Does Socioeconomic Environment Is A Risk Factor For Malaria In Senegal ? A DHS Data Analysis of Malaria Trends From 2010 To 2016 In Senegal

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Abstract

Introduction

Analysis of the evolution of malaria will help address the determinants of malaria elimination in this country. The aim of this study is to analyze the evolution of malaria in Senegal from 2010 to 2016.

Methods

This article uses data from the Senegalese Demographic and Health Surveys (for 2010-2011, 2012-2013, 2014, 2015 and 2016). To assess the factors associated with the positivity of the RDT, a multivariate logistic analysis was conducted to account for the effect of confounding factors. Adjusted odds ratios were calculated with their 95% confidence intervals.

The dependent variable was the result of the Malaria rapid diagnostic test.

Results

The malaria prevalence rate varies from 3.01% in 2010 to 0.87% in 2016. The risk factors associated with the evolution of malaria were the age of the child (4 years (aOR=1.82 [1.14-2.89]) and 5 years (aOR=1.98 [1.21-3.25])). The richest wealth quintile was a protective factor against malaria with aOR=0.02 [0-0.18]. Other protective factors against malaria were the construction characteristics of the houses. These are houses with improved wall and roof materials with aOR 0.45 [0.24-0.85] and 0.48 [0.25-0.93] respectively.

Conclusion

Factors associated with the evolution of malaria in Senegal are children's age, level of wealth of the household and type of dwelling in the house. It should be noted that the level of development of countries, by influencing better living conditions for communities, remains an important prerequisite for the elimination of malaria in the African sub region and in Senegal in particular.

Introduction

The fight against malaria and its possible eradication have been priorities of the international community since the 1950s and 1960s [1,2]. However, Africa still remains the epicentre of this endemic. With the scarcity of resources following the halt of the global malaria eradication plan (UNICEF and other donors having withdrawn their financial contributions), the disease has been completely neglected for decades, resulting in the resurgence of malaria in areas where it had been reduced with outbreaks leading to high mortality [3,4]. The WHO African Region accounted for 93% of global malaria deaths in 2017; however, it accounted for 88% of the 172 000 fewer malaria deaths compared to 2010 [5].

However, it should be noted that in recent years, some countries in sub-Saharan Africa have significantly reduced the prevalence of malaria and in some regions are in a state of elimination, although other countries in sub-Saharan Africa remain countries with high malaria endemicity.

In recent years, Senegal has seen a marked decline in malaria incidence, which fell by more than 50% between 2009 and 2015. In fact, parasite prevalence fell from 3–1.2% and all-cause mortality from all causes from 72% of live births to 33‰ among children under 5 years of age between 2009 and 2014. These convincing results have enabled Senegal to reach the Roll Back Malaria targets in 2015 [4]. However, several studies have shown that the risk of malaria infection could be correlated with factors related to the level of development of countries. For example, the risk of malaria infection has been correlated with the level of household wealth. [6,7]. Studies have also shown that the quality of housing construction is an important risk factor for malaria [8]. Some of these factors identified in the scientific literature might suggest that despite health interventions, malaria elimination would be difficult to achieve in sub-Saharan Africa. The aim of this study is to analyze the evolution of malaria in Senegal from 2010 to 2016.

Methods

Data

This article uses data from the Senegalese Demographic and Health Surveys (DHS) [e.g Demographic and Health Surveys (DHS)] for 2010–2011, 2012–2013, 2014, 2015 and 2016. The DHS sample is representative at the national level, at the regional level, for urban and rural areas, and at the level of the 14 regions of Senegal. The DHS sample is drawn stratum by stratum. Thus, in accordance with the DHS methodology, the sample is based on a stratified, two-stage, areal sample drawn in accordance with the DHS sampling methodology [9]. For the DHS in Senegal, at the first level, the survey covers 400 clusters (Primary Survey Units PSU) which are drawn from the list of Enumeration Zones established during the General Census of Population and Housing, Agriculture and Livestock, using a systematic draw with probability proportional to size, the size of the UPS being the number of households [9]. A count of households in each of these clusters provides a list of households from which a second-stage sample of 22 households per cluster was drawn, in both urban and rural areas, with a systematic draw with equal probability. In 2010–2011, 7902 households were surveyed; in 2012–2013, 4131 households were surveyed; in 2014, 4231 households were surveyed; in 2015, 4511 households were covered by the DHS.

