Malaria Risk Factors in Dielmo, A Senegalese Malaria-Endemic Village, Between October and November of 2013: A Case-Control Study

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Abstract. The incidence of malaria has decreased recently in parts of Africa, coinciding with the widespread use of long-lasting insecticide-treated nets (LLINs) and artemisinin-based combination therapy (ACT). This reduction was also observed in Dielmo, our study area, and it was associated with the use of ACT as the first-line treatment against malaria beginning in 2006 and the implementation of LLINs in 2008. However, an unexplained slight increase in malaria incidence was observed in October and November of 2013. The aim of this study was to identify individual and environmental risk factors for malaria using a case-control study approach. Thirty cases and sixty controls were investigated. The use of LLINs was protective against malaria (adjusted odds ratio [AOR] = 0.10; 95% confidence interval [95% CI] = 0.02–0.45; P = 0.003). The risk of malaria transmission was high among villagers who watched television outside the house or the bedroom during the night (AOR = 8.83; 95% CI = 1.39–56.22; P = 0.021). The use of LLINs should be reinforced by the use of individual protection measures to avoid malaria transmission outside of the home.

BACKGROUND

The use of long-lasting insecticide-treated nets (LLINs) and indoor residual spraying play a key role in malaria control. The association of these vector control strategies with the use of artemisinin-based combination therapy (ACT) has led to an important decrease of the malaria burden in various areas in Africa.[1–7] The subsequent decline of malaria morbidity was also observed in Dielmo, a Senegalese malaria-endemic village where ACT has been used as the first-line treatment since June of 2006 and LLINs were introduced and distributed to all villagers in July of 2008.[5] Two years after the implementation of LLINs, an increase of malaria morbidity was unfortunately observed in 2010 and 2011, which was explained by the non-use of the LLINs (Wotodjo AN, personal communication), the resistance of *Anopheles* against pyrethroid insecticide, and the loss of immunity.[8,9] After this recrudescence of malaria morbidity, all LLINs were replaced in July of 2011, which resulted in a significant decrease of the disease from January of 2012 to September of 2013.[5] However, between October and November of 2013, an unexplained slight increase of malaria clinical attacks occurred again. During this upsurge of malaria, the morbidity was 0.04 per person per month compared with 0.01 in October and November of 2012. This situation was surprising and required a specific investigation, because we did not know whether malaria cases were caused by particular new risk factors. The aim of this case-control study is to identify individual and environmental risk factors for malaria and make recommendations in the current context of the significant reduction of this scourge.

METHODS

Setting. The study took place in Dielmo, a Senegalese malaria-endemic village, which has been described elsewhere.[5,10] It had approximately 500 habitants in 2013. The rainfall levels in this village were 949.2 and 949.7 mm in 2012 and 2013, respectively. A river, the Nema, which allows a permanent presence of Anopheline breeding sites year round, crosses the Dielmo village. Malaria epidemiology had greatly changed in this village from holoendemic in 1990[10] to hypoendemic since 2010,[5] and transmission is now occurring in Dielmo principally between July and October during the rainy season.[5] The entomological inoculation rates were 76, 8, and 49 infected bites per person per year in 2011, 2012, and 2013, respectively. Malaria prevalence and malaria morbidity were 0.3% and 0.05 per person per year, respectively, in 2012. Malaria asymptomatic carriage decreased greatly, because almost all infections were symptomatic from 2010 onward.[5]

Definition of cases and controls. The cases were villagers of Dielmo who had uncomplicated malaria detected at the health center of Dielmo between October and November of 2013. Malaria cases were defined as patients with fever (rectal temperature ≥ 38°C or axillary temperature ≥ 37.5°C) associated with malaria parasites detected by a thick smear and/or rapid diagnostic test (RDT).

The controls were Dielmo villagers who did not have fever, did not have parasites detected on a thick smear, and/or were RDT-negative for the malaria parasite between October and November of 2013. Thick smears and RDTs were performed each month among all inhabitants of Dielmo to assess the asymptomatic carriage.

