

# Factors Associated with Prevalence of Malaria Infection among Children under 5 Years of Age in Mozambique: 2015 vs 2018

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## Research

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## Abstract

**Background:** Malaria is still a leading cause of morbidity and mortality among children under five years old in Mozambique. In this study we sought to determine the prevalence of malaria infection and its predictors among children six to 59 months old in Mozambique.

**Methods:** Data from two national malaria indicators surveys in 2015 and 2018 were compared. In both surveys, blood samples were collected among children six to 59 months old to detect *Plasmodium falciparum* antigen by a rapid diagnostic test, and questionnaires were applied to collect socio-economic, demographic and vector control data from their households. Association of malaria rapid diagnostic test positivity with age, gender, residence, region, use of a vector control intervention, mother's level of education and wealth index was assessed by logistic regression, using both univariate and multivariate analysis. A complex sampling logistic regression model was used to identify factors associated with malaria infection with estimated adjusted odds ratio and respective 95% confidence intervals.

**Results:** A total of 9,068 children were tested for malaria infection of which 4,640 were in 2015 and 4,428 in 2018. The prevalence of malaria infection was 40.2% and 38.9% in 2015 and 2018, respectively. From 2015 to 2018, insecticide-treated nets ownership increased from 72.3% to 90.2% ( $p < 0.001$ ) and insecticide-treated nets use increased from 45.5% to 72.4% in children under the age of 5 years ( $p < 0.001$ ). In multivariate analysis, malaria infection was associated with region (north and central regions) and rural area for both surveys. Living in households with a wealth quintile lower than the wealthiest was associated with an increased odds of malaria infection ( $p < 0.001$ ). Maternal level of education and absence of an insecticide-treated net in the household were associated with malaria infection in 2015 ( $p < 0.001$ ) but not in 2018. Malaria infection was associated with age older than 12 months in 2015 and with age 24-35 months and 48-59 months in 2018.

**Conclusions:** Although insecticide-treated nets ownership and use have increased between the two surveys, prevalence of malaria infection remained stagnant. The main predictors of malaria infection were region, place of residence and socioeconomic status, underscoring the importance of broader developmental and socioeconomic factors on malaria prevalence.

## Background

Malaria is still a leading cause of morbidity and mortality among children under five years of age around the world. In 2018, 228 million cases and 405,000 deaths from malaria were reported globally. The sub-Saharan Africa region accounted for 93% of the cases and 94% of the deaths. Mozambique contributed 4% of the global malaria case burden (1). The distribution of malaria prevalence in Mozambique is heterogeneous, with a higher prevalence in the northern and central regions compared to the southern region (2). The National Malaria Control Program (NMCP) of Mozambique developed the 2017–2022 National Strategic Plan to implement and monitor interventions for malaria control. In order to reduce the burden of malaria in the country, the NMCP is investing resources in a combination of vector control and case management interventions (3). However, the impact of the interventions on high risk populations and areas of high prevalence is not yet known. Understanding the factors associated with the prevalence of malaria infection and its distribution is important to improve the planning of national and sub-national malaria control strategies.

Previous global research on the factors associated with malaria prevalence and distribution have shown varied results. Some studies have shown that access and use of prevention strategies such as insecticide treated nets (ITNs) and indoor residual spray (IRS) reduced malaria prevalence (4, 5) while in others the use of these strategies have shown no significant impact (6). Higher socioeconomic and educational status have also been indicated as protective by some authors (7) while others found no relation (8). In this analysis we sought to determine the prevalence of malaria infections and its predictors among children six to fifty-nine months old in Mozambique by comparing the 2015 Malaria, HIV/AIDS, and Immunization Indicator Survey (IMASIDA) and the 2018 Malaria Indicator Survey (MIS). The analysis will provide information on the coverage of interventions for malaria control and factors associated to the prevalence of malaria. These information can support the NMCP to strengthen the planning malaria control interventions.