During these surveys, malaria parasitemia tests were carried out. Malaria parasitemia tests had been performed on children aged 6–59 months. Two tests for the diagnosis of malaria were performed: a Rapid Diagnostic Test [e.g. Rapid Diagnostic test (RDT)], the results of which were communicated to the parents/caregiver, and a thick drop. Children who tested positive on the RDT were referred to a health service by the survey laboratory technicians according to the protocol in effect. This study uses the results of the RDTs.

Dependent variable

The dependent variable was the result of the Malaria rapid diagnostic test. This variable is a binary DHS variable which has 2 modalities "Positive" and "Negative".

Independent variables

The study considered explanatory variables related to socio-economic and demographic factors. These included individual factors, household factors and factors related to means of prevention.

With respect to (A) individual factors: (1) Age was analyzed by 1-year age group. (2) sex was a 2-modality binary variable. (3) The variable "Child works on a farm or with animals" was also binary (B) Household factors: (1) Household wealth - The wealth index, a measure of relative economic well-being based on household assets, was ranked by quintiles (lowest, second, middle, fourth, highest). (2) Residence - The place of residence has been dichotomized into "urban" or "rural". (3) The construction material of the houses with the following variables- The variable "Main wall material (wall)" was generated from an EDS variable with 14 modalities : No walls, Cane / palm / trunks, Dirt, Bamboo with mud, Stone with mud, Adobe uncovered, Plywood, Cardboard, Reused wood, Cement, Lime stone / cement, Bricks, Cement blocks, Adobe covered (Adobe is sun-hardened brick, made from mainly clay soil, diluted and mixed with straw or chopped dry grass), Wood planks / shingles, Other. It has been recoded into 2 modalities "improved material" and "unimproved material". The "improved material" modality corresponded to the modalities Cement, Limestone / cement, Bricks, Cement blocks, Adobe coated, Wood planks / shingles. The variable "Main roof material" was generated from an EDS variable with 12 modalities: No roof, Stubble/palm leaves, Grass, Rustic carpet, Palm/bamboo, Wood planks, Cardboard, Metal, Wood, Scale/Cement fibre, Ceramic, Cement and Roof shingles. It has been recoded into a binary variable with two modalities "improved material" and "unimproved material". The "improved material" modality corresponded to the Metal, Wood, Cement Fibre/Calamine, Ceramic, Cement and Roofing Shingles modalities.

The variable "main soil material" was recoded from the EDS variable with the modalities: "Earth, sand", "Manure", "Wood planks", "Palm, bamboo", "Parquet, polished wood", "Vinyl, asphalt strips", "Ceramic tiles", "Cement", "Carpet" and others. This variable has been recoded as "improved material" and "unimproved material". The enhanced material modality was "Parquet, polished wood", "Vinyl, asphalt strip", "Ceramic tile", "Cement", "Carpet".

With regard to (C) factors relating to means of prevention. The following variables were concerned. (1) The variable "Existence of windows with mosquito nets in the house" had 2 modalities "yes" and "no". (2) The variable "Child sleeps under mosquito nets all night" was generated from a variable "Children under 5 years who slept under mosquito nets last night". This variable had 4 modalities "No", "All children", "Some children", "No nets in the household". The variable was recoded into a binary variable with two modalities "yes" and "no", the yes modality corresponding to children having "slept under a net last night". (3) the variable "Use of mosquito nets as a means of prevention outside sleeping rooms" was also binary.

Analysis

The analysis was carried out using STATA/SE 15.1 software. A merger of the 2010–2011, 2012–2013, 2014, 2015 and 2016 EDS surveys using the STATA append function.

