., 2008, Tami et al., 2012). The number of inhabitants in a house and their age were also risk factors. Greater numbers of mosquito are attracted to houses as the number of occupants increase (Charlwood et al., 2013). Should infected mosquitoes be more likely to take interrupted feeds on different hosts (Anderson et al., 2000) then even if the numbers of mosquito per inhabitant remain the same the risk of transmission will be greater. The risk of being parasite positive was lower towards the southern end of the peninsula, which is more exposed to wind and has a lower exposure to anophelines (Charlwood et al., 2013) than the northern end of the peninsula.

The increasing number of people who did not have an associated house number in the years following the census indicates that, despite its isolation, there was a considerable movement of people into, and perhaps out of, Linga Linga. Should people arrive without nets and should there not be a system that enables them to obtain them, then the risk of transmission will be maintained. Fortunately in the present study the likelihood of an immigrant (i.e. a person not included in the 2007 census) having slept under a net the night before a survey was the same at that of residents who had received a net during the distribution process. During the distribution process there was a marked preference for pink nets among the villagers of Linga Linga. Having had the opportunity to choose the colour of net may have enhanced utilization and when questioned during the surveys the majority of people said that they had used a net the night before.

Among non-residents 58% of attendees at the clinic came from areas where active transmission was likely to have occurred and so they may have been importing malaria into Linga Linga whilst 42% came from urban areas where

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transmission is low or absent and they would probably have acquired their malaria on the peninsula. Thus, not only do areas like Linga Linga pose a threat to non-immunes (from the cities) but importation of malaria is also a continuing possibility. Importation of malaria will pose problems for future elimination projects in isolated areas like Linga Linga.

Elsewhere malaria has been eliminated or appears to be close to elimination in a number of islands in which ACTs and bednets, (Ishengoma et al., 2013) and/or indoor residual spraying of insecticides (Teklehaimanot et al., 2010) combined with active surveillance of cases (Lucas, 2010, Lum et al., 2007) have been used. Although the widespread use of nets may have impacted the mosquito population in 2011 (when the expected rise in numbers was not observed) additional control measures are likely to be needed in places like Linga Linga. Applying shade cloth or old netting over house openings might be useful (Kampango et al., 2013). This has the advantage that it does not dramatically reduce airflow or illumination whilst preventing mosquito entry. Another advantage of such a technique is that once in place it also does not need the householder to do anything to maintain protection. Larviciding the limited number of known breeding sites at the start of the rainy season would be also be an obvious choice (Keiser et al., 2005) as might preventively treating children under nine years of age, the most at risk group, at this time (Aponte et al., 2009).

