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Improving the Use of Insecticide-Treated Nets among Children under Five Years Old in Benin, West Africa

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Abstract

Background: In Benin, malaria represents the first cause of consultation and hospitalization (48% for children under 5 years old) in health units. It also accounts for 23.1% of deaths recorded in health facilities (MoH, 2019). Between the two main components of vector control adopted by Benin government, the mass distribution campaigns of Insecticide-Treated Nets (ITNs) remained the only proven cost-effective way to rapidly achieve high and equitable coverage (WHO, 2017). After the fourth mass distribution campaign conducted in 2017, the Demographic and Health Survey (DHS) data indicated that the percentage of children who slept under an ITN has increased from 20% in 2006 to 70% in 2011-2012 and to 76% in 2017-2018 while the incidence of malaria (tested positive) is increasing rapidly among children under 5 years old, growing from 36.5% in 2009 to 28.8% in 2012 and then to 51.4% in 2019. This study aims to understand this contrast by identifying the origin of the increase in ITN use over time among children under five years old and the factors which determine this use. **Methods:** Data from the Demographic and Health Survey (DHS) conducted in Benin respectively in 2006 and in 20018 were used during the analysis, which covered 13,445 children under five years old from 2006 DHS and 12,255 children from 2017-2018 DHS. Firstly, the data were analyzed using decomposition method to highlight the origin of the increase of ITN use over time among children under five years old. Secondly, the chi-square test analysis estimated the association between ITN use and some characteristics (wealth index, maternal or caregiver education level and child age). Finally, the logistic regression model was used to identify the main factors, which influence the net use over the study period. **Results:** This study shows that the improvement of basic condi-

tions is the main origin of behavior change in the use of ITNs among children under five years old. This improvement of the basic conditions consists of making ITNs available in households and informing household members about the benefits of ITN use. So, the free ITN distribution campaigns, routine distribution, awareness campaigns about the benefits of ITN use are the strategies, which increase the household capacities and knowledge, allowing household members to make their children sleep under net. The analysis also shows that region of residence, wealth index of household, household size, religion, and child age continue to determine the ITN use among children under age 5 years old and MNCP will integrate the factors in malaria prevention strategies in order to achieve universal use of ITNs. **Conclusions:** Although, sleeping under ITN behavior has indeed spread among children under 5 years old, policymakers and other stakeholders should design strategies to maintain and improve the current level of ITN use to reach the collective protection threshold (80% according to WHO). Therefore, to address the challenges of universal use of ITN, the study recommends expanding the routine distribution system to private sector health centers; discussing issues related to health service utilization (particularly ITN use) within a consultation framework at the communal level. In addition, collecting qualitative and quantitative data in the Oueme region will allow better understanding of all aspects of the ITN use gap among children under 5 years.

Keywords

Malaria, Long-Lasting Insecticidal Net (LLIN), Child under 5 Years Old, Health Policy, Benin

1. Introduction

Malaria is one of the major vector-borne human diseases. It is one of the leading causes of child mortality worldwide. Indeed, children under 5 years of age represented 67% (272,000) of malaria-associated deaths in 2018 [1]. The phenomenon was most widespread in Africa in 2018, with 94% of deaths reported as malaria-related worldwide.

In Benin, malaria represents the first cause of consultation and hospitalization (48% for children under 5 years old) in health center. It also accounts for 23.1% of deaths recorded in health facilities [2]. Faced with this unfortunate situation, Benin has adopted indoor residual spraying (IRS) and Insecticide-Treated Nets (ITNs) [3] as the two main components of its vector control. But mass distribution campaigns of Insecticide-Treated Nets (ITNs) constitute now the only proven cost-effective way to rapidly achieve high and equitable coverage [4]. So, since 2007, free ITN distribution campaigns were implemented and supported by routine distribution (during prenatal consultations; vaccinations) during the inter-campaign period. This distribution strategy has led to a significant increase in nets availability in households and with a consequent, upward trend in net

accessibility and use by household members. Indeed, the last three Benin DHS reports indicate that there is an upward trend in ITN ownership (25% in 2006; 80% in 2011-2012 and 92% in 2017-2018) and in net accessibility by household populations (15% in 2006; 64% in 2011-2012 and 77% in 2017-2018). Similarly, net use by household populations increased by 56 percentage points from 2006 to 2018. Within the child population, there is an improving trend in terms of ITN use. The percentage of children who slept under an ITN increased from 20% in 2006 to 70% in 2011-2012 and to 76% in 2017-2018. It results from these indicators' trend that the various programs, which fight against malaria particularly among the population of children under 5 years old, were successfully implemented.

However, the incidence of malaria (simple and severe) testing positive is increasing rapidly among children under 5 years old, growing from 36.5% in 2009 to 28.8% in 2012 [5] and then to 51.4% in 2019. Also, the malaria case fatality rate among children under 5 years old grew from 3.9‰ in 2012 to 2.6‰ in 2018 [6] and then to 3.0‰ in 2019 [1]. With the current increase rate of these indicators, Benin will fail to meet malaria elimination targets by 2030 because malaria incidence as well as case-fatality rates were expected to decline while ITN use by children under 5 years old improved over the same period [7].

This observation leads us to understand and identify all the elements contributing to the increase in ITN use among children under five years old. Is the improvement in ITN use the result of widespread behavior change among children under five years old? In other words, what is the source of the social change observed? What levers can be used to further improve ITN use among children under five years old?