As noted above in the section on data source, a two-stage sampling design was adopted. To account for the multi-stage sampling design of the survey, all data were weighted to account for disproportionate sampling and non-response.

In the descriptive analysis, the variables were presented in terms of frequency and percentage of data. Inter-group comparisons were made using the Chi2 test. The significance level was set at 5, and 95% confidence intervals (CI) were used. Variables where p was less than 0.2 in the bivariate analysis were selected for the multivariate analysis. [10].

To assess the factors associated with the positivity of the RDT, a multivariate logistic analysis was conducted to account for the effect of confounding factors. Adjusted odds ratios [e.g. Adjusted odd ratio (ORa)] were calculated with their 95% confidence intervals. To handle complex sampling (multi-stage sampling, weighting and stratification), the identification variables for weights, strata and primary sampling units (PSUs) were defined before using the svy command (survey prefix STATA). The logistic model was fitted with the independent variables mentioned above.

Results

Participants

In our study, a secondary analysis of the Senegal DHS (2010–2016) data was performed. Participants from urban and rural areas were selected from all 14 administrative regions of Senegal. The study focused on the diagnosis of malaria by RDTs in children under 5 years of age. The population size for our study was 408 969 children across 5 years. The flow diagram of the study population is represented in Fig. 1.

Socio-demographic characteristics

Table I : Distribution of individual and household characteristics by year

Survey					
	1	2	3	4	5
	(2010-2011)	(2012-2013)	(2014)	2015)	(2016)
Age of children (year)					
Less than 1 year	2562(3.39%)	1370(3.53%)	1262(3.32%)	1292(3.34%)	1208(3.18%)
1	2379(3.15%)	1249(3.22%)	1301(3.43%)	1205(3.11%)	1161(3.06%)
2	2555(3.39%)	1362 (3.51%)	1335(3.52%)	1347(3.48%)	1216(3.21%)
3	2669(3.54%)	1389(3.58%)	1239(3.26%)	1301(3.36%)	1295(3.41%)
4	2398(3.18%)	1236(3.19%)	1304(3.44%)	1292(3.34%)	1248(3.29%)
5	2302(3.05%)	1173(3.02%)	1102(2.9%)	1126(2.91%)	1061(2.91%)
Level of economic wealth					
the poorest	15076(19.98%)	7749(19.98%)	7510(19.79%)	7694(19.87%)	7590(20%)
the poor	15054(19.95%)	7726(19.92%)	7544(19.88%)	7775(20.08%)	7587(19.99%)
the middle	15113(20.03%)	7795(20.1%)	7558(19.91%)	7719(19.93%)	7584(19.98%)
the rich	15060(19.96%)	7747(19.97%)	7533(19.85%)	7712(19.91%)	7592(20%)
the richest	15160(20.09%)	7774(20.04%)	7810(20.58%)	7828(20.21%)	7598(20.02%)
Place of residence					
Urban	33862(44.87%)	15895(40.98%)	18339(48.31%)	16904(43.65%)	17254(45.46%)
Rural	41600(55.13%)	22896(59.02%)	19621(51.69%)	21824(56.35%)	20698(54.54%)
Building material for houses					
House with Improved Roof Material	57618(76.36%)	29898(77.15%)	30022(80.42%)	32105(82.92%)	30970(81.62%)
House with improved floor	49796(65.99%)	28370(73.33%)	27346(72.53%)	30004(77.47%)	28819(77.11%)
House with improved	52875(70.1%)	23828(63.87%)	27816(73.28%)	28292(73.5%)	26601(70.91%)

wall material					
Anti-malarial prevention measures					
Child sleeps under mosquito nets all night long	17662(23.41%)	11858(30.57%)	12937(34.08%)	14972(38.66%)	17565(46.28%)
Existence of windows with mosquito nets	11203(14.85%)	3324(8.57%)	4402(11.6%)	8003(20.66%)	8984(23.67%)
Use of mosquito nets outside sleeping rooms	13882(24.45%)	8562(26.88%)	9024(28.15%)	7118(22.26%)	10056(30.47%)