## Methods

### Study setting

The analysis is based on two nation-wide surveys. Mozambique is divided in three regions, northern, central, and southern. The northern region includes the provinces of Niassa, Cabo Delgado and Nampula, and the central region includes the provinces of Tete, Zambézia, Manica and Sofala, and the southern region includes the provinces of Inhambane, Gaza, Maputo and Maputo City. Typically, Mozambique has a tropical climate with two distinct seasons: a hot and humid season from October to March and a dry and cool season from April to September, although there are variations depending on the region and altitude. Malaria transmission is higher in the hot and humid season due to the abundance of water and vegetation, which favours breeding of *Anopheles* mosquitoes. *P. falciparum* accounts for 90% of all malaria infections (9).

## Study Design and data source

We conducted a retrospective analysis of data from two community-based surveys conducted in 2015 and 2018. The IMASIDA was conducted from June to September in 2015, while the MIS was conducted from March to June 2018. For both surveys, the sampling was representative nationally, for rural and urban areas, and at the provincial level. Households were selected using data from the General Population and Housing Census 2007 (RGPH 2007). In the first stage of sampling, Enumeration Areas (EAs) were selected from the total EA outlined in the RGPH 2007, with probability-proportional-to-size, in which some were located in urban areas and others in rural areas. A total of 307 EAs, in which 134 (43.6%) were urban, were selected for the IMASIDA 2015 and 224 EAs, in which 92 (41.1%) were urban, were selected for the MIS 2018. In the second sampling stage, all households within the EA were listed followed by random selection of households. A total of 24 and 28 households per EA were selected for the IMASIDA 2015 and for the MIS 2018, respectively. In total, 7,368 households were selected in IMASIDA 2015 and 6,279 households were selected in MIS 2018. Women aged 15–49 years and children aged 6–59 months, who were habitually resident or had spent the night before the survey in the household were eligible for interview and malaria testing respectively. For the IMASIDA, responses rates were 97.6% for selected households and 94.5% for eligible women; for the MIS 2018, response rates were 99.0% for households and 98.3% for eligible women.

## Data collection

For both surveys data was collected from three sources: i) a household questionnaire was used to collect information to determine the household wealth index, information of the household ownership and use of insecticide treated nets (ITN), and exposure to indoor residual spraying (IRS); ii) a questionnaire addressed to women aged 15–49 was used to collect information on age, residence history, educational level, intermittent preventive treatment of malaria during pregnancy, use of ITN, treatment of malaria in children under 5 years of age and knowledge of malaria; iii) a biomarkers questionnaire was used to record the results of the malaria and anaemia tests in children 6–59 months of age.

## Malaria testing

Malaria tests were performed using capillary blood samples taken from the fingers or heels of included children. In the IMASIDA 2015, malaria testing was performed using rapid diagnosis test (RDT) SD Bioline Malaria Ag Pf and Pv (Abbott) to detect *P. falciparum* and *P. vivax* antigens while in the MIS 2018 the RDT was SD Bioline Malaria Ag Pf (Abbott) which detects only the *P. falciparum* antigen.

## Statistical analysis

To prepare the data for analysis, the individual members (PR) datasets from both surveys were merged into one dataset. Special (svy) survey commands were used to account for complex multilevel survey design. Data were weighted to account for the differential selection probabilities at the EA, household and individual levels. Only weighted survey data are presented in this manuscript. Socio-economic, demographic and vector control characteristics were compared between 2015 and 2018 using *t-student* test. Logistic regression was used to evaluate factors associated with presence of *Plasmodium sp* antigen as detected by RDT among children under 5 years of age (dependent variable). The independent variables included: age; gender; residence (urban vs rural); region (southern, central or northern); use of ITNs; IRS in the past 6 months; highest education level attained by the mother; and wealth index. Multivariate complex sampling logistic regression was used to identify factors associated with malaria infection, with estimated adjusted odds ratio (AOR) and respective 95% confidence intervals (CI). All statistical analyses were performed using Stata, version 15 (Stata Corporation, College Station, Texas).