Seeking to answer this concern, this paper aims to identify the factors influencing the use of ITNs by children under five years old over the period 2006-2018 after determining the origin of changes in levels of net use. This paper is organized into three sections: the first summarizes the literature review on ITN use and the second section describes the used methodology. The last section presents the main results and the different analysis done.

1.1. Review of the Literature

Many studies explain net use based on socioeconomic factors such as household wealth, household size, and the economic activity of the child's mother. Indeed, net use seems to be dependent on economic constraints including financial and geographic accessibility. However, the main factor influencing ITN use among children is the ratio of the number of nets available in the household to the number of people sleeping in the household [8]. Therefore, the ITN use increases with increasing numbers of residents per household [9]. Indeed, the treated bed net use depends on the probability that the user is aware of its benefits. In other words, the more occupants in a household, the more likely it is that someone will educate others about the benefits of ITN use. However, the results

found in Burkina Faso showed that the larger the household size, the less likely children are to sleep on ITNs [10]. This may likely be a consequence of the low availability of the net in these households. But the generalizability of this statement is questionable given that free net distribution campaigns consider household size. In addition, it was found in Nigeria that children under 5 years old from households with the lowest standard of living were 1.4 times more likely to sleep under an ITN than those from households with the highest [11]. In other words, ITN use is expected to increase with an improvement in household wealth.

Socio-cultural factors (place of residence, religion, ethnic group and educational level) were identified as influencing the ITN use behaviors of the population. In contrast to the rural-urban disparity in ITN use [12], the place of residence was not significantly associated with ITN use among children in households holding ITNs [13]. Although ITN use behavior is the same in both urban and rural areas, people in some rural areas consider ITN from the free distribution campaign to be technically unsuitable for sleeping conditions [14]. Other households often use them as a "trophy" or symbol of political activism [15]. These considerations or perception of ITN does not promote its real use in households.

The cultural beliefs are not the real factors explaining the non-use of ITNs but various social, economic, environmental and technical factors (such as negligence, resale of the ITN to buy food, difficulty of use, the feeling of suffocation and sleep disturbance) including the perceived usefulness of the ITN and opportunity cost of its use [14]. Indeed, ITNs do not seem to be perceived by the community as an effective malaria control tool, but rather as a means of controlling the nuisance caused by mosquitoes [16] [17]. People in some households prefer to protect themselves with other prevention tools (such as sprays, smoke coils) at the expense of ITNs [18]. As religion has a significant influence on the use of ITNs [19], some research highlighted the existence of a significant relationship between mothers' education level and ITN use [20]. Therefore, mothers' education level contributes more to the use of ITNs within households [21] because mothers with a high level of education are those who use ITNs the most for the protection of their children. However, in Cameroon, no significant relationship between education level and ITN use was noticed [9]. This lack of link between these two variables can be the result of the effects of the sensitization campaign (including communications during ANC or immunization sessions) emphasizing the benefits of ITN use as a malaria prevention tool and the repeated mass distribution of ITNs to ensure universal coverage.

Individual characteristics of the mother and child have also been emphasized to explain ITN use by children under 5 years old. Usually, families allocated more resources to the healthy child than adult health [22]. Thus, as his age increases, there is a tendency not to have him sleep under the ITN. In other words, children aged 0 - 11 months are more successful at sleeping under a treated bed net than those aged 12 - 35 months. However, sex is not expected to influence ITN use because children of both sexes are highly vulnerable to malaria disease. In this

line, a study in Nigeria revealed no significant difference in ITN use among children based on sex [8] [11]. Although the age of mother or caregiver is an important factor associated with health service utilization, its effect on ITN use is not yet very well understood in the literature. But the study conducted in Ghana reveals that the children which mothers or caregivers aged 17 - 25 are most likely to use an ITN than those whose mothers were aged 26 - 35 or 36 and above [23].

1.2. Conceptual Framework for ITN Use

Figure 1 is designed from Literature Review and it shows that none factor does not determine the level of ITN use among children under 5 year old.

According to Figure 1, socio-economic factors have a direct influence on the use of insecticide-treated nets by 5 years old during the period 2006-2018. This relationship is also influenced by the residency context, the political context, cultural factors, and demographic characteristics.

Thus, specifically, we suppose that:

- The increasing the level of household wealth increases the chance that children will sleep under an ITN;
- The improvement of maternal education increases ITN use among children under 5 years old;
- The growth of household size reduces the chance of children sleeping under ITNs;
- Children under one year old are more likely to sleep under a net than their older homologous.

2. Methodology

2.1. Definitions of Main Concepts

Insecticide-treated net:

