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Working Paper · July 2017

DOI: 10.13140/RG.2.2.19388.13445

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Risk Perception: Bed Net Use Against Malaria in Cameroon

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July 14, 2017

Abstract

In spite of undeniable recent progress, malaria today represents one of the global public health issues making the greatest impact on the economy. The present study carries out on the basis of the malaria indicator survey conducted in Cameroon in 2011. Only children under six years old are considered. We estimate the probability of being ill while benefiting from protection against malaria to be endogenous, which to our knowledge is new. Our findings allow an estimate of the effect of protection. Predictably, sleeping regularly under a bed net significantly decreases the probability of being ill. Our results also show that the children who are best protected are apparently those at greatest risk of infection. Households therefore seem to have a "good" perception of the risk of disease.

Keywords : malaria, protection, risk, bed net, instrumental variables, bivariate probit, Africa, Cameroon.

JEL Codes : I15, C35, C36

1. Introduction

Along with AIDS and tuberculosis, malaria today represents one of the global public health issues making the greatest impact on the economy, in spite of undeniable recent progress (Manguin et al., 2008). According to the WHO statistics (WHO, 2016), the population at risk is estimated at 3.2 billion in 2015. The estimated number of malaria occurrences stands at 214 million, of which 88% are in Africa. The number of malaria-induced deaths was estimated at 438,000 in 2015, of

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which 90% in Africa. Younger children are still the hardest hit, with 70% of deaths, but malaria is no longer the first cause of death among African children less than 5 years old. In 2012, the direct costs of malaria were evaluated, on the scale of the African continent, at 12 billion USD a year, not counting the indirect economic losses. Malaria prevention and treatment reportedly absorbed up to 25% of a household's income and represented up to 40% of the health care costs incurred by the States (PSNLP, 2011).

There is at present no approved vaccine against malaria. Risk reduction can be achieved through to reduction of exposure to mosquito bites (Alaii et al., 2003). According to the WHO, there are two main forms of vector control: insecticide-treated bed nets (ITN) [1] and indoor residual spraying (IRS) with insecticide. Confronted with such an endemic disease, which threatens the development of poor countries and the well-being of their populations, pride of place was given to the fight against this in the Millennium Development Goals (MDGs) adopted by the United Nations in 2000. It is in this context that Cameroon took the initiative, in 2002, to prioritize the fight against malaria. In Cameroon, malaria is the first cause of death (41%) among children less than five years old and accounts for 18% of adult deaths. In 2011, malaria prevalence among children from 6 to 59 months was 30%, peaking at 37% in rural areas and averaging at 21% in urban zones. In the years between 2004 and 2011, the evolution was patchy, with malaria prevalence spiking in rural areas and declining in urban zones (INS, 2012).

Why does a household decide to purchase an ITN? Why does a household decide to use an ITN? In many countries, ITNs are distributed free of charge. Cohen and Dupas (2010) have shown that even if a financial participation were imposed on the households, the rate of ITN use would not budge significantly [2]. The quantity of ITNs bought has been shown to decrease with the increase in the financial participation requested (Dupas, 2009), although Keefer and Khemani (2012) find that households' willingness to pay can be enhanced by media campaigns. The policy of free ITN distribution, with a view to attaining universal coverage of populations at risk, is therefore supported by these studies but is probably insufficient to ensure actual utilization of the net. The chances of success in the fight against malaria can be improved by identification of the variables explaining the rate of ITN use. A substantial body of literature has raised the issue on the basis of several country case studies (Adjei and Gyimah (2012); Bennett et al. (2012); Bowen (2013); Chukwuocha et al. (2010); Macintyre et al. (2012) to quote only the most recent articles [3]), with occasionally contradictory findings. Macintyre et al. (2012) argue that if the pollster observes that a household has spread out an ITN then there is a 90% chance that the ITN has been used on the night preceding the survey. This would still fail to address our question inasmuch as spreading out the ITN is endogenous. We cannot take the hanging of an ITN to be an explanatory variable in the use of this ITN. However, this study does indirectly lead us to think that the person in charge of the household makes a familiar economic trade-off. Hanging an ITN represents an effort and thus a disutility to the person doing it. If the conditions exist in the house for the ITN to be spread out once and for all, this disutility is a one-off. Otherwise, this disutility arises every evening.

Measures of climate parameters (Ye et al., 2009) show that temperature is the best predictive factor for the abundance of mosquitoes and for malaria incidence. An interesting analysis (Huldén et al., 2013) of the impact of the average number of people living in one household on the probability of eradicating malaria determines a “critical mass” of four persons per

1. Mosquito nets subjected to long-lasting insecticide treatment (ITN, “insecticide-treated nets”) are the most frequently distributed in public health programs.

2. See Augustincic Polec et al. (2015) for a review of the recent body of scientific evidence on the effect of cost on ITN ownership and use.