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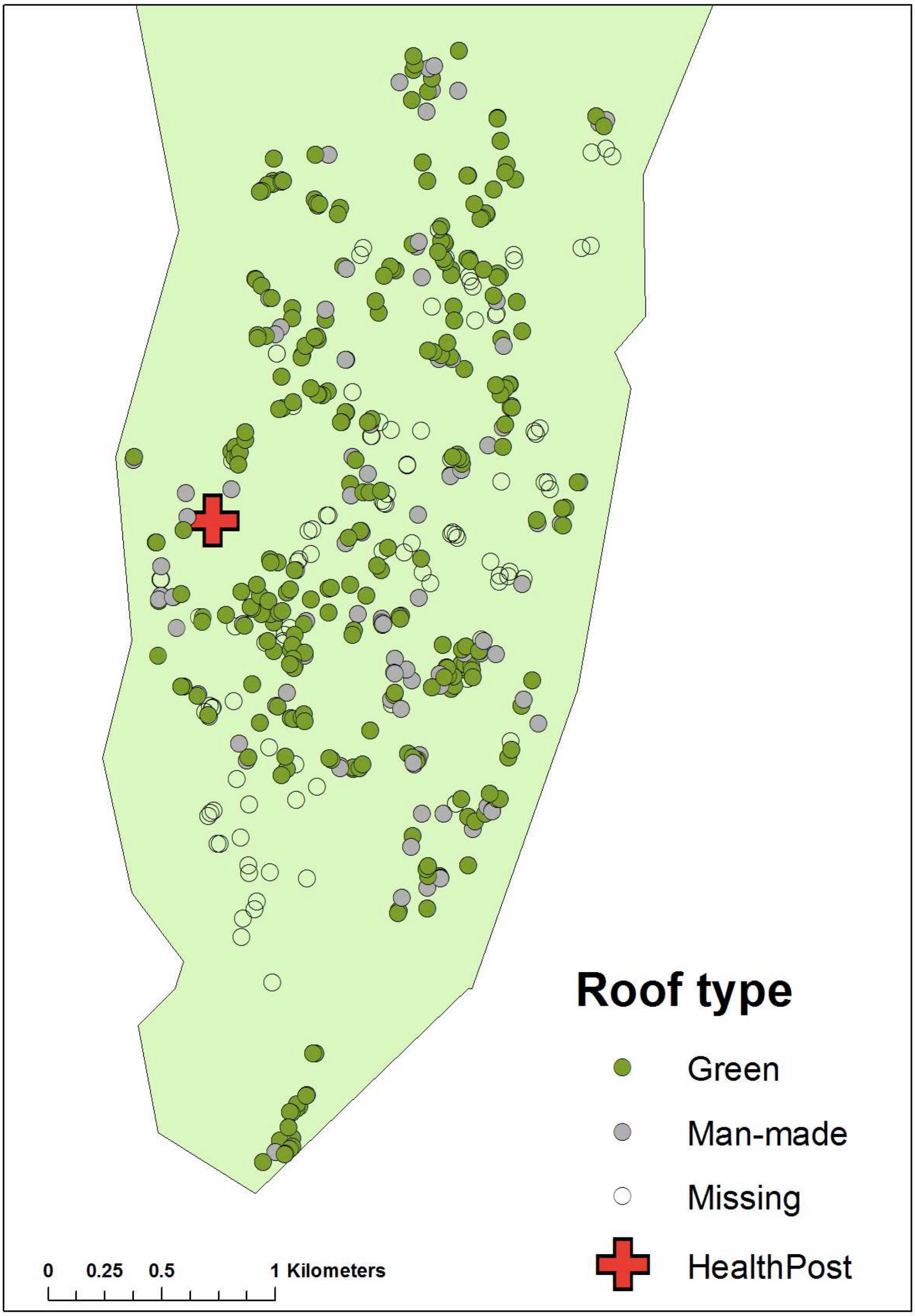
www.theodora.com (accessed 7/11/2014).

Figure 1 (on next page)

Map of Linga Linga showing the distribution of houses recorded in the census of 2007 according to roof type.


Roof type
Green
Man-made
Missing
HealthPost
0 0.25 0.5 1 Kilometers

2

Local transport from Linga Linga to the 'mainland'.

The majority of people who traveled away from Linga Linga did so by boat, making the peninsula a virtual ecological island.

Figure 3 (on next page)

Prevalence of *Plasmodium falciparum* by age group and year of survey, Linga Linga, Mozambique.