An insecticide-treated net (ITN) is a factory-treated net that requires no

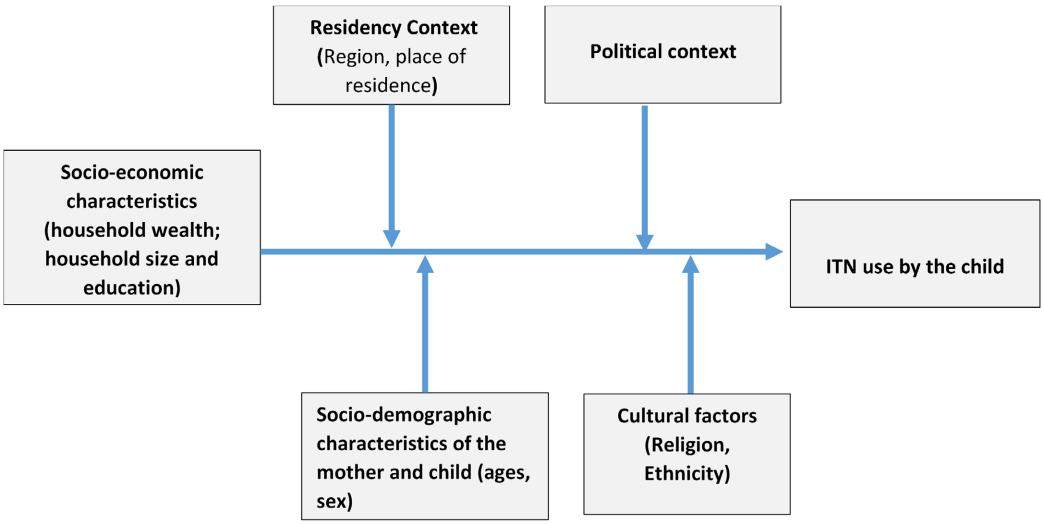

Figure 1. Conceptual framework and analysis of the déterminants of ITN use by children under five years old.

additional treatment [24] But before 2018, it was called a Long-Lasting Insecticidal Net (LLIN), and an Insecticide-Treated Net (ITN) was either:

1) a factory-treated net requiring no additional treatment;

2) an Insecticide-Treated Net (ITN) within the last 12 months.

Composition effect: The composition effect is the part of the social change that is due to variation (from 2006 to 2018) in the proportion of children from mothers in different educational categories.

Performance effect: The performance effect indicates the part of social change that is imputable to the variation (from 2006 to 2018) in its use level by children under 5 years old coming from various social categories. Thus, during the advanced decomposition, this effect will divide into the baseline performance effect, the differential performance effect, and the residual effect.

Baseline performance effect: This is the behavior developed by all social categories of the population without distinction. An increase in the percentage of ITN use, for example, means an improvement in children's mothers the educational level when educational level is the classification variable.

Differential performance: The performance effect can be explained by differentiation in ITN use related to social categories. It is a risk of sleeping without a net related to social category.

Residual effect: This is the proportion of change that is not explained by either the baseline performance effect or the differential performance. These effects are very often attributable to spontaneous changes in some social phenomenon, or other variables/policies not considered.

2.2. Data Sources and Target Population

The data come from the Demographic and Health Surveys (DHS) that were conducted in Benin in 2006 and 2017-2018 respectively.

The samples are composed of children under five years old from women eligible for the DHS surveys in Benin and exposed to the risk of sleeping without a net. Only children under 5 years of age whose ages are known and correctly recorded and who slept in the household the night before the interview are included in the analyses. Thus, the analyses cover 13,445 children under five years old in 2006 [25] and 12,255 children in 2017-2018 [26]. These data are available and downloadable from The DHS Program website. The Appendix table presents the characteristics of the children included in this analysis.

2.3. Study Variables

Dependent Variable: The dependent variable for this study is insecticide-treated net use by children under 5 years old, which is directly identified from the DHS database by the variable hm12 in the PR File. The variable created 'ITN use' has two modalities: 'Yes' if the child under 5 years old slept under an insecticide-treated net the night before the interviewer's visit and 'No' otherwise.

Independent variables: Household wealth, education level, and the child's age are the main independent variables in this study. Other variables are also used as substantial variables or classification variables for the simple and advanced decomposition. Additionally, region, place of residence, household size, ethnic group, religion, mother's age, and child's sex were used as control variables.

2.4. Methods and Tools of Analysis

This study will use three analysis methods: first, the decomposition analysis [27] highlights the origin of change observed in the levels of ITN use. Second, bi-variate analysis describes the association between ITN use and independent variables using the chi-square test. Finally, the logistic regression model was used to identify the main factors, which influence the net use over the period 2006-2018. While Micro Soft Excel version 2013 was used to format the tables, Stata (version 16) was used to perform the Chi-square test and to run the logistic regression model.

2.5. Ethical Consideration

The DHS team in Benin has obtained ethical clearance from two national bodies:

- National Statistical Council (CNS) for the statistical visa of opportunity and conformity.
- National Ethics Committee for Health Research for obtaining the enforceable scientific and ethical opinion of the survey.

At the international level, the authorization of the ICF ethics committee was obtained.

Additionally, before each interview, surveyors obtained informed consent from each respondent.

3. Results of the Analysis of Net Use by Children under Five Years Old

3.1. Analysis of Net Use by Decomposition Method

Table 1 presents the results of the simple and advanced decomposition analysis. The results show that between 2006 and 2018, the increase in net use levels among children under five years old is 56.2 percentage points. The simple decomposition indicates that the increase in ITN use levels is mainly due to the performance effect, *i.e.*, behavior effect whatever the classification variable used (wealth index, child age, maternal or caregiver education level).

3.1.1. Decomposition According to Level of Living

When we consider the wealth index of the household in which the child lives, the analysis shows that 99.7% of the increase in net use in Benin is due to the behavior effect, against 0.3% due to the composition effect. In other words, this increase reflects a generalized change in behavior among the population of

Table 1. Summary of analysis using the decomposition method.