There are more people living in rural areas than in the countryside in any given year from 2010 to 2016, with respective rates of 55.13% of the population living in rural areas in 2010 to 54.54% in 2016 (table I). We note an improvement in the construction of houses with improved roofing material, which leaves the rate of 76.36% to represent 81.62% of houses in 2016 (table I). The percentage of houses with improved floor construction equipment increases from 65.99% in 2010 to 77.11% in 2016 (table I). The percentage of houses with improved wall construction material is relatively constant from 2010 to 2016. It increases from 70.1% in 2010 to 70.91% in 2016.

With regard to means of prevention, there is a growing increase in the number of children from 2010 to 2016, from 23.41–46.28% (table I).

Use of mosquito nets outside sleeping rooms increases from 24.45% in 2010 to 30.47% in 2016.

The number of houses with mosquito nets on the windows increases from 14.85% in 2010 to 23.67% in 2016 (table I).

Evolution of malaria cases from 2010 to 2016

The malaria prevalence rate varies from 3.01% in 2010 to 0.87% in 2016 (Table II).

The evolution of malaria cases shows an increase in Survey 2 which corresponds to the years 2012–2013. This results in a significant and steady reduction until 2016 (Fig. 1).

Table II: Distribution of RDT-positive malaria cases from 2010 to 2016 in Senegal

positive RDT		
Survey	Percentage	Frequency
2010–2011	3.01	137
2012–2013	3.65	239
2014	1.15	69
2015	0.66	40
2016	0.87	50

Associated factors with the evolution of malaria in Senegal from 2010 to 2016

The risk factors associated with the evolution of malaria are the age of the child. Children aged 4 and 5 years are respectively 1.82 times (aOR = 1.82 [1.14–2.89]) and 1.98 times (aOR = 1.98 [1.21–3.25]) more likely to have malaria (table III).

The richest wealth quintile is associated with the evolution of malaria. It is a protective factor against malaria with aOR = 0.02 [0–0.18] (table III).

Other protective factors against malaria are the construction characteristics of the houses. These are houses with improved wall and roof materials with aOR 0.45 [0.24–0.85] and 0.48 [0.25–0.93] respectively (table III).

Table III: Year-on-year adjustment of factors associated with the evolution of malaria from 2010 to 2016 in Senegal

Positive RDT	aOR	[CI 95%]	P>t
Year	0.81	[0.56-1.17]	0.26
Child's age (year)			
Less than 1 year	1		
1	1.04	[0.63-1.71]	0.87
2	1.33	[0.83-2.14]	0.24
3	1.35	[0.91-2.02]	0.14
4*	1.82	[1.14-2.89]	0.01
5*	1.98	[1.21-3.25]	0.01
Level of economic wealth			
poorest	1		
poor	1.07	[0.56-2.02]	0.84
middle	0.48	[0.14-1.71]	0.26
rich	0.14	[0.01-1.49]	0.1
richest*	0.02	[0-0.18]	0.001
Existence of window with mosquito net			
No	1		
yes	0.45	[0.18-1.10]	0.08
Child works on a farm or in contact with animals			
no	1		
yes	0.97	[0.72-1.29]	0.81
Use of mosquito nets outside sleeping rooms			
no	1		
yes	1.03	[0.69-1.54]	0.88
Place of residence			
Urban	1		
Rural	1.49	[0.55-4.07]	0.43
Child sleeps under mosquito nets all night long			
no	1		
yes	1.02	[0.61-1.66]	0.99

Soil materials of the dwelling place			
not improved	1		
improved	1.17	[0.78-1.75]	0.45
Roof materials of the dwelling place			
Not improved	1		
Improved*	0.48	[0.25-0.93]	0.03
Materials of the wall of the dwelling place			
not improved	1		
improved*	0.45	[0.24-0.85]	0.01