## Ethical considerations

For both surveys, ethical approval was obtained from the Mozambique National Bioethics Committee for Health (CNBS) prior to data collection, IMASIDA 2015 (42/CNBS/2014) and MIS 2018 (69/CNBS/18). Written informed consent was obtained from study participants. Parental consent was also provided for all children who were tested for malaria and anaemia.

## Results

### General characteristics of study participants and prevalence of malaria infection

A total of 9,068 children under the age of five years were tested for malaria infection, of which 4,640 (51.2%) from the 2015 survey and 4,428 (48.8%) from the 2018 survey. Table 1 shows the socio-demographic characteristics of study participants for both surveys; no significant differences were found. The proportion of households who owned at least one ITN was significantly higher in 2018, with 72.3% in 2015 and 90.2% in 2018 ( $p < 0.001$ ). Similarly, the proportion of children under 5 years who reported sleeping under ITN the night before the survey increased from 45.5% in 2015 to 72.4% in 2018 ( $p < 0.001$ ).

Table 1  
Demographic characteristics of children 6–59 months old and vector control interventions indicators in two surveys in Mozambique, 2015 and 2018.

Variable	IMASIDA 2015 N = 4640		MIS 2018 N = 4428		P value
	n	% (95% CI)	n	% (95% CI)	
Malaria infection					
Negative	2773	59.8 (55.6–63.8)	2705	61.1 (56.3–65.7)	0.696
Positive	1867	40.2 (36.2–44.4)	1723	38.9 (34.3–43.7)	
Gender					
Male	2312	49.8 (48.0–51.7)	2248	50.8 (48.4–53.1)	0.531
Female	2328	50.2 (48.3–52.0)	2179	49.2 (46.9–51.6)	
Child's age in months					
6–11	492	10.6 (9.6–11.7)	526	11.9 (10.6–13.2)	0.243
12–23	1073	23.1 (21.9–23.4)	967	21.8 (20.1–23.6)	
24–35	1020	22.0 (20.6–24.6)	988	22.3 (20.5–24.2)	
36–47	1069	23.0 (21.6–24.6)	953	21.5 (19.9–23.2)	
48–59	986	21.3 (19.9–22.7)	994	22.5 (21.0–24.0)	
Maternal education level					
No education	1272	30.2 (26.9–33.8)	1005	26.1 (22.2–30.5)	0.062
Primary	2343	55.7 (52.4–58.9)	2085	54.2 (49.6–58.8)	
Secondary/Higher	595	14.1 (12.2–16.4)	755	19.6 (15.1–25.1)	
Region					
North	1775	38.25 (32.9–44.0)	1600	36.2 (29.0–44.0)	0.436
Central	1845	39.8 (34.5–45.3)	2044	46.2 (38.4–54.2)	
Southern	1020	22.0 (18.4–26.0)	783	17.7 (14.0–22.1)	
Place of residence					
Rural	3505	75.5 (71.1–79.5)	3238	73.1 (67.0–78.5)	0.598
Urban	1135	24.5 (20.6–28.9)	1189	26.9 (21.5–33.0)	
Wealth Index					
Poorest	1099	23.7 (21.0–26.6)	1058	23.9 (20.0–26.1)	0.989
Poorer	1051	22.6 (20.2–25.3)	1031	23.3 (20.2–26.7)	
Middle	984	21.2 (18.7–23.9)	913	20.6 (17.6–24.0)	
Richer	873	18.8 (16.3–21.7)	834	18.8 (15.7–22.4)	
Richest	633	13.6 (11.3–16.3)	591	13.4 (10.7–16.5)	
Household has at least one ITN					
Yes	3353	72.3 (68.9–75.4)	3996	90.2 (87.4–92.5)	< 0.001
No	1287	27.7 (24.6–31.1)	432	9.8 (7.5–12.6)	
Child under 5 slept under LLIN					
Yes	2110	45.5 (42.4–48.6)	3204	72.4 (69.2–75.3)	< 0.001