Classification variables	Simple decomposition				Advanced decomposition				
	Composition effect	Performance effect	Contribution		Base line effect	Differentiation effect	Residual Effect	Contribution	
			#	%				#	%
Wealth quintile									
Lowest	−0.35	13.00	12.6	22.5	14.09	−0.48	−0.62	12.99	23.17
Second	0.00	12.44	12.4	22.1	13.29	−0.91	0.07	12.45	22.21
Meddle	−0.15	11.72	11.6	20.6	13.21	−1.36	−0.13	11.72	20.91
Fourth	0.00	10.47	10.5	18.6	12.79	−1.76	−0.55	10.48	18.69
Highest	0.64	8.43	9.1	16.2	11.20	−1.93	−0.85	8.42	15.02
Total	0.14	56.06	56.2	100.0	64.58	−6.44	−2.08	56.06	100.00
	0.25%	99.75%			115.2%	−11.49%	−3.71%		
Child's age in month									
<12 months	0.26	11.21	11.47	20.4	11.35	0.32	−0.47	11.2	19.92
12 - 23	−0.36	11.19	10.83	19.3	10.2	0.59	0.4	11.19	19.9
24 - 35	0.04	10.68	10.72	19.1	9.67	0.83	0.18	10.68	18.99
36 - 47	−0.45	12.01	11.56	20.5	10.67	1.23	0.12	12.02	21.38
48 - 59	0.50	11.14	11.64	20.7	9.98	1.43	−0.27	11.14	19.81
Total	−0.01	56.23	56.22	100.0	51.87	4.4	−0.04	56.23	100.00
	−0.02%	100.02%			92.24%	7.83%	−0.07%		
Mother education level*									
No education	−4.25	40.05	35.80	64.1	44.87	−4.46	−0.36	40.05	73.47
Primary	0.32	9.13	9.45	16.9	11.30	−2.24	0.07	9.13	16.75
Secondary 4.7		4.98	9.68	17.4	6.98	−2.08	0.08	4.98	9.14
University	0.54	0.35	0.89	1.6	0.59	−0.23	−0.01	0.35	0.64
Total	1.31	54.51	55.82	100.0	63.74	−9.01	−0.22	54.51	100.0
	2.35%	97.65%			116.93%	−16.53%	−0.40%		

*The information relates to children whose mothers were interviewed only.

children under five years old. Moreover, children living in households with the lowest wealth quintile (22.5%) had the most contributed to total change observed in ITN use, followed by children living in households with the second wealth quintile (22.1%).

With advanced decomposition, the results show that the whole performance effect comes from the basic effect (115.2%), which reflects the improvement in household living conditions due to the free mass distribution of insecticide-treated nets to households. This means, that the behavior effect is mainly due to the generalized increase in the ITN use in all social categories. This increase would

have been even greater without the appearance of differentiation effect (−11.49%) in ITN use and the residual effect (−3.71%) that reflects the effect of other variables not considered.

3.1.2. Decomposition According to the Age of the Child

The decomposition according to the children's age shows that the performance effect is predominant (100.2% against −0.2% for the composition effect). Thus, the increase in ITN use is essentially due to behavior change. In other words, "sleeping under an ITN every night" becomes a widespread behavior among children under five years old. In addition, the contribution to total change observed is slightly higher (20%) among children in the 0 - 11 months, 36 - 47 months, or 47 - 59 months old groups than among those in the 12 - 23 months or 24 - 35 months old groups (19%). However, 92.2% of this performance effect is due to the baseline effect, which is the result of all parents being aware of the benefits of net use for children in all age groups; whereas the contribution of the differentiation effect is only 7.8%. Children aged 36 - 47 months contributed more to this basic effect.

3.1.3. Decomposition According to Mother's Education Level

By using maternal education level, we find that 97.65% of the increase in ITN use results from the behavior effect. The contribution of composition effect is 2.35%. The advanced decomposition analysis provides more details about the performance effect, resulting from generalized increase (116.93%) in ITN use among children from mothers of all education levels. This generalized increase would have been greater if it had not been reduced by 16.53% by the differentiation effect and 0.40% by the effect of other variables not taken into account (residual effect). This result leads us to conclude that the improvement of basic conditions (through free ITN distribution campaigns, distribution during prenatal consultations and vaccinations, awareness campaigns about the benefits of ITN use, etc.) is the main origin of behavior change in the use of ITNs among children under five years old.

3.2. Differential Trend Analysis of ITN Use by Children under 5 Years Old

The results in Table 2 focus on the relationship between the variable "ITN use by children under 5 years old " and the variables identified in the literature review that could influence net use, but do not indicate the direction of the relationship.

The table reveals that among children under 5 years old, the ITN use is significantly associated with household wealth, household size and mother's education. This association is significant in both 2006 and 2018.

Indeed, Table 2 shows that ITN use among children under 5 years old increases as the household wealth improves, both in 2006 and in 2018. ITN use in 2006 grows from 9.9 percent for households with the lowest wealth to 35.8 percent

Table 2. Distribution of children under 5 years old who slept under ITNs in 2006 and in 2018 according to some characteristics.