* : $p < 0.05$

Discussion

Malaria trend in Senegal from 2010 to 2016

Globally, the number of malaria cases is estimated at 228 million in 2018 (95% confidence interval [CI]: 206–258 million), up from 251 million in 2010 (95% CI: 231–278 million) and 231 million in 2017 (95% CI: 211–259 million). Most cases (213 million or 93%) were registered in 2018 in the WHO African Region. Nineteen countries in sub-Saharan Africa and India accounted for almost 85% of the total number of malaria cases worldwide. The six countries that alone recorded more than half of the cases are all from the African region: Nigeria (25%), the Democratic Republic of Congo (12%), Uganda (5%), Côte d'Ivoire (4%), Mozambique (4%) and Niger (4%) [11]. However, as of 2016, WHO has identified 21 countries with the potential to eliminate malaria by 2020. WHO is working with the governments of these so-called "E-2020" countries to help them meet their elimination targets [11].

This study showed a prevalence of malaria in Senegal of 0.87%, which places Senegal among the countries with elimination potential.

Analysis of the evolution of malaria in Senegal has shown that there has been a slight increase in the prevalence of malaria in Senegal from 2010 to 2013 from 3.01 to 3.65%.

From 2013 onwards, there will be a gradual reduction in the malaria prevalence rate to 0.87% in 2016. Despite its proximity to some countries in the West African sub-region, Senegal has been able to make significant progress in reducing its malaria prevalence rate. These countries bordering Senegal, although having similar Sudano-Sahelian climates, have higher malaria prevalence than those of Senegal. In Mali the prevalence of malaria according to the RDT is 19% [12], in Guinea Conakry 26% of children are reported to have been treated for malaria [13], in Burkina Faso the prevalence of malaria is 17% [14].

Senegal's low prevalence could be attributed to Senegal's health policy in the fight against malaria. In fact, many interventions are implemented in Senegal, such as chemo-prevention of seasonal malaria, universal coverage with impregnated mosquito nets and intermittent preventive treatment for pregnant women.

Chemo-prevention of seasonal malaria using sulfadoxine-pyrimethamine plus amodiaquine, administered monthly during the transmission season, is recommended for children living in areas of the Sahel where malaria transmission is highly seasonal. Chemo-prevention of seasonal malaria's recommendation is currently limited to children under five years of age, but in many areas of seasonal transmission, the burden of older children may justify the extension of this age limit. The implementation of chemo-prevention started in Senegal in 2008 and was generalized in all districts in 2010. Evaluations of its effectiveness in Senegal had shown that the introduction of seasonal chemo-prevention of malaria in children was effective and associated with an overall reduction in malaria incidence [15,16].

Other prevention measures recommended by the World Health Organization (WHO) in endemic areas to reduce malaria-related morbidity and mortality include vector control through the provision and use of insecticide-treated nets [e.g. insecticide-treated nets (ITNs)] and intermittent preventive treatment during pregnancy [intermittent preventive treatment (IPT)] to prevent malaria associated with pregnancy [17]. In Senegal, since 2011, national ITN distribution has been extended to the entire population through different channels, such as health centers, community organizations, schools and social marketing activities [18]. It should be noted, however, that the level of use of IPT and ITNs in Senegal is higher in the 2013–2014 DHS than in previous years, according to the results of successive Demographic and Health Surveys: in 2009, IPT use was 12%, and in 2010 it rose to 39% [19]. This could explain the acceleration of the curve of the decline of malaria that is noticed by our study. Studies have shown that the adoption of malaria prevention methods (IPT and ITNs) in Senegal has been effective in the fight against malaria [20].

Associated factors with the evolution of malaria in Senegal from 2010 to 2016

Studies have shown that malaria morbidity is higher in children under 7 years of age [21]. This study showed that the age of the child was a factor associated with the evolution of malaria. Children aged 4 and 5 years were respectively 1.82 times (aOR = 1.82 [1.14–2.89]) and 1.98 times (aOR = 1.98 [1.21–3.25]) more likely to have malaria. Other studies have shown a correlation between the age of the child and the occurrence of malaria. In Malawi, children who were 4 years old were more likely to be infected with malaria with aOR = 2.1; 95% CI: 1.3–3.3 [22]. This is also the case in Burkina Faso where children aged 4 and 5 were also the most vulnerable OR: 6.79 [5.62–8.22] [23].

