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Reduced Plasmodium Infection in Primary School Children Following Universal Distribution of Insecticide Treated Bed Nets in Kasipul, Homa-Bay County, Kenya

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Abstract

Malaria is endemic in areas bordering Lake Victoria basin of Kenya. Untreated malaria in school children, result in reduced ability to concentrate and learn in school. Available data show that the overall prevalence of *Plasmodium* among primary school children in Kasipul was 25.8 % in 2013. There was a need to establish the current status of *Plasmodium* prevalence in Kasipul following mass distribution of insecticide treated nets (ITNs) in 2014. This study assessed the prevalence of *Plasmodium* infection among school children living in Kasipul and their reported use of bed nets, one year after mass distribution of ITN in Kasipul, Homa-Bay County. A cross-sectional study of 398 primary school pupils was conducted in the area. Pupil's finger prick blood was used for malaria parasite detection by microscopy. Data on ITNs use was collected using a questionnaire. The overall prevalence of *Plasmodium* among children was 10.05%. The association between net ownership and *Plasmodium* prevalence among pupils was significant ($\chi 2= 14.46$, df =1, p = 0.000). The study observed a significant decline in *Plasmodium* prevalence from 25.8% in 2011 to 10.05% in 2016, providing evidence that ITNs, which was the major control strategy implemented in Kasipul reduced *Plasmodium* infection in the study population. Overall pupil net ownership increased from 33% in June 2014 to 51% in 2016. In conclusion, the prevalence of *Plasmodium* infections reduced significantly following distribution of free ITNs in Kasipul. The study demonstrates that universal distribution of free ITNs is an effective strategy in reducing the prevalence of *Plasmodium* infection among school children.

Keywords: Insecticide treated nets; Malaria reduction; School Children; Homa-Bay.

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1. Introduction

In 2013, approximately 198 million cases of malaria and 584,000 deaths occurred globally, and 90% of the deaths were in Sub-Saharan Africa which bears the heaviest brunt of malaria, with 77% among children under the age of five years [1]. Eighty per cent of malaria cases in Africa occurred in thirteen countries, and over half were in Nigeria, Democratic Republic of Congo, Ethiopia, United Republic of Tanzania and Kenya [2]. Kenya has an estimated malaria mortality rate of 27.7 per 100,000 people, malaria accounting for almost 9 million outpatients cases annually [3]. Kasipul experiences a 25.8 % *Plasmodium* prevalence among primary school children [4]. Infection with *Plasmodium falciparum* can give rise to neuro-cognitive impairments, affecting speech, language and memory in affected children [5, 6].

Studies indicate that school children are rarely treated for asymptomatic *Plasmodium* infections and they can contribute considerably to the infectious reservoirs of malaria [7]. Asymptomatic *Plasmodium* infections, if untreated in children, persist and maintain malaria induced inflammation associated with iron deficiency anaemia in primary school age children. Repeated episodes of malarial anaemia affect child development as well as school attendance [8, 9]. Even though, school children are included in all malaria control strategies, often they have the lowest ownership of malaria preventive measures, such as mosquito bed nets, because of misuse such as ITNs being used for economic activities in agriculture and fishing [10]. While reduction of infections is observed in children below five years that are targeted by control measures, *Plasmodium* prevalence among school children may even increase, as observed after the national distribution of bed nets in Kenya [11].

Insecticidal nets are dependable malaria control tools [12]. Since 2001, use of ITNs has prevented over three million malaria-related deaths [13]. When used by more than eighty per cent in a particular village, ITN protects everyone in the area, including households without nets since fewer people are bitten due to a reduced mosquito population and this provides community protection [14]. Few data exist on patterns of ITN use and effectiveness of nets in controlling malaria among primary school children [15]. The ministry of health (MOH) in Kenya commonly uses mass net distribution campaigns done every three years as a strategy to control malaria in populations living in epidemic prone and endemic areas of the country. In 2011, ITN policy was changed to cover the entire population at risk regardless of age and sex. In 2014, the third round of mass distribution was launched in Kenya to boost ITN coverage and replace old nets[16]. In the last 10 years, ownership of ITN has increased from 6% to 68% in malaria endemic Lake Victoria basin of Kenya [17]. However, reported use of bed net among primary school children is considerably low (33%), mostly because these children do not sleep under bed nets and the increase in *Plasmodium* prevalence among school children in the region likely reflects an increase in exposure to infective *Anopheles* mosquito bites [11].