Characteristic	ITN use by children under five years old					
	2006			2018		
	%	Confidence Interval	Number of children	%	Confidence Interval	Number of children
Wealth quintile						
Lowest	9.9	[8.3 - 11.8]	3010	69.5	[65.6 - 73.1]	2642
Second	16.4	[14.3 - 18.7]	2747	77.0	[74.3 - 79.4]	2456
Meddle	21.5	[19.4 - 23.8]	2792	78.1	[74.8 - 81.1]	2470
Fourth	27.9	[25.5 - 30.4]	2677	79.4	[77.0 - 81.6]	2449
Highest	35.8	[33.2 - 38.5]	2220	83.8	[81.3 - 86.0]	2237
Total	21.5	[20.3 - 22.7]	13,445	77.3	[75.7 - 78.9]	12,255
	Pr = 0.000 < 5%					
Household size						
1 - 4 persons	29.2	[27.2 - 31.3]	3510	85.9	[84.0 - 87.6]	2662
5 - 6 persons	22.7	[20.8 - 24.7]	4060	83.9	[82.1 - 85.5]	3559
7 - 9 persons	18.1	[16.3 - 20.1]	3322	76.3	[74.1 - 78.4]	3144
10 persons & more	13.4	[11.4 - 15.7]	2553	62.5	[58.9 - 66.0]	2889
Total	21.5	[20.3 - 22.7]	13,445	77.3	[75.7 - 78.9]	12,255
	Pr = 0.000 < 5%					
Mother education level						
No education	17.7	[16.4 - 19.0]	10,083	74.6	[72.5 - 76.6]	8061
Primary	30.7	[28.3 - 33.3]	2346	82.2	[79.9 - 84.3]	2207
Secondary	37.5	[33.4 - 41.8]	948	83.0	[80.6 - 85.2]	1821
University	45.2	[31.6 - 59.6]	68	83.0	[75.0 - 88.8]	165
Total	21.5	[20.3 - 22.7]	13,445	77.3	[75.7 - 78.9]	12,255
	Pr = 0.000 < 5%					
Child's age in months						
Under 12	27.1	[25.2 - 29.0]	3095	78.0	[75.8 - 80.1]	2927
12 - 23	22.6	[20.8 - 24.5]	2851	79.2	[76.9 - 81.3]	2493
24 - 35	19.7	[18.0 - 21.6]	2535	76.8	[74.7 - 78.8]	2299
36 - 47	18.0	[16.3 - 19.8]	2678	76.4	[74.1 - 78.6]	2324
48 - 59	18.6	[16.9 - 20.6]	2286	75.9	[73.5 - 78.1]	2211
Total	21.5	[20.3 - 22.7]	13,445	77.3	[75.7 - 78.9]	12,255
	Pr = 0.000 < 5%			Pr = 0.056 < 10%		

for the highest household wealth. The trend is the same in 2018. Similarly, the chance of sleeping under ITNs grows in 2006 from 17.7 percent for children of mothers with no educated to 45.2 percent for those whose mothers have the highest level or university degrees. The same trend occurs in 2018, as for size, the chance of children sleeping in ITNs decreases as the number of people living in the household increases. This trend is the same, either in 2006 or in 2018.

While the relationship between net use and child age was significant in 2006, it was not significant in 2018 at the 5% level. This lack of association in 2018 model could be due to parents' conscious decision to have all 5-years-old children in the household sleep under a net.

In summary, these results, which show the significant influence of the household wealth, the mother's education level and household size on the ITN use, corroborate those expected.

3.3. Results

To better understand and identify the factors that may explain ITN use among children under 5 years old, two econometric models was run and the main results are detailed in Table 3.

Table 3 shows that the tendency of ITN use over the period 2006-2018 is influenced by the following factors: place of residence, household wealth, household size, religion and child age. Indeed, in 2006, children living in Atacora, Borgou, Collines, Couffo, Donga, Littoral, Mono, Oueme, Plateau, and Zou regions were between 2 and 5 times more likely to use ITNs than those in Alibori region. But behaviors of children living in Atlantic and Alibori regions are similar in 2006. in 2018, children living in all regions (Atacora, Borgou, Collines, Couffo, Donga, Littoral, Mono, Oueme, Plateau, and Zou) behave similarly to children in Alibori, except those living the Oueme region who are 54% less likely to use ITNs.

ITN usage among children under five years old increases with increasing wealth quintile. In 2006, children living in households with the second wealth quintile had 70% more chance to sleep under an ITN than their homologous form households with the lowest wealth quintile. Those living in households with a middle, fourth, or highest wealth quintile had respectively 2, 3, and 4 times more likely to use ITNs than those in the lowest wealth quintile. But in 2018, only children in the second wealth quintile are most likely to sleep under a net. So children in the other wealth quintile adopt the same behavior as those living in households with the lowest wealth quintile.

The household size increased with decreasing in ITN usage among children under five years old in 2006. Children in household sizes of 5 - 6 persons are 17% least at risk of not sleeping under a net than those in small household sizes (1 - 4 persons). The risks of sleeping without ITN are 30% for children in household sizes with 7 to 9 persons and 48% for those in households with 10 or more persons. As in 2006, the tendency is similar in 2018 but the risk increases

Table 3. Logistic regression results for the determinant factors of ITN usage among children under five years old, both in 2006 and 2018.