3. See Pulford et al. (2011) for a review of the literature on the reasons for households' failure to use their ITNs.

household. However, these models fail to explain the spatial heterogeneousness in the intensity of transmission that can be observed from one village to another in a zone identified as endemic or very favorable to the proliferation of anopheles (Pierrat, 2012). Since transmission takes place mainly at night and thus inside the house, the extent to which the house is finished arguably plays a role in the risk pattern. In particular, the nature of the roof, the walls and the number of openings may have an incidence (Konradsen et al., 2003). The environment close to the house also plays a role: certain sanitation practices create human-made micro-shelters for parasites. However, recent studies have shown that the correlation between the number of vectors identified in a living space and the extent of transmission was not strong enough to explain the phenomenon of transmission (Bousema et al., 2010). According to Pierrat (2012), malaria should be traced back to "a certain level of vulnerability that characterizes individuals or groups of individuals, and that becomes entrenched in the reality of a territory, making it a pathogenic system". A number of socioeconomic and cultural patterns (wealth, type of construction, education, land use, access to health care, religion, etc.) may increase the odds of occurrence of the disease.
Models incorporating a more comprehensive consideration of the different socioeconomic and cultural factors that can explain the risk of transmission should be used. This is what we attempt to do in the present article. Our objective is to highlight the effect of protection on disease prevalence among children under 6 years old. The studies attempting to explain the ownership and use of ITNs suggest that these two variables are associated with the household's decision to protect itself. Such a decision is therefore an endogenous choice of the household, and this is particularly true in our sample because Cameroonian households are far from all possessing mosquito nets. This decision can depend on observable elements (size of the household, ability to afford an ITN, for example) or factors harder to assess (perception of the risk of disease, risk aversion). It is necessary to determine the profile of the children protected against malaria in Cameroon by an ITN and/or indoor residual spraying. To this end, it is necessary to estimate simultaneously the probability of protecting oneself through prevention and the probability of contracting the disease by an instrumental variable method. The data used to carry out this work is drawn from the Malaria Indicators Survey (EIP, 2011). The survey covers a nationwide sample of Cameroonian households, and supplies the information necessary for the monitoring and evaluation of the programs to fight against malaria implemented in Cameroon. Data are described in the following section, section 3 develops the model and section 4 presents the results obtained. Section 5 will allow us to conclude briefly.

2. Data

The database used is the EIP 2011 carried out by the Ministry of Health of the Republic of Cameroon. The survey covers a sample of 6702 households. 6044 children under 6 years were counted, for 3291 households. With the agreement of the person in charge of the child (the referent), a rapid diagnostic test (RDT) for malaria was performed on 4939 children, i.e. 82% of the eligible children. However, because of non-responses on key variables (RDT outcome, referent and presence of an ITN in the house), we worked on a sample of 4465 children for 2677 households, i.e. on average 1.7 children under 6 years per household.
Several key pieces of information concerning the children are available. We have, for every child, his or her own individual characteristics: age in months, sex, link with the head of the household (HH), and RDT outcome. We identify the referent (always a woman) and we observe a number of the referent's characteristics: age, level of education, family link with the child, religion, general knowledge of the disease. We know if this person regularly listens to the radio or watches TV (where messages on malaria prevention are frequently broadcast), if she knows the causes and symptoms of the disease and if she heard a message about ITN during the last

month. We also have information on the household where the child lives: the HH's sex and age, the household size, the number of children under 6 years old, the presence or absence of an ITN in the house and the household's income level. Unfortunately, we have no information on the HH's or the referent's professional activity.

TABLE I : Descriptive statistics concerning protection and RDT

		Yes		No		Total
		count	%	count	%	
The child lives in an accommodation with at least one ITN		2693	60.3	1772	39.7	4465
The child sleeps regularly under an ITN		1606	59.6	1087	40.4	2693
The child tests positive at the RDT	all	1646	36.9	2819	63.1	4465
	accommodation without ITN	712	40.2	1060	59.8	1772
	accommodation with at least one ITN	934	34.7	1759	65.3	2693
	does not sleep regularly under an ITN	393	36.2	694	63.8	1087
	sleeps regularly under an ITN	541	33.7	1065	66.3	1606

Source: ministry of Health, EIP 2011. Reading: 2693 children, i.e. 60.3% of the sample, live in an accommodation having at least an ITN and 1772 children, i.e. 39.7% of the sample, live in an accommodation without ITN; among these 1772 children, 712 have a positive test, i.e. 40.2% of this subsample, and 1060 children, i.e. 59.8% of this subsample, a negative test.

Finally, we know some features of the child's housing: location (region, rural or urban area, close to a stream or to a field), number of sleeping places, housing type (building materials and finish of walls and roof, and floors) as well as the sanitation patterns (toilet with flush, latrines, no toilet). Based on the information on the materials, we have built a synthetic index of the extent to which the accommodation is finished. Details about this indicator are given in Table V. All the houses finished to a very high degree have a floor, a roof, finished walls and glass windows, whereas almost all of the houses with zero finish have unfinished floors, roof and walls without windows. Since the number of sleeping places is generally linked to the household size, we have calculated the number of people per sleeping place. We count 2693 (60.3%) protected children (cf. Table I). Yet we know that the child may not sleep regularly under the ITN. The protection variable has three levels: no protection (no ITN); reasonable protection (the child lives in a home possessing an ITN but may not sleep regularly under it); high protection (the child lives in a home possessing an ITN and sleeps regularly under it). Among the children living in a house equipped with at least an ITN, about 60% sleep regularly under it (cf. Table I).