Previous studies in other parts of Africa have found that even after universal net distribution, school children were significantly less likely to use ITNs compared to other age groups [18]. There is an urgent need for research into the effectiveness of ITNs in controlling *Plasmodium* infection among primary school children in particular malaria endemic areas such as Kasipul, which benefited from free distribution of ITNs in September 2014. The findings of this study shed light on the overall prevalence of *Plasmodium* infection among primary school children following mass distribution of free ITNs as the main strategy in the control of infections in this part of Kenya. Such information provides a rationale for targeting schools and school children to assess effectiveness of ITNs in controlling *Plasmodium* infection.

2. Materials and methods

2.1. Description of the Study Area

The study was conducted in Kasipul located within Homa-Bay County (34.75 to 34.95°E, 0.41 to 0.52°S)[19]. Kasipul lies within the Lake Victoria basin, which has high overall malaria prevalence of 40% [20], among the residents. It has an area of 365.5 sq. Kms and a population of 129,854 [19]. The altitude is between 1400 m to 1600 m. Most malaria is caused by *P. falciparum* [4]. This region benefited from free distribution of ITN in 2014[21].

2.2. Study design

A school-based cross-sectional study targeting pupils from nine randomly selected primary schools within Kasipul, Homa-Bay County was undertaken to establish the prevalence of *Plasmodium* infections among primary school children. The minimum sample size was determined using the formula $n = t^2p(1-p)/m^2$ [22], by setting area prevalence at 40.0% [20], precision 0.05 (5%) and confidence level at 95% (standard value of 1.96), the minimum sample size for this study was 369 subjects. The sample size was increased to 450 children to account for eventualities such as failure to sign an informed consent form and absenteeism, in the end complete data for a total 398 pupils was obtained. Random sampling technique was employed to select participants.

Blood lancet was used to puncture the child's finger to obtain two blood samples of about 5 µl each and used to prepare thick and thin blood smears for malaria parasite diagnosis using microscopy technique. A questionnaire was also used to collect information on demographic characteristics, ownership and usage of ITNs. The data was analysed using Statistical Package for Social Sciences (SPSS) computer software. The association between variables was tested using Chi-Square. Odds ratio (OR) was used to assess the strength of association between various risk factors and *Plasmodium* infection. A difference, giving a p-value <0.05 was considered statistically significant.

2.3. Ethical consideration and clearance

Ethical clearance certificate for the study was obtained from the Ethical Review Committee, Kenyatta University. Research permit for this study was issued by the National Council for Science, Technology and Innovation (NACOSTI). Consent from the parents of participating children was also obtained.

3. Results

This survey included school children from Kalando, Kokwanyo, Agawo, Umai, Andingo, Nyawango, Omiro, Got and Manga primary schools in Kasipul. Of the total 398 pupils studied, male were 206 (51.76%) and female were 192 (48.24%). The minimum age was 9 years and maximum age was 18 years.

3.1. Prevalence of Plasmodium by demographic characteristics of participants

Analysis of blood smears from study participants revealed an overall prevalence of malaria of 10.05 %, (40 out of 398 children positive for malaria). Eighteen (8.74%) out of the 206 male children had malaria parasites against 22 (11.46%) of the 192 females. Pupils' gender had no significant effect on malaria prevalence ($\chi 2$= 0.814, df = 1, p = 0.367). The highest infection rate of 11.4% was recorded in respondents of 12-14 years age set. Pupils not owning ITNs were 4.1 times (95% CI: 1.89, 8.81) more likely to acquire *Plasmodium* infection compared to children owning treated bed nets (Table 3.1).