Use	2006				2017-2018			
	Odds Ratio	P > t	[95% Conf. Interval]		Odds Ratio	P > t	[95% Conf. Interval]	
Region								
Alibori	Ref.				Ref.			
Atacora	5.13	0.000***	2.898	9.079	1.49	0.056*	0.990	2.237
Atlantique	1.44	0.236	0.788	2.618	1.30	0.333	0.761	2.235
Borgou	2.73	0.001***	1.550	4.793	1.15	0.405	0.826	1.603
Collines	4.57	0.000***	2.533	8.256	0.64	0.054*	0.420	1.008
Couffo	5.40	0.000***	2.825	10.305	1.01	0.985	0.558	1.811
Donga	5.34	0.000***	2.852	10.001	0.95	0.783	0.664	1.361
Littoral	2.14	0.015**	1.161	3.946	1.24	0.431	0.725	2.126
Mono	3.65	0.000***	1.810	7.379	1.48	0.207	0.805	2.718
Ouémé	4.21	0.000***	2.335	7.595	0.46	0.003***	0.281	0.766
Plateau	3.93	0.000***	2.078	7.423	1.00	0.993	0.558	1.803
Zou	4.19	0.000***	2.313	7.602	1.47	0.158	0.862	2.497
Area of residence								
Urban	Ref.				Ref.			
Rural	1.15	0.104	0.971	1.366	0.92	0.351	0.780	1.093
Wealth quintile								
Lowest	Ref.				Ref.			
Second	1.70	0.000***	1.353	2.130	1.25	0.026**	1.028	1.531
Meddle	2.21	0.000***	1.779	2.755	1.24	0.075*	0.979	1.563
Fourth	2.95	0.000***	2.313	3.762	1.12	0.293	0.906	1.385
Highest	4.20	0.000***	3.221	5.472	1.22	0.165	0.923	1.601
Household size								
0 to 4 persons	Ref.				Ref.			
5 to 6 persons	0.83	0.018**	0.710	0.968	0.83	0.067*	0.686	1.013
7 to 9 persons	0.70	0.000***	0.593	0.820	0.54	0.000***	0.443	0.655
10 persons & more	0.52	0.000***	0.419	0.644	0.31	0.000***	0.249	0.382
Religion								
Traditional	Ref				Ref			
Islam	1.42	0.015**	1.070	1.877	1.23	0.150	0.928	1.626
Catholic	1.77	0.000***	1.440	2.179	1.28	0.044**	1.006	1.624
Protestant/Celestial	1.57	0.000***	1.259	1.964	1.13	0.360	0.871	1.459

Continued

Other Christian	1.19	0.122	0.955	1.478	1.25	0.072*	0.980	1.598
Other/No religion	1.31	0.053*	0.997	1.709	1.07	0.686	0.785	1.444
Ethnic group								
Adja & App.	Ref.				Ref.			
Bariba & Dendi	0.76	0.229	0.485	1.189	0.87	0.586	0.537	1.422
Fon & App.	0.85	0.217	0.665	1.097	1.08	0.691	0.747	1.553
Lokpa & Bétamaribè	0.60	0.022**	0.388	0.930	0.66	0.126	0.390	1.124
Peulh & App.	0.41	0.006***	0.224	0.772	0.62	0.080*	0.369	1.057
Yoruba & App.	0.70	0.039**	0.504	0.983	0.94	0.781	0.588	1.490
Otherethnic group	0.53	0.086*	0.253	1.096	1.14	0.658	0.642	2.017
Mother's age								
15 - 19 years old	Ref.				Ref.			
20 - 24 years old	0.93	0.625	0.704	1.235	1.59	0.002***	1.191	2.136
25 - 29 years old	1.00	0.986	0.760	1.322	1.51	0.004***	1.145	2.001
30 - 34 years old	0.82	0.177	0.616	1.093	1.85	0.000***	1.383	2.466
35 - 39 years old	0.95	0.731	0.707	1.275	1.59	0.003***	1.174	2.163
40 - 44 years old	0.74	0.108	0.506	1.070	1.92	0.000***	1.377	2.678
45 - 49 years old	0.87	0.564	0.541	1.398	1.17	0.398	0.797	1.767
Education level								
No-education	Ref.				Ref.			
Primary	1.23	0.007***	1.057	1.424	1.14	0.149	0.953	1.370
Secondary	1.33	0.008***	1.077	1.655	1.18	0.106	0.966	1.437
Superior	1.91	0.081*	0.924	3.955	0.76	0.307	0.452	1.285
Occupation								
None	Ref				Ref.			
Professional/liberal	1.17	0.493	0.751	1.810	1.43	0.100	0.934	2.185
Shopkeepers	1.00	0.978	0.831	1.209	1.19	0.051*	0.999	1.425
Women farmers	0.94	0.573	0.753	1.170	1.00	0.981	0.820	1.225
Services	-	-	-	-	1.39	0.004***	1.109	1.752
Manual not & qualified	1.34	0.019*	1.050	1.708	1.13	0.263	0.91	1.414
Other	-		-	-	1.01	0.983	0.581	1.743
Child's age								
0 to 11 months	Réf.				Réf.			
12 to 23 months	0.75	0.000***	0.660	0.860	1.00	0.975	0.869	1.155

Continued

24 to 35 months	0.65	0.000***	0.571	0.748	0.86	0.028**	0.746	0.983
36 to 47 months	0.62	0.000***	0.545	0.707	0.88	0.045**	0.776	0.997
48 to 59 months	0.67	0.000***	0.583	.0781	0.83	0.011**	0.717	0.958
Child's gender								
Male	Réf.				Réf.			
Female	0.97	0.492	0.891	1.057	1.034305	0.498	0.938061	1.140425

(*) = P < 0.1; (**) = P < 0.05; (***) = P < 0.01.

more dramatically, particularly for children in household sizes with 10 or more persons.