Sampling. All Dielmo villagers who had uncomplicated malaria between October and November of 2013 were included in this study. Individuals with asymptomatic malaria were excluded from this study. In total, 30 malaria cases were recorded. For each case, two controls were matched by age (±5 years), gender, and concession. Therefore, 60 controls were investigated. The controls were selected based on the list of Dielmo villagers.

Exposure variables. A standardized questionnaire was used to record information about the use of LLINs, the ownership of a television, watching television at night, staying outside at night for a few hours, bedtime, and travel during October and November of 2013. Information about being collectors of

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TABLE 1
Sociodemographic characteristics of the population of the study

Characteristic and subcategory	Cases	Controls	Total
Number of study population n (%)			
Total	30 (33.3)	60 (66.7)	90 (100)
Females	12 (40)	24 (40)	36 (40)
Males	18 (60)	36 (60)	54 (60)
Average of age in years (95% CI)			
All	17.01 (11.75–22.27)	17.68 (14.15–21.22)	–
Females	15.84 (8.66–23.04)	16.75 (12.04–21.46)	–
Males	17.79 (9.86–25.72)	18.31 (13.15–23.47)	–
Age (years)			
Oldest	59.9	58.9	–
Youngest	2.1	1.3	–
Age group (years) n (%)			
< 15	18 (60)	33 (55)	51 (57)
≥ 15	12 (40)	27 (45)	39 (43)

mosquitos and the presence of water in the house was also obtained. The houses that were near a well or a fountain were noted. The cases were investigated progressively, and the controls were investigated in December of 2013.

Statistical analyses. The association between each variable and malaria was analyzed through conditional logistic regression. Variables associated with malaria in a univariate analysis ($P < 0.2$) were selected and analyzed using a conditional logistic regression model ($\alpha = 0.05$).

RESULTS

Description of variables among cases and controls. There were 30 cases and 60 controls included in our study. Males represented a larger percentage of the recruited population (60%). The average age of the cases and the controls was 17.01 (95% confidence interval [95% CI] = 11.75–22.27) and 17.68 (95% CI = 14.15–21.22) years, respectively. The average age was not significantly different between sexes (Table 1).

Among the case group, only 30% (9 of 30) always used their nets, but among controls, 72% (43/60) declared that they always used their nets. Almost the whole study population went to bed before midnight (93% of cases and 97% of controls). The majority did not travel during the study period (93% of cases versus 95% of controls). Only 27% (8 of 30) of cases and 18% (11 of 60) of controls had a television at home; 53% (16 of 30) of cases declared that they often watched television at night, but only 25% (15 of 60) of controls had frequently watched television at night. A total of 93% of cases declared spending a few hours outside at night before sleeping compared with 55% of controls. The variable "spend few hours outside at night" included persons who watch television outside of the room at night; 10% of the cases were mosquito collectors during October and November 2013, and 8% of the

TABLE 2
Results of the survey of malaria risk factors

Characteristic and subcategory	Case and control groups		Univariate analysis		Multivariate analysis	
	Cases (N = 30) n (%)	Controls (N = 60) n (%)	OR (95% CI)	P value	AOR (95% CI)	P value
Use of LLINs						
No	21 (70)	17 (28)	1		1	
Yes	9 (30)	43 (72)	0.12 (0.03–0.42)	0.001	0.10 (0.02–0.45)	0.003
Bedtime						
Before midnight	28 (93)	58 (97)	1			
After midnight	2 (7)	2 (3)	2.73 (0.23–33.00)	0.429		
Trip						
No	28 (93)	58 (97)	1			
Yes	2 (7)	2 (3)	2 (0.28–14.20)	0.488		
Presence of water in the house						
No	13 (43)	35 (58)	1		1	
Yes	17 (57)	25 (42)	3.04 (0.80–11.50)	0.101	3.24 (0.46–22.80)	0.24
House near well or fountain						
No	14 (47)	26 (43)	1			
Yes	16 (53)	34 (57)	1.85 (0.56–6.16)	0.313		
Ownership of television						
No	22 (73)	49 (82)	1			
Yes	8 (27)	11 (18)	2.5 (0.57–10.96)	0.224		
Watching television at night						
No	14 (47)	45 (75)	1		1	
Yes	16 (53)	15 (25)	3.47 (1.31–9.23)	0.013	1.60 (0.37–6.99)	0.53
Stay outside at night for a few hours						
No	2 (7)	26 (43)	1		1	
Yes	28 (93)	34 (57)	9.05 (2.04–40.12)	0.004	8.83 (1.39–56.22)	0.021
Collector of mosquitos						
No	27 (90)	55 (92)	1			
Yes	3 (10)	5 (8)	1.36 (0.2–9.0)	0.752		