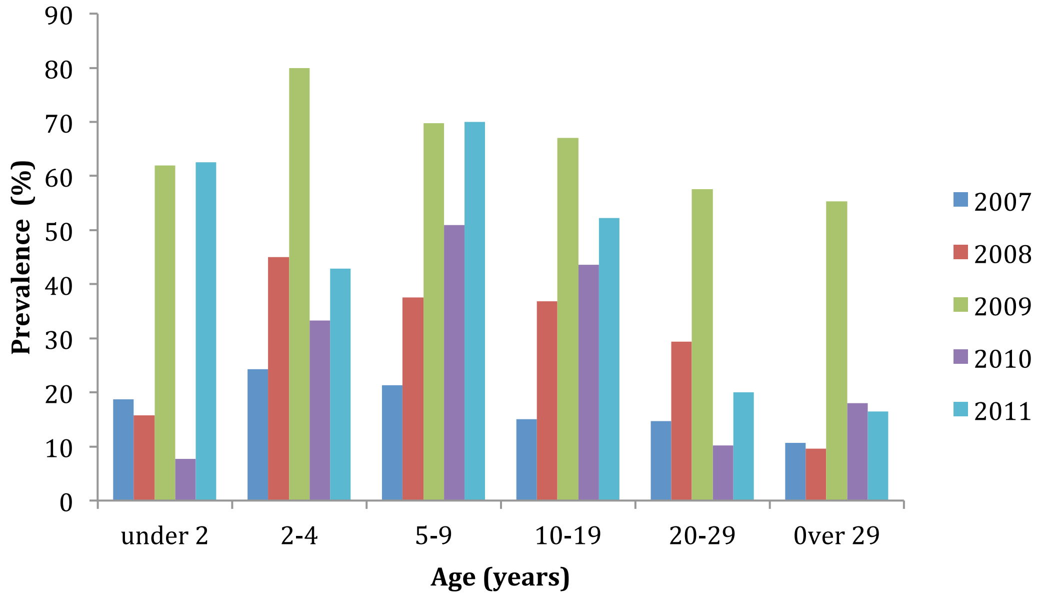
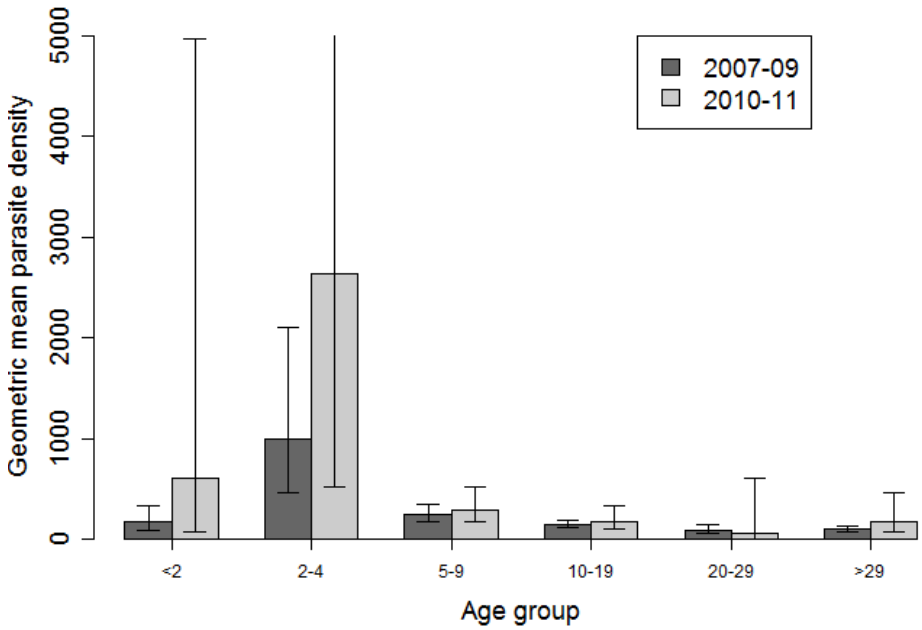

Prevalence (%)
90
80
70
60
50
40
30
20
10
0
under 2
2-4
5-9
10-19
20-29
Over 29
Age (years)
2007
2008
2009
2010
2011

Figure 4 (on next page)

Geometric mean densities of *Plasmodium falciparum* positive people by age group and survey period, Linga Linga, Mozambique