Variable	IMASIDA 2015		MIS 2018		<i>P value</i>
	N = 4640		N = 4428		
	n	% (95% CI)	n	% (95% CI)	
No	2530	54.5 (51.4–57.7)	1224	27.6 (24.7–30.8)	
IRS					
Yes	594	12.8 (10.2–16.0)	680	77.0 (73.1–80.4)	< 0.001
No	3987	86.0 (82.6–88.8)	200	22.6 (19.2–26.5)	
Don't know	57	1.2 (0.1–1.7)	4	0.4 (0.0-1.2)	

The overall prevalence of malaria infection was 40% in 2015 and 39% in 2018 (Table 1). Changes in malaria infection prevalence were observed in some provinces from 2015 to 2018. In the province of Cabo Delgado, the prevalence of malaria infection increased from 29.4–57.3% while in the province of Zambézia the prevalence of malaria infection decreased from 67.9–44.3% (Fig. 1).

## Analysis of factors associated with malaria infection among children under 5 years of age

As shown in Tables 2 and 3, in the bivariate analysis of both surveys malaria infection was associated with living in northern or central region, living in rural areas, mother's low level of education and low household wealth ( $p < 0.05$ ). No ITN ownership was associated with malaria infection, in the 2015 survey, while age 24–35 months and 48–59 months were associated with malaria infection in the 2018 survey ( $p < 0.05$ ).

Table 2  
Logistic regression analysis of factors associated with malaria parasitaemia in children 6–59 months old in Mozambique in 2015 IMASIDA

Variable	Bi-variable analysis		Multivariable analysis	
	OR(95% CI)	p-value	AOR (95% CI)	p-value
Gender				
Male	1		1	
Female	0.9 (0.8-1.1)	0.259	1.0(0.8-1.1)	0.529
Child's age in months				
6–11	1		1	
12–23	1.4 (1.1–1.9)	0.018	1.6 (1.1–2.0)	0.015
24–35	1.8 (1.4–2.4)	< 0.001	2.1 (1.6–2.9)	< 0.001
36–47	1.6 (1.2–2.1)	0.003	1.8 (1.3–2.4)	0.001
48–59	1.7 (1.3–2.3)	< 0.001	2.0 (1.5–2.6)	< 0.001
Mother's education level				
Secondary/Higher	1		1	
No education	4.7 (3.0-7.5)	< 0.001	1.6 (1.1–2.3)	0.028
Primary	3.7 (2.5–5.4)	< 0.001	1.5 (1.1–2.1)	0.007
Region				
Southern	1		1	
North	7.1 (4.6–10.8)	< 0.001	3.5 (2.1–5.7)	< 0.001
Central	4.3 (2.8–6.6)	< 0.001	2.1 (1.3–3.4)	0.002
Location of residence				
Urban	1		1	
Rural	3.7 (2.3–5.9)	< 0.001	1.8 (1.1-3.0)	0.022
Wealth index				
Richest	1		1	
Richer	4.0 (2.7-6.0)	< 0.001	2.8 (1.8–4.3)	< 0.001
Middle	7.6 (4.9–11.9)	< 0.001	3.6 (2.1–6.3)	< 0.001
Poorer	14.6 (9.2–23.0)	< 0.001	5.6 (3.3–9.7)	< 0.001
Poorest	19.0 (12.1–29.8)	< 0.001	6.8 (4.0-11.8)	< 0.001
Household with child < 5 which has at least one ITN				
Yes	1		1	
No	1.5 (1.2–1.9)	< 0.001	1.3 (1.0-1.6)	0.033
Child < 5 slept under ITN last night				
Yes	1		1	
No	1.0 (0.8–1.3)	0.854	0.8 (0.7–1.1)	0.140
IRS				
Yes	1		1	
No	1.0 (0.6–1.7)	0.993	0.5 (0.3-1.0)	0.042

Table 3  
 Logistic regression analysis of factors associated with malaria parasitaemia in children 6–59 months old in Mozambique, MIS 2018.