Religion is a differentiating factor in ITN usage among children under five, either in 2006 or 2018. Indeed, in 2006, children with Muslim, Protestant/Celestial, and Catholic parents had 42%, 57%, and 77% more of a chance to use ITNs, respectively, than their peers from parents who practice traditional religion. In 2018, all children from different religious congregations, except Catholics, adopt the same behavior as their homologous from traditional religion. Catholic children had 28% more chance to sleep under a net than those from endogenous religious households.

Child age has a significant influence on ITN use in both 2006 ($p = 0.000 < 0.05$) and 2018 ($p = [0.011; 0.045] < 0.05$). However, the child age increases with the decrease of ITN usage among children under five years old. In 2006, children aged 12 to 23 months had 25% more at risk of sleeping without an insecticide-treated net. This risk increases slightly with age, reaching 33% for children aged 48 - 59 months. In 2018, the tendency is the same, especially from children aged 24 months to their older. However, there is no significant difference between children aged 12 to 23 months and those aged 0 to 11 months in terms of ITN usage (Table 3).

3.4. Discussion

The use of decomposition allowed us to determine the proportion of the change in ITN use levels due to the change in the proportion of children (composition effect) and the proportion due to the change in ITN use behavior (performance effect) resulting from the multiple free ITN distribution campaigns. First, the simple decomposition method showed that the 56 points increase in ITN use by children was almost entirely due to the performance effect (see Table 1), whatever the variable used (Household wealth index, education level, and age of the child). The advanced decomposition of this performance effect revealed that the change in ITN use was due primarily to the baseline performance effect (see Table 1). The baseline performance effect reflects not only the improved availability of ITNs in households but also the effects of sensitization on the benefits of ITN use for children under 5 years old. In other words, a true practice of using

ITNs has been established in the sleeping habits among children under 5 years old during the period 2006-2018. Free ITN distribution campaigns supported by routine distributions and sensitization campaigns are driving this change [15]. These government actions, supported by those of various actors in the sector, have removed several obstacles to the use of ITNs, particularly among children under 5 years old. However, some barriers continue to influence the use of ITNs [15] that slow down the malaria eradication target set by the NMCP for 2030. Among those barriers, the use of ITNs for other purposes such as protecting young vegetable plants to prevent insect damage to produce vegetables [28]. Moreover, additional workload associated with the use of ITNs is another category of barrier, especially for mothers of young children [29].

This situation calls for traditional institutions, community opinion leaders and social agents to strengthen their beneficial role [30] to reduce or even eradicate deficiencies in knowledge, attitudes and practices regarding the use of ITNs.

The in-depth analysis shows that in both 2006 and 2018, place of residence, household wealth, household size, religion, and child age have significant effects on ITN usage among children under age 5 years old (**Table 3**). Additionally, the results reveal that the disparity noted in ITN usage between regions in 2006 has canceled in 2018, except in the Oueme region where children under 5 years old had 54% least likely to sleep under ITNs compared to their homologous in other regions. In other words, children in this region are exposed to a higher risk (more than 50%) of sleeping without ITNs. If the free distribution campaign increases ITN usage [12], then the low propensity of ITN usage among children is a consequence of low household coverage within ITN. But the 2017-2018 DHS reported that 78% of households in the Oueme region have at least one ITN and only 49.6% of households own at least one ITN for every two persons. Therefore, it is important to improve the achievement of full household ITN coverage in the Oueme region through both routine distribution [31] and targeted distribution. This would increase the propensity of children in this region to sleep under ITNs.

The analysis also revealed in 2006 that household wealth has a negative effect on ITN usage among children under 5 years old [11]. However, this effect began fading in 2018 because all children adopted similar behaviors, except those in households with the second wealth quintile who had 25% more likely to sleep under ITN than others. Indeed, with the advent of free ITN distribution (especially in 2011, 2014, and 2017 campaigns) aimed at universal coverage, households with the lowest or second wealth quintile no longer needed to devote financial resources to purchasing ITNs. This situation accelerated ITN use among children under 5 years old in the lowest wealth quintile more than those in the highest wealth quintile. These households with the lowest wealth quintile used to forego ITN purchases because of low income, which has a negative impact on ITN use among children. In contrast, in the households with the highest wealth quintile, insecticide sprays, coils, or window and door screens are used extensively as a means to prevent malaria.

Although the region was significant in 2018, only Catholic religion had an influential effect on ITN use. Indeed, children under 5 years old whose parents practice the Catholic religion are 28% more likely to sleep on ITNs than their peers from other religions. This finding is consistent with those obtained in Burkina Faso [32]. This means that mothers from the Christian community benefit from peer counseling on the ITN effectiveness and their importance for pregnant women and children.

A high household size is a constraint to the ITN usage among children under 5 years old. In fact, household size increases with the decrease in ITN use, similar to the finding in Burkina Faso [10]. So household size is a barrier to ITN use among children under 5 years old, and especially in some households with large size, where four or five children slept under one ITN, making heavy pressure on it, which eventually tears [15].

The child's age is a determinant factor in ITN use in both 2006 and 2018. The increase in child age decreases slightly with ITN usage. The result of **Table 3** indicates that children under one year old are more likely to sleep under ITNs than their homologous of other age categories [15] [33]. In many beninese communities, many pregnant women kept their ITNs (received during the free distribution campaign or during prenatal consultations) in suitcases or wardrobes to secure them, which will be only used after delivery [15]. So ITNs are kept for major events like birthdays or baptism, etc., where visitors should see the new condition of the bed, sheet, cloth and others. But after the child's first birthday, the enthusiasm of mothers or caregivers to regularly make the children sleep under the ITNs decreases by time until the fifth birthday [15]. Also, it is only children under one year old receive ITN during measles vaccination. Thus, no specific strategy (other than mass distribution campaigns) is developed for children in other age groups.