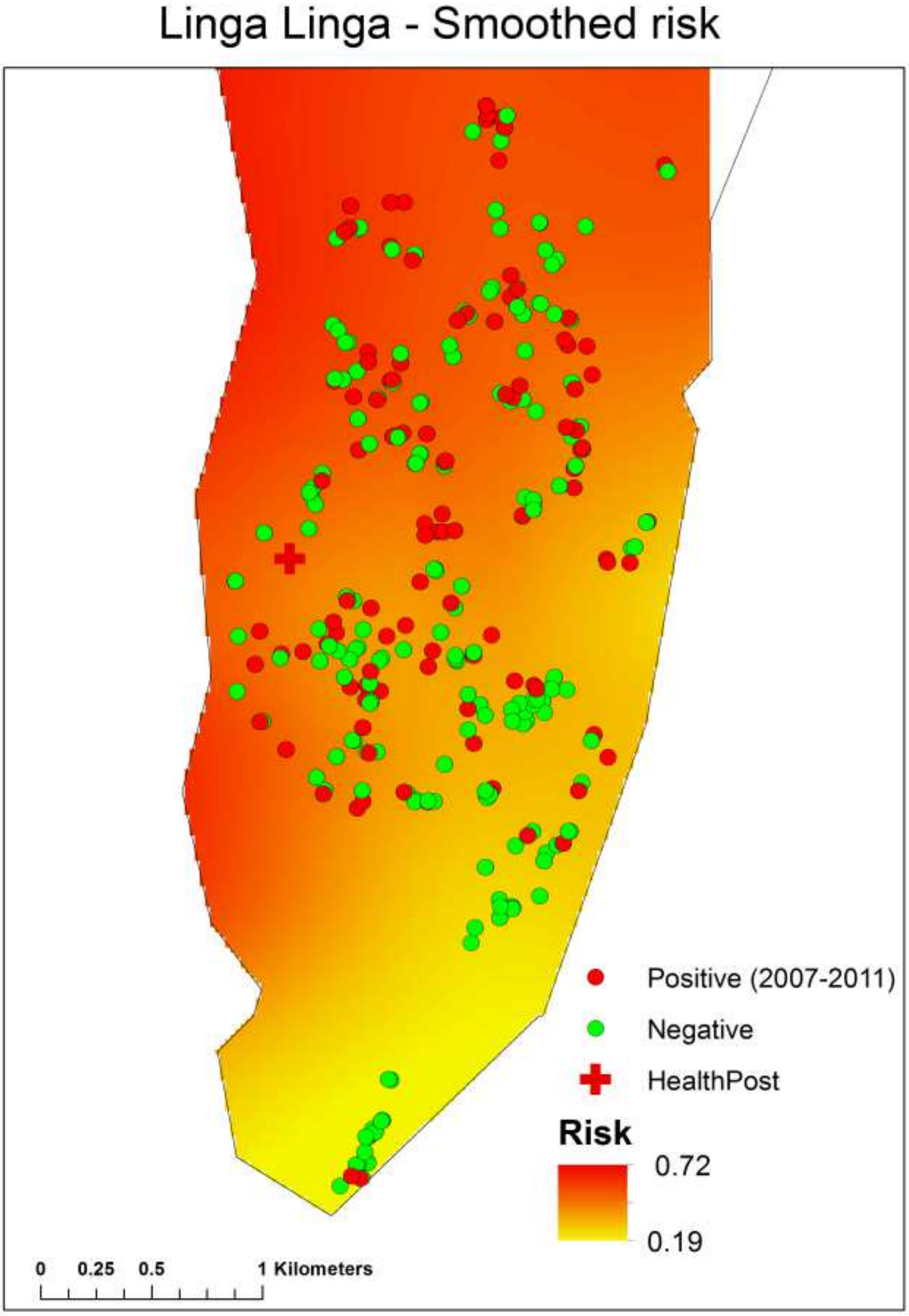


Geometric mean parasite density
0
1000
2000
3000
4000
5000
2007-09
2010-11
<2
2-4
5-9
10-19
20-29
>29
Age group

Figure 5 (on next page)