Variable	Bi-variable analysis		Multivariable analysis	
	OR (95% CI)	p-value	AOR (95% CI)	p-value
Gender				
Male	1		1	
Female	0.9 (0.8–1.11)	0.414	1.0 (0.4–1.9)	0.948
Child's age in months				
6–11	1		1	
12–23	1.2 (0.8–1.6)	0.340	1.3 (0.7–2.4)	0.353
24–35	1.5 (1.2–2.0)	0.003	2.1 (1.3–3.5)	0.005
36–47	1.2 (0.9–1.7)	0.233	1.6 (0.7–3.3)	0.219
48–59	1.4 (1.1–1.9)	0.020	2.1 (1.3–3.6)	0.005
Mother's education level				
Secondary/Higher	1		1	
No education	6.1 (4.0–9.3)	< 0.001	1.1 (0.4–2.9)	0.817
Primary	4.1 (2.9–5.7)	< 0.001	1.7 (0.8–3.6)	0.146
Region				
Southern	1		1	
North	5.3 (3.3–8.5)	< 0.001	5.6 (2.5–12.9)	< 0.001
Central	3.4 (2.2–5.3)	< 0.001	4.3 (2.1–9.1)	< 0.001
Local of residence				
Urban	1		1	
Rural	3.8 (2.3–6.4)	< 0.001	2.3 (1.2–4.5)	0.016
Wealth index				
Richest	1		1	
Richer	8.9 (5.0–15.8)	< 0.001	2.0 (0.8–5.2)	0.135
Middle	24.4 (13.8–43.2)	< 0.001	5.0 (2.1–12.0)	< 0.001
Poorer	36.0 (19.9–65.1)	< 0.001	4.1 (1.8–9.4)	< 0.001
Poorest	47.5 (27.1–83.2)	< 0.001	5.4 (2.1–13.8)	< 0.001
Household with child < 5 which has at list one ITN				
Yes	1		1	
No	1.5 (1.0–2.3)	0.042	0.5 (0.2–1.4)	0.172
Child < 5 slept under ITN last night				
Yes	1		1	
No	0.9 (0.7–1.2)	0.548	1.2 (0.7–1.9)	0.508
IRS				
Yes	1		1	
No	0.9 (0.7–1.4)	0.741	1.0 (0.6–1.5)	0.821

As shown in Table 2, the results of the 2015 survey multivariate analysis showed that malaria infection was independently associated with children who were 12–23 months old (AOR 1.6; 95% CI: 1.1–2.0), 24–35 months old (AOR 2.1; 95% CI: 1.6–2.9), 36–47 months old (AOR 1.8; 95% CI: 1.3–2.4), 48–59 months old (AOR 2.1; 95% CI: 1.5–2.6), living in the northern region (AOR 3.5; 95% CI: 2.1–5.7) or central region (AOR 2.1; 95% CI: 1.3–3.4), living in rural areas (AOR 1.8; 95% CI: 1.1–3.0), mother with no education (AOR 1.6; 95% CI: 1.1–2.3) or with primary education level (AOR 1.5; 95% CI: 1.1–2.1), no ITN ownership (AOR 1.3; 95% CI: 1.0–1.6) and children living in poor households ( $p < 0.05$ ).

As shown in Table 3, the results of 2018 survey multivariate analysis showed that malaria infection was independently associated with age 24–35 months (AOR 2.1; 95% CI: 1.3–3.5) or 48–59 months (AOR 2.1; 95% CI: 1.3–3.6); living in the central region (AOR 4.3; 95% CI: 2.1–9.1) or northern region (AOR 5.6; 95% CI: 2.5–12.9); lower household wealth, and living in rural areas (AOR 2.3; 95% CI: 1.2–4.5).

## Discussion

The prevalence of malaria parasitemia in Mozambique remained high between the two surveys, 40% in 2015 and 39% in 2018, despite the significant increase in access to ITNs. These findings are similar to some previous studies in countries with high malaria prevalence that reported no malaria reduction after the increase of interventions for malaria control (4, 5).