4. Conclusions

This article aimed to elucidate the sources of change in ITN use levels among 5 years old in Benin between 2006 and 2018, and to identify the main determinant factors that influence this use.

The decomposition analysis shows that behavior change (*i.e.*, integrating ITN into sleeping habits) is the base of the increase in ITN use level among children under 5 years old during the 2006-2018 period. This result encourages the government's commitment to aim elimination of malaria by 2030 and challenges the PNLP to identify better strategies which likely to maintain or improve the current ITN coverage level. 2020 ITN mass distribution campaign digitization is a tangible example of strategy that has improved household identification, quality, timeliness, and real-time monitoring of campaign data collection [34].

Given that the proportion of children under five sleeping under ITNs (76.3%) remained below the collective protection threshold (80% according to WHO), place of residence, household wealth, household size, religion, and child's age are

the levers that policies must use to further improve ITN use among t children under-five years old.

Our findings suggested the following recommendations:

- Maintain and improve the current ITN coverage level through a regular system of net distribution (mass distribution campaigns; routine distribution; school distribution) to achieve or exceed at least the threshold (80%) of mass protection effect;
- Extend the systematic distribution system to private sector health centers to allow pregnant women and children attending these centers for ANC and Rouvax to receive also ITN, given that a large percentage of the population attends these health facilities;
- Conduct a mixed-methods survey (quantitative and qualitative) to collect a wide range of information needed to better understand all aspects of the insecticide-treated net use gap among children under 5 years old in the Oueme region;
- Strengthen awareness campaigns in local languages on benefits and effectiveness of the insecticide-treated net in preventing malaria, especially for children under 5 years;
- Establish a consultation framework at the district level to discuss issues related to the use of health services, in particular the ITN usage, and thus effectively involve community leaders, including religious leaders and traditional healers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix: Percentage of Children under Five Years Who Sleep under an Insecticide-Treated Net According to Background Characteristics

Background characteristics	2006		2018	
	Percentage	# of children	Percentage	# of children
ITN use				
No	78.5	10,554	22.7	2779
Yes	21.5	2891	77.3	9476
Region of residence				
Alibori	8.9	1200	13.7	1676
Atacora	7.3	988	8.9	1094
Atlantique	11.4	1526	11.3	1384
Borgou	10.3	1386	13.3	1633
Collines	7.2	970	6.4	788
Couffo	8.4	1124	6.6	813
Donga	4	534	6.6	803
Littoral	6.3	852	4.4	543
Mono	5.8	779	4.5	550
Ouémé	13.8	1853	8.9	1089
Plateau	5.1	689	5.9	722
Zou	11.5	1544	9.5	1160
Place of residence				
Urban	33.9	4561	38.9	4766
Rural	66.1	8884	61.1	7488
Househld wealth quintile				
Lowest	22.4	3010	21.6	2642
Second	20.4	2747	20	2456
Middle	20.8	2791	20.2	2470
Fourth	19.9	2677	20	2449
Highest	16.5	2220	18.3	2237
Household size				
1 - 4 persons	26.1	3510	21.7	2662
5 - 6 persons	30.2	4060	29	3559
7 - 9 persons	24.7	3322	25.7	3144
10 persons & more	19	2553	23.6	2889

Continued

Ethnic group				
Adja and Affiliate	17.3	2331	12.8	1573
Bariba and Dendi	12.3	1659	18.3	2241
Fon and Affiliate	42.3	5688	33.5	4105
Lokpa and Bétamaribè	10.8	1445	9.6	1178
Peulh and Affiliate	6.4	854	10.6	1297
Yoruba and Affiliate	10.4	1401	10.1	1233
Other	0.5	67	5.1	627
Religion				
Traditional	19.6	2632	9.6	1181
Islam	23.2	3122	33.9	4150
Catholic	25.2	3388	19.8	2429
Protestant/Celestial	14.5	1945	16.1	1973
Other Christian religion	10.2	1372	13.7	1674
Other	7.3	986	6.9	848
Mother education level				
No education	75	10083	65.8	8061
Primary	17.4	2346	18	2207
Secondary	7.1	948	14.9	1821
University	0.5	68	1.3	165
Mother's age (in years)				
15 - 19	3.7	502	4.4	536
20 - 24	18.9	2544	20.7	2540
25 - 29	31.8	4271	30.7	3763
30 - 34	23.5	3156	21.5	2639
35 - 39	13.8	1860	14.3	1750
40 - 44	6	808	6	733
45 - 49	2.3	304	2.4	293
Mother's occupation				
None	12,2	1641	17.1	2099
Professional	1,5	201	3	366
Traders	40,9	5504	32.3	3955
Women farmers	38,1	5121	23.4	2865
Services	-	-	11.6	1427
Manual workers (skilled & unskilled)	7.3	979	11.1	1354

Continued

Other	-	-	1.5	189
Child's age (in month)				
< 12	23	3095	23.9	2927
12 - 23	21.2	2851	20.3	2493
24 - 35	18.9	2535	18.8	2299
36 - 47	19.9	2678	19	2324
48 - 59	17	2286	18	2211
Gender				
Male	50.3	6768	50.7	6215
Female	49.7	6677	49.3	6040
Total	**100**	**13,445**	**100**	**12,255**