Spatial pattern in malaria prevalence

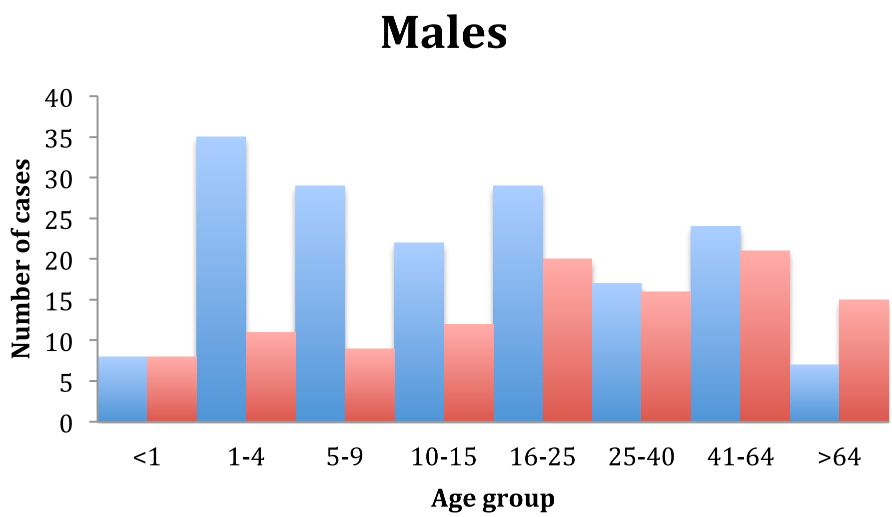
Spatial pattern in malaria prevalence, after accounting for observed risk factors, determined by a Generalised Additive Model (GAM), fitted to the individual-level data. (For details see the supplementary information).



Linga Linga - Smoothed risk
Positive (2007-2011)
Negative
HealthPost
Risk
0.72
0.19
0
0.25
0.5
1 Kilometers

Figure 6 (on next page)

Number of people attending the Linga Linga Health Post (2009-2011) reporting symptoms of malaria by sex and age group and positivity


Males
Number of cases
40
35
30
25
20
15
10
5
0
<1
1-4
5-9
10-15
16-25
25-40
41-64
>64
Age group

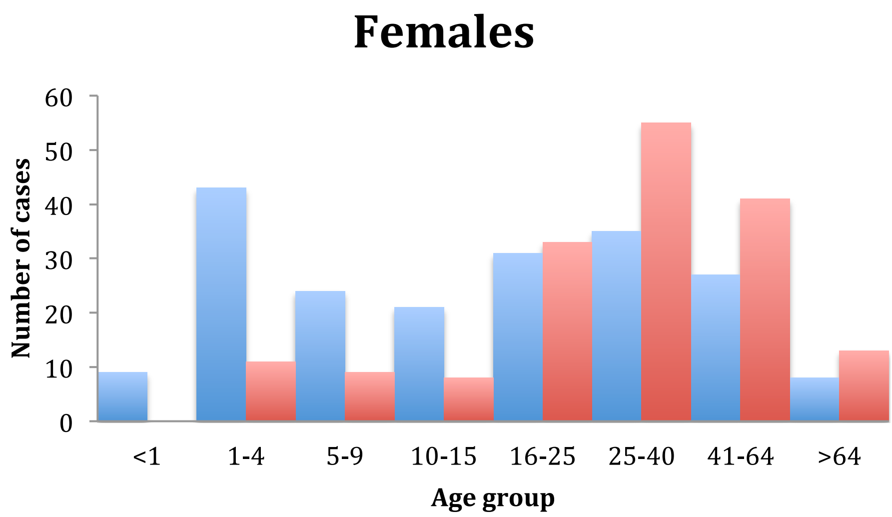

Females
Number of cases
60
50
40
30
20
10
0
<1
1-4
5-9
10-15
16-25
25-40
41-64
>64
Age group

Figure 7 (on next page)

Distribution of people attending the Health Post by location according to the relative number of positive malaria tests performed.