controls were collectors. The description of variables among the cases and the controls is shown in Table 2.

Univariate and multivariate analyses. The use of LLINs was protective against malaria (odds ratio [OR] = 0.12; 95% CI = 0.03–0.42; P = 0.001) but watching television at night (OR = 3.47; 95% CI = 1.31–9.23; P = 0.013) and staying outside at night for a few hours (OR = 9.05; 95% CI = 2.04–40.12; P = 0.004) were statistically associated with malaria risk. Variables, such as proximity to a well or a fountain, presence of water in the house, television ownership, traveling, being mosquito collectors, and bedtime, were not significantly associated with malaria risk. In the final multivariate model, the use of LLINs remained protective (adjusted OR [AOR] = 0.10; 95% CI = 0.02–0.45; P = 0.003) against malaria attacks, and staying outside at night for a few hours was a malaria risk factor (AOR = 8.83; 95% CI = 1.39–56.22; P = 0.024) when adjusting for watching television (AOR = 1.66; 95% CI = 0.37–6.99; P = 0.53) and the presence of water in the house (AOR = 3.24; 95% CI = 0.46–22.80; P = 0.24). Table 2 shows the results of the univariate and multivariate analyses.

DISCUSSION

Malaria decreased substantially in some areas of Africa over the last decade.[1,2,4,5] The same trend was observed in Dielmo,[5] where a longitudinal survey has been conducted since 1990.[10] This drastic reduction has led to the implementation of strategies targeted to eliminate malaria in this village. Based on a case-control study approach, we investigated the causes of a slight increase of malaria clinical attacks, which occurred in October and November of 2013 in Dielmo village. The use of LLINs was protective against malaria. The cases declared using their nets less than the controls, which was observed in a recent study in this village (Wotodjo AN, personal communication). The non-use of LLINs was explained in some studies by their cost and an individual's social and educational status,[11–13] but nets were free in Dielmo. A qualitative study in Dielmo about the perception of LLINs use remains necessary.

Staying outside at night for a few hours was highly associated with malaria. People who declared watching television were also considered to be individuals who stayed outside at night for a few hours, because television is watched outside in Dielmo. Additionally, 50% of the individuals who declared staying outside at night were persons who watched television. Electricity was introduced in this village through our project in early 2012 and allowed the population to use the electric mill for economic activities and to watch television. Unfortunately, watching television at night outside exposed Dielmo inhabitants to mosquito bites. The positive impact of the media on the prevention and knowledge of malaria has been shown in previous studies,[14–16] and television is important for learning about malaria and how to prevent this disease. One solution to avoid the risk of malaria in Dielmo would be to raise awareness about watching television inside the house with the doors closed or the use of insecticide spray. Finally, to maintain the good outcome of malaria control achieved in this village, Dielmo inhabitants should be made aware of the benefit of frequently using their nets and individual protection tools, like insecticide spray, when they stay outside at night.

CONCLUSION

To reach the goal of the pre-elimination and elimination of malaria in Dielmo, more education on the use of LLINs is needed. Investigating the perception of the inhabitants of the benefit of LLINs for preventing malaria seems very important. The risk of malaria by staying outside at night or watching television outside can be avoided by using personal protection tools at night in Dielmo.

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