This situation of vulnerability of older children could be linked to behavioral factors influencing the use of preventive measures in the 4–5 age group. Age had been identified by other studies as a factor associated with ITN use. Older children (5 years) were less likely to use ITNs (OR = 0.37, 95% CI: 0.28–0.47) [24].

This study showed that in Senegal, the richest wealth quintile is associated with the evolution of malaria. It is a protective factor against malaria with aOR = 0.02 [0–0.18]. Several studies have shown that socio-economic conditions have an impact on the occurrence of malaria. Thus, in several countries such as

Burkina Faso and Pakistan, compared to children living in the richest wealth quintile, those in the poorest wealth quintile were more exposed to malaria [25,23].

Other protective factors against malaria identified by this study were the construction characteristics of the houses. These were houses with improved wall and roof materials with aOR 0.45 [0.24–0.85] and 0.48 [0.25–0.93] respectively. The results of our study were similar to those of a systematic review of studies evaluating the relationship between modern housing and malaria infection (n = 11 studies) and clinical malaria (n = 5 studies). The latter study showed that residents of modern homes were less likely to be infected with malaria than residents of traditional homes [8]. The 2015 study concluded that future research should assess the protective effect of certain house characteristics and incremental housing improvements associated with socio-economic development.

As in our study in Nigeria, also the finding was that children who lived in houses built entirely of unimproved materials were more likely to be infected with malaria (aOR = 1.4, CI 1.08–1.80, p = 0.01). Our study was able to focus on improved wall and roof materials as protective factors against malaria with aOR 0.45 [0.24–0.85] and 0.48 [0.25–0.93] respectively.

Limits

Some limitations were identified in this study. These include differences in the specificity and sensitivity of the diagnostic methods (RDT and microscopy) and the way the sampling strategy was conducted, which may be biased in favor of certain individuals in the population. This study used only the results of Rapid Diagnostic Tests.

Conclusion

This study was able to conclude that the factors associated with the evolution of malaria in Senegal are the age of the child, the level of wealth of the household and the type of dwelling in the house. Health policies in Senegal should consider the protection of the 4 to 5 age group that is vulnerable to malaria infection. Educating Senegalese communities about the malaria-protective role of modern housing and encouraging the use of improved materials for house design (roof and wall) in addition to other malaria prevention strategies could help strengthen malaria control measures for children under five years of age.

It should be noted that the level of development of countries, by influencing better living conditions for communities, remains an important prerequisite for the elimination of malaria in the African sub region and in Senegal in particular.

Declarations

Availability of data and material

Data supporting the conclusions of this study are available from MEASURE DHS. Data are available from MEASURE DHS upon request and with the permission of <http://www.dhsprogram.com>.

Ethics approval and consent to participate

This study was a secondary analysis of DHS data conducted in Senegal in 2010-2011, 2012-2013, 2014, 2015 and 2016. All Senegal Demographic Health Survey (DHS) was approved by the National Ethics Committee (CNERES). The surveys also obtained the visa of the Committee of Ethics (Institutional Review Board) of the ICF. The informed consent obtained from all participants was written. <https://dhsprogram.com/What-We-Do/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm>

Published abstracts cited: Trend of malaria in Senegal from 2010 to 2017 by same authors in 2020 Word congress of public health

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

NMS analyzed and interpreted the data. AF proceeded to verify the statistical tests. AF, MMML and OB were major contributors in writing the manuscript. IS was major contributor in the manuscript. All authors read and approved the final manuscript.

Availability of data and materials

The datasets analyzed during the current study are publicly available upon request at <https://dhsprogram.com/data/available-datasets.cfm>.

Consent for publication

Not applicable.

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Figures

Figure 1

Study diagram flow

Figure 2

Evolution of malaria cases from 2010 to 2016 in Senegal