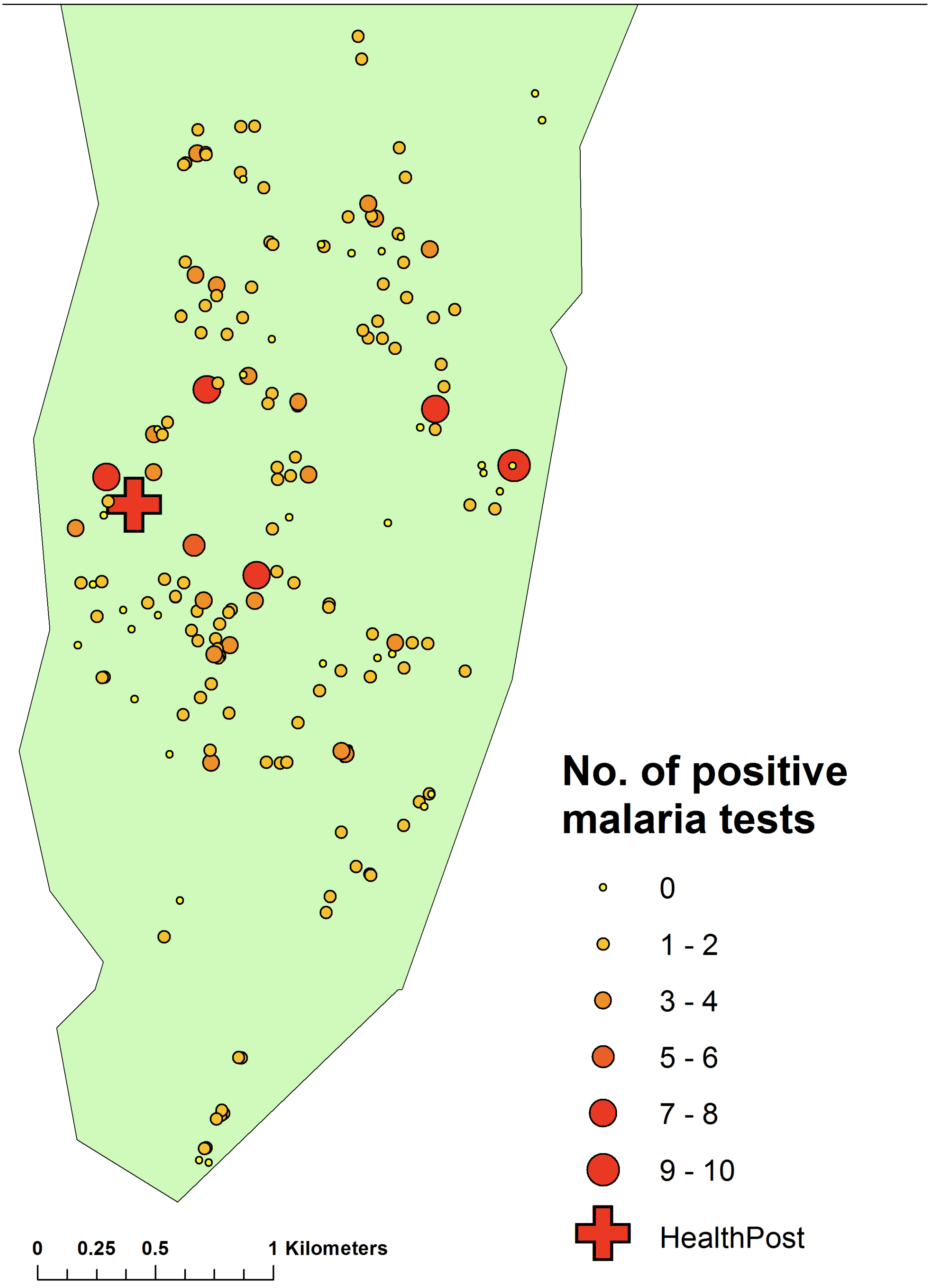
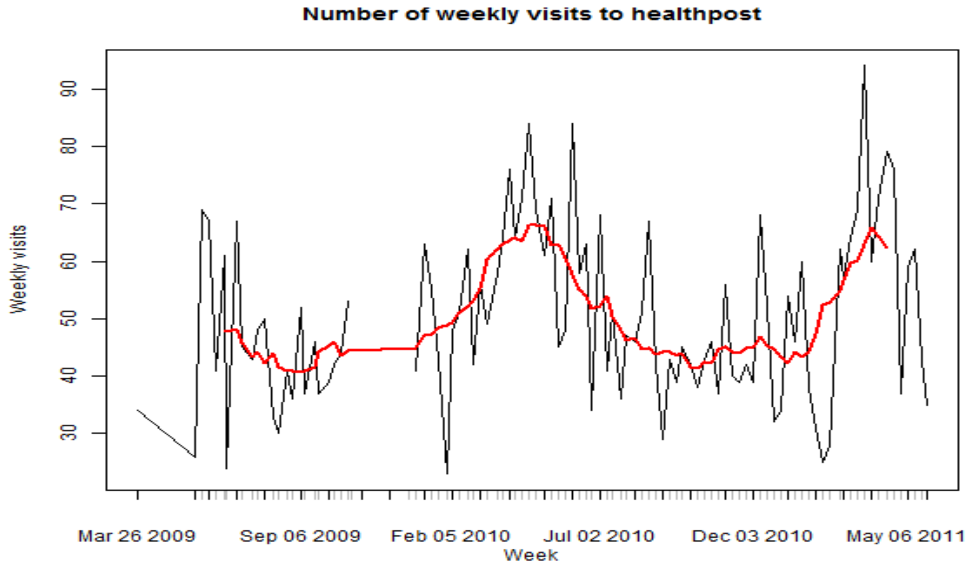