In 2015 the probability of having malaria parasitemia was higher for children living in households with no ITNs, but not in 2018. Previous studies have reported reduction of malaria parasitemia for children living in household with at least one ITN (10, 11). Yet the finding in 2018, that showed no impact of ITN ownership with malaria parasitemia prevalence, is consistent with some other works (6, 12). Others studies conducted in African countries showed that the increase in the ITN ownership does not directly imply the reduction of malaria parasitaemia (5, 13, 14). There are many possible explanations for this findings, including those related to use. The irregular or inappropriate use of nets and possible exposure of children to mosquito bites during times of day when ITN are not in use could limit their impact (6). Also not all people who own ITN appropriately use it (15, 16) and others authors have attributed it to the lack of caregiver's knowledge to use ITN as the many reason for increase malaria parasitemia when the coverage of ITN is high (17). Mosquito insecticide resistance have been reported in Mozambique (18) which could also limit the effectiveness of ITNs to protect against malaria. This information can provide valuable guidance to the NMCP on the need to implement others control measures (6).

Children older than 12 up to 59 months of age had higher odds of testing positive for malaria in 2015 and in 2018 only children aged 24–35 months and 48–59 months had higher odds of testing positive. These findings are consistent with previous studies (8, 17, 19). As suggested by other authors older children have higher probability of being bitten by mosquitoes when they are playing in the evening while younger children up to 24 months of age may have lower exposure (17). On the other hand, children in areas of high malaria transmission intensity develop immunity while they grow due to the continuous exposure to infective mosquitoes' bites. This immunity allow older children to harbour parasites without developing malaria symptoms (20, 21). These children with no sterilizing immunity can be a reservoir of parasites and drive malaria transmission Therefore, assessing the prevalence of asymptomatic malaria infections is useful in high transmission areas to guide the designs of interventions for malaria control. Our findings also suggest that other interventions, such as malaria chemoprophylaxis, may be warranted to protect this risk group (22, 23).

The results from these two surveys showed that children from poorer families were more likely to test positive for malaria parasitemia compared to those from wealthiest families, a finding common across several African countries (19, 24). Other studies in African countries have found that children from higher socioeconomic status families were more likely to sleep under ITN compared to those from lower socioeconomic strata (25). We also found in both surveys that children living in rural areas have higher risk of malaria infection compared to those in urban area (26, 27). These results may be explained by previous reports that indicate that rural areas are more suitable breeding grounds for malaria vectors (27). In addition, in rural areas there is a greater probability of finding precarious housing that facilitates the entry of mosquitoes (28). The finding that low wealth index and living in rural areas contribute to increase malaria prevalence shows that the interventions to malaria control cannot be isolated, but must involve improving socio-economic status of the population, like improving environment sanitation to avoid mosquitoes breeding and improving house conditions to avoid biting (6).

In 2015, children from mothers with primary level or no education had higher probability of testing positive for malaria parasitemia. Other studies have reported that lower education as risk factor for malaria parasitemia (29). Mothers with lower education are more likely to develop activities that expose them to mosquito bites and are potentially less informed on how to protect their children from malaria (8).

## Limitations Of The Study

It is important to note, that data collection for the two surveys was performed at slightly different transmission season. This may can mask the impact of malaria control interventions over the years.

## Conclusions

From 2015 to 2018 the prevalence of malaria parasitemia in children under five years old in Mozambique was stagnant although vector control interventions increased. Our findings show that malaria in Mozambique remains a disease associated to low wealth index and living in rural areas. It suggests that multiple factors like mother's education, wealth index, area of residence must be considered on malaria control interventions, underscoring the importance of integrated responses that address both the malaria vector and the underlying socioeconomic vulnerabilities that facilitate its spread.