Table 1: Demographic characteristics and prevalence of *Plasmodium* in children

Variable	**N**	**Malaria parasite infection**		**χ2 (df)**	***p*-value**	**OR**	**95%**
		Positive n (%)	**Negative n (%)**				**CI**
Sex							
Males	206	18 (8.7)	188 (91.3)	0.392	0.531	1.35	0.70-2.60
Female	192	22 (11.46)	170 (88.5)	0.421	0.516	1	
Totals	**398**	**40 (10.05)**	**358 (89.9)**	**0.814 (1)**	**0.367**		
Age(Years)							
9-11	94	6 (6.4)	88 (93.6)	1.398	0.237	0.59	0.19-1.83
12-14	238	27 (11.4)	210 (88.6)	0.473	0.492	1.10	0.46-2.66
15-17	66	7 (10.8)	60 (89.2)	0.2601	0.847	1	
Totals	**398**	**40 (10.05)**	**358 (89.9)**	**2.131 (3)**	**0.546**		
ITN Ownership							
No	195	31(15.8%)	165(84.1%)	7.2878	0.000	4.075	1.89-8.81
Yes	203	9(4.4%)	194(95.6%)	7.1714		1	
Totals	**398**	**40(10.05%)**	**358(89.9%)**	**14.46(1)**			

Overall *Plasmodium* prevalence was 10.05%. Pupils not owning ITNs were 4.1 times (95% CI: 1.89, 8.81) more likely to acquire *Plasmodium* infection compared to children owning treated bed nets

3.2. ITN ownership and Plasmodium prevalence per school

Table 3.2 shows that insecticide treated net ownership varied per school, ranging from 34.1 % in Omiro primary school to 73.8% in Kokwanyo primary. The data reveals that distribution of free ITNs was not implemented uniformly in Kasipul. Children from Kalando primary school, which registered the lowest ITN ownership (26.2%) were 9.9 times (95% CI: 1.18, 82.95) more likely to be infected with *Plasmodium* compared to children from Manga primary school. Majority of schools, which recorded high ITN ownership, registered low *Plasmodium* prevalence among children.

Table2: ITN ownership and *Plasmodium* prevalence per school

School	n	ITN ownership n (%)	Malaria Positive No. (%)	OR	95% CI Lower	Upper	P-value
Kalando	42	11 (26.2)	8 (19.5)	9.88	1.177	82.95	**0.04**
Kokwanyo	45	33 (73.3)	4 (8.9)	4.10	0.439	38.23	0.22
Agawo	44	26 (59.1)	1 (2.27)	0.98	0.059	16.13	0.99
Umai	49	17 (34.7)	10 (20.4)	10.77	1.317	88.06	**0.03**
Andin'go	39	23 (59.0)	3 (7.7)	3.50	0.349	35.14	0.29
Nyawango	49	28 (57.1)	4 (8.2)	2.74	0.274	27.36	0.39
Omiro	44	15 (34.1)	4 (9.1)	4.20	0.450	39.20	0.21
Got	43	21 (48.8)	5 (14)	6.81	0.783	59.21	0.08
Manga	43	29(67.4)	1 (2.3)	1			
TOTAL	**398**	**203 (51.0)**	**40(10.05)**				

Children from Umai were 10.8 times (95% CI: 1.32, 88.1) more likely to be infected with *Plasmodium* compared to children from Manga.

3.3. Association between daily ITN usage and Plasmodium prevalence among pupils

The majority of respondents (75%) reported using ITN daily. The study revealed that children not using nets daily were 2.5 times (95% CI: 0.65, 9.70) more likely to acquire *Plasmodium* infection compared to daily net users.