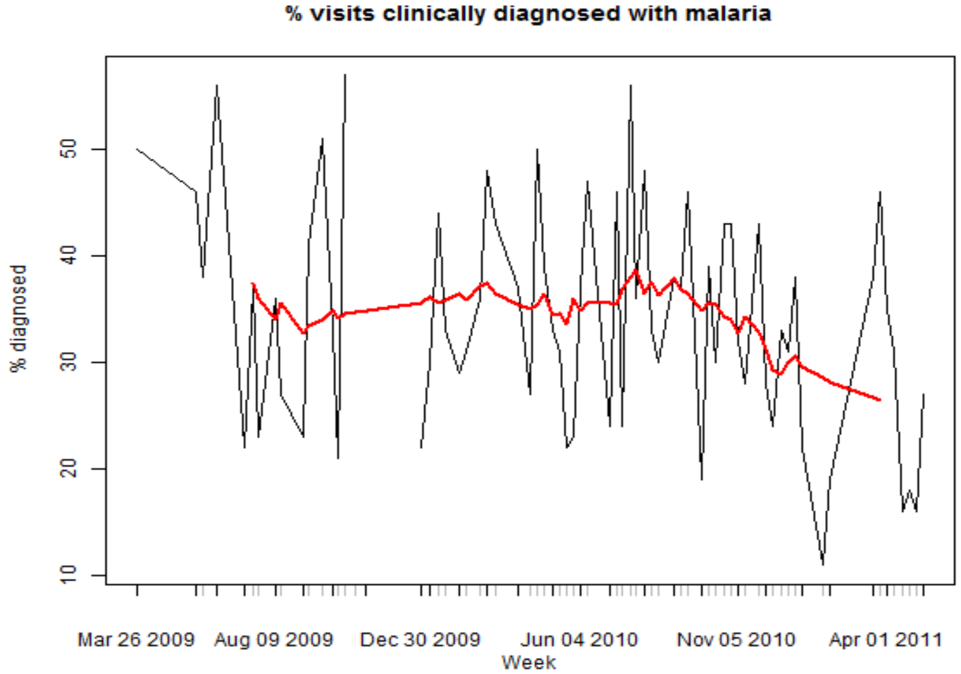