## Abbreviations

AOR – Adjusted Odds Ratio; CI – Confidence Intervals; CNBS – National Bioethics Committee for Health; EA – Enumeration Areas; IMASIDA – Malaria, HIV/AIDS and Immunization Indicator Survey; IRS – Indoor Residual Spaying; ITN – Insecticide Treated Nets; MIS – Malaria Indicator Survey; NMCP – National Malaria Control Program; OR – Odds Ratio; RDT – Rapid Diagnosis Test; RGPH – General Population and Housing Census

## Declarations

### Ethics approval and consent to participate

The IMASIDA 2015 and MIS 2018 protocols were approved by the ICF Institutional Review Board and the Mozambican National Bioethics Committee. Prior to enrolment, all eligible participants from both surveys provided written informed consent to participate. The consent was obtained from the mother or guardian of a child. The data were analysed anonymously.

### Consent for publication

Not applicable.

### Availability of data and materials

The datasets analysed on this study are available in the DHS Program, [<https://dhsprogram.com/what-we-do/survey-Types/dHs.cfm>].

### Competing interests

The authors declare that they have no competing interests.

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## Authors' contributions

SE conceptualization and revision of manuscript; CS writing original manuscript; PA writing and revision of manuscript. AC data analysis and revision of manuscript. BR, AS and BC Revision of manuscript. All authors read and approved the final manuscript.

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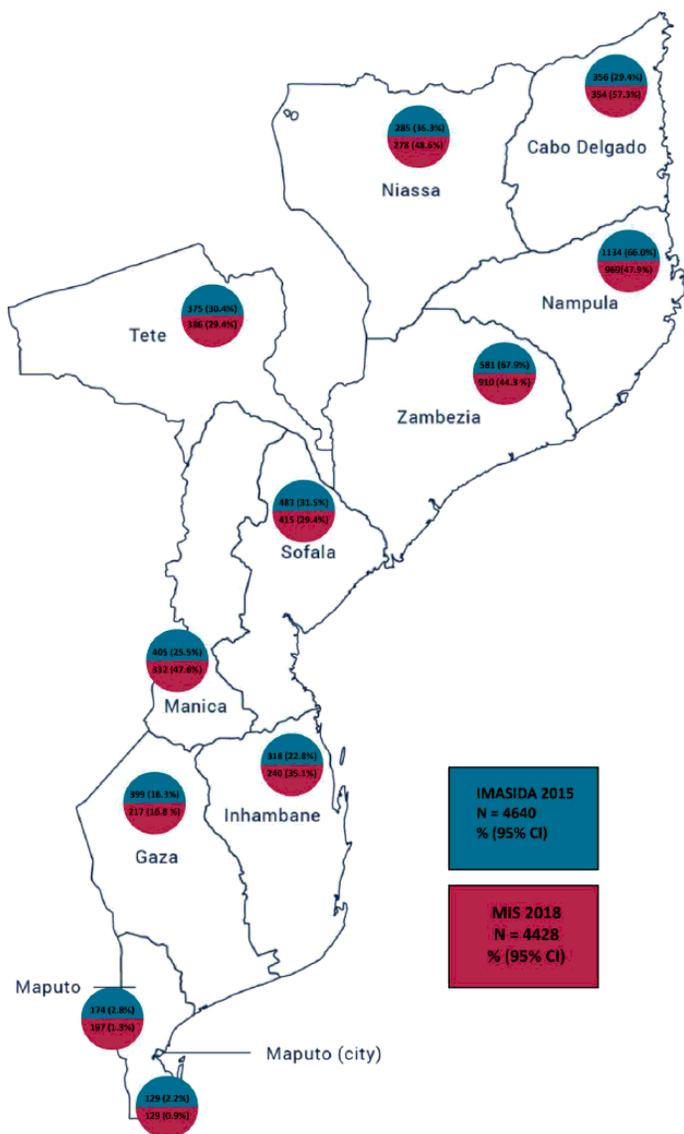
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## Figures



**Figure 1**

Distribution of malaria prevalence in children 6-59 months old in Mozambique by province, 2015 and 2018