Table 3: Association between daily ITN usage and *Plasmodium* prevalence among pupils

Daily ITN use	n	Malaria Positive	Negative	χ^2 (df)	p-value	OR	95% CI
No	51(25%)	4(7.8%)	47(92.2%)	1.3993	**0.172**	**2.5**	**0.65-9.70**
Yes	152 (75%)	5(3.3%)	147(96.7%)	0.4695		1	
Total	**203 (100%)**	**9(4.4%)**	**194(95.6%)**	**1.869(1)**			

Children not using ITN daily were 2.5 times (95% CI: 0.65, 9.70) more likely to acquire *Plasmodium* infection compared to net users.

4. Discussion

This survey of 398 primary school children in Kasipul reported a 10.05% prevalence of *Plasmodium*, which was high compared to less than 5% recorded in other parts of the country [23]. Similar primary school malaria surveys in Kasipul, reported a prevalence of 25.8% in 2011 [4]. The decrease in prevalence in the present study may be conceivably explained to be due to the effects of mass distribution of free ITNs. Effects of ITN ownership on *Plasmodium* infection prevalence were significant in this survey. Insecticidal nets kill and repel mosquitoes within a community[14]. Children aged 12-14 (11.4%) years were slightly more predisposed to *Plasmodium* infections, than those older than 15 years (10.8%) and malaria was slightly higher among female children (11.5%) compared to males (8.7%). Similar studies in Bumula, western Kenya, also revealed that malaria was more prevalent in primary school girls compared to boys [7]. According to cultural practices girls assist their mothers in domestic activities at home until late hours of the night which could expose them to more mosquito bites than boys [24]. Studies in Nigeria recorded low prevalence in 15-16 years age group. *Plasmodium* prevalence in both sexes followed a similar pattern; and infection rate in terms of sex was found not to be significant and therefore not sex- dependent [25]. The reported use of ITNs among school children in this study was high (75%) compared to previous reports of 33 % bed net usage among pupils in the same area [26]. Owning ITN in Kasipul was significantly associated with a lower risk of malaria parasitaemia among pupils. Insecticidal nets are indoor malaria control tools and mainly target indoor biting and resting species of *Anopheles* mosquitoes. They are ineffective in controlling vectors that rest and bite outdoor [27]. The recorded 3.3% infection among children using ITNs daily in this study may be due to *Plasmodium* parasite inoculations outside the house by *Anopheles arabiensis*. Unlike *Anopheles gambiae*, *Anopheles arabiensis* readily feeds and rests outside as well as indoors [28]. In Kilombero Valley in Tanzania, despite high coverage and usage of ITNs, *Anopheles arabiensis* has continued to maintain intense transmission of malaria over several years [29]. Studies indicate that *Anopheles arabiensis* is a common malaria vector in Kasipul [4].

5. Conclusions

This study established that the overall prevalence of *Plasmodium* infections among primary school children was 10.05%. Malaria infection was found to be most prevalent among 12-14 years old, while age group 9-11 had the least infection. Increased ITN ownership among participants significantly reduced *Plasmodium* prevalence. The significant decline in malaria prevalence observed in this study provides evidence supporting the health benefits of ITNs use in Kenya. According to the findings from this study, malaria infection has dropped from 25 % in 2011 to 10.05% in 2016, following free distribution of ITNs in 2014 by Kenya government agencies, to replace ITNs distributed in 2011.

6. Recommendations

The study recorded moderate decrease in malaria prevalence following mass distribution of ITN, however, prevalence of 10.05 per cent is still high compared to less than 5 per cent reported in other parts of the country. Other control strategies such as chemotherapy, controlling mosquito breeding and indoor residual spraying to kill mosquitos apart from ITNs should also be promoted by both national and county government. More studies on the prevalence of malaria in children, using households as sampling units need to be conducted in Kasipul. This is because school survey can report lower malaria prevalence because it does not capture pupils absent from school due to illness, which may include malaria.

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7. Abbreviations

ITN: Insecticide treated nets; MOH: Ministry of health; OR: Odds ratio.

8. Competing interests

The authors declare that they have no competing interests.

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