No. of positive malaria tests
0
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
HealthPost
0
0.25
0.5
1 Kilometers

Figure 8 (on next page)

Proportion of patients attending the Health Post diagnosed with malaria 2009 -2011, Linga Linga, Mozambique.


Number of weekly visits to healthpost
Weekly visits
90
80
70
60
50
40
30
Mar 26 2009
Sep 06 2009
Feb 05 2010
Jul 02 2010
Dec 03 2010
May 06 2011
Week

A


% visits clinically diagnosed with malaria
% diagnosed
50
40
30
20
10
Mar 26 2009
Aug 09 2009
Dec 30 2009
Jun 04 2010
Nov 05 2010
Apr 01 2011
Week

B

Table 1 (on next page)

Summary of data sets from the prevalence surveys 2007-2011, Linga Linga peninsular, Mozambique.

Year	Raw data				Matched data		
	Number of individuals	% with house number	Number of Houses	% Positive	Number of individuals	Number of Houses	% Positive
2007	411	91%	229	16%	308	179	15%
2008	345	59%	158	34%	191	136	24%
2009	435	68%	183	65%	285	160	67%
2010	398	56%	137	29%	220	127	27%
2011	282	48%	103	44%	131	99	44%
Total	1871	66%	230	38%	1135	332	35%

Table 2 (on next page)

Individual and household characteristics by malaria status

Summaries of individual and household characteristics by malaria status and adjusted oddratios obtained from fitting a multiple logistic regression model to the data from malaria prevalence surveys 2007-2011, Linga Linga peninsular, Mozambique

	Malaria test result							
	Positive		**Negative**		**Total**	**OR**	**95% CI**	**p-value**
	N	**(%)**	**N**	**(%)**				
Year								
2007	45	(15%)	263	(85%)	308			
2008	46	(24%)	145	(76%)	191	1.9082	(1.10 3.29)	0.0206
2009	190	(67%)	94	(33%)	284	11.3694	(7.29 18.07)	<0.0001
2010	60	(27%)	160	(73%)	220	3.0543	(1.88 5.00)	<0.0001
2011	57	(44%)	74	(56%)	131	4.9673	(2.88 8.63)	<0.0001
Sex								
Female	226	(32%)	472	(68%)	698			
Male	167	(40%)	255	(60%)	422			
Missing	5	(36%)	9	(64%)	14			
Age group								
< 1	12	(27%)	32	(73%)	44			
1-4	39	(44%)	49	(56%)	88	2.7067	(1.04 7.50)	0.0472
5-9	108	(45%)	133	(55%)	241	3.3090	(1.40 8.44)	0.0086
10-15	106	(39%)	167	(61%)	273	2.2208	(0.94 5.64)	0.0783
16-25	21	(21%)	78	(79%)	99	0.7552	(0.28 2.14)	0.5879
>25	83	(27%)	223	(73%)	306	1.1822	(0.50 3.00)	0.7119
NA	29	(35%)	54	(65%)	83			

	Malaria test result							
	Positive		**Negative**		**Total**	**OR**	**95% CI**	**p-value**
	N	**(%)**	**N**	**(%)**				
Used net								
No	124	(30%)	289	(70%)	413			
Yes	143	(38%)	229	(62%)	372			
NA	131	(38%)	218	(62%)	349			
No people								
1	46	(26%)	134	(74%)	180			
2	137	(37%)	231	(63%)	368	1.425	(0.86 2.39)	0.1744
3	120	(43%)	160	(57%)	280	1.849	(1.09 3.17)	0.0236
>3	95	(31%)	211	(69%)	306	0.932	(0.55 1.61)	0.7987
No bedrooms								
1	314	(34%)	600	(66%)	914			
2	70	(38%)	113	(62%)	183			
3	14	(38%)	23	(62%)	37			
Own animals								
Yes	248	(35%)	468	(65%)	716			
No	150	(36%)	268	(64%)	418			
Wall category								
Other	53	(39%)	83	(61%)	136			
'Green'	331	(35%)	621	(65%)	952			

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	Malaria test result							
	Positive		**Negative**		**Total**	**OR**	**95% CI**	**p-value**
	N	**(%)**	**N**	**(%)**				
NA	14	(30%)	32	(70%)	46			
Roof category								
Other	93	(30%)	222	(70%)	315			
'Green'	293	(37%)	501	(63%)	794	2.163	(1.41 3.38)	0.0005
NA	12	(48%)	13	(52%)	25			
Water source category								
House	62	(31%)	138	(69%)	200			
Neighbouring	84	(28%)	214	(72%)	298			
Well	252	(40%)	384	(60%)	636			
Washing category								
House	70	(27%)	188	(73%)	258			
Neighbouring	75	(30%)	175	(70%)	250			
Well	253	(40%)	373	(60%)	626			

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