The malaria RDT outcomes are provided in Table I: 37% of the children test positive. The rate is significantly higher for children living in accommodation with no protection (more than 40%) and is significantly lower for children sleeping regularly under an ITN (less than 34%). The descriptive statistics tables (cf. Table VI; Table VII and Table VIII) suggest some differences depending on the subgroup under consideration (protection level or RDT outcome). Out of the total sample, we note that over half the children have a very poorly educated referent (she cannot read) and over one third live in a household of more than eight people. Housing is mainly in rural areas (over 60%) and close to a field (over 80%). As to the extent to which the house is finished, we notice that approximately a quarter of the children live in a house referred to as unfinished or very weakly finished and about 20% live in a house of a high or very high standard of finish.

3. Econometric Model

The literature review highlights the need to take into account the endogenous nature of protection. The fact of protecting oneself against malaria is related to several observed or unobserved variables that can also have an impact on the probability of being taken ill. One could think, for example, as mentioned by Pierrat (2012), of the immediate surroundings of the house, the micro-climate (Konradsen et al., 2003), the perception of the risk of disease [4] by the referent or the HH. All these considerations might have effects on the decision to protect oneself and the prevalence of the disease.

The existence of relevant unobserved variables does not allow us to use matching methods or propensity score estimations. We consider a bivariate Probit model. The first equation accounts for the level of protection chosen and the second for a positive RDT. The identification of these models requires the presence of instrumental variables. These instruments should influence the level of protection but not the RDT outcome. The variables serving as instruments are variables linked to the referent (his or her knowledge of the disease, his or her religion) as well as the characteristics of the HH. The explanatory variables introduced into the two equations are linked to the different characteristics of the child, the referent, the household and the housing. As the variable characterizing the wealth of the household is, by construction, very strongly correlated to the variables characterizing the quality of the housing, we have decided not to include it in the regressions.

The variable [5] P, characterizing protection takes on three modalities:

$$P = \begin{cases} 0 & \text{if the child lives in an unprotected house,} \\ 1 & \text{if the child does not sleep regularly under an ITN,} \\ 2 & \text{if the child does sleep regularly under an ITN.} \end{cases}$$

The level of protection is modeled by an ordinal probit model:

$$P = k \Leftrightarrow t_k < P^* = X_P\beta_P + u_P \leq t_{k+1}, k = 0, 1, 2. \tag{1}$$

Let us note P^1 and P^2 the dummies associated with the two modalities characterizing the level of protection. u_P, the error term, is supposed to follow a standard normal distribution. By convention, $t_0 = -\infty$, $t_3 = +\infty$ and $t_1 = 0$ in order to make identification possible. Thus we suppose that the vector X_P includes a constant term. It is necessary to estimate the vector of parameters β_P and the threshold t_2. The RDT outcome is modeled by a simple Probit model:

$$M = \begin{cases} 0 & \text{if} \quad M^* = P^1\alpha_1 + P^2\alpha_2 + X_M\beta_M + u_M < 0, \\ 1 & \text{if} \quad M^* = P^1\alpha_1 + P^2\alpha_2 + X_M\beta_M + u_M \geq 0. \end{cases} \tag{2}$$

So, the child is positive in the test (affected by malaria) if the latent variable M^* is positive ans the test is negative if the latent variable is negative (2). M^* depends i) on variables characterizing the degree of protection, whether the child does not sleep regularly (P^1) or sleeps regularly (P^2) under an ITN, the latter two variables being potentially endogenous (α_1 and α_2 are the parameters to be estimated linked to the intensity of protection); ii) on a set of exogenous individual characteristics X_M (β_M is the vector of corresponding parameters to be estimated) and iii) on a random error term u_M supposed to follow a standard normal distribution. The set of parameters to be estimated for this equation is thus (α_1, α_2, β_M). In order to take into account

4. Tarozzi et al. (2009) show the importance of the degree of risk aversion in the case of malaria, when the households have the choice between various contracts to finance the acquisition of an ITN.

5. To simplify notations, the child index i is omitted.

the endogenous nature of the use of an ITN, the errors are supposed to follow a normal bivariate distribution. Both terms of measurement error are supposed to be correlated (σ_{PM}). We have two types of contributions to the likelihood [6], depending on whether the child tests positive or negative.

Based on the estimated model, it is possible to calculate the effects of the level of protection. We compare the probability that a child is ill, according to his or her level of protection, with the probability that this child would have been ill if he had not been protected. This involves calculating the effect of the treatment (level of protection) on those having undergone the treatment (the children who sleep, regularly or not, under an ITN). This effect is referred to as ATT (Average Treatment on Treated). Let M_k be the child's potential illness, k the level of protection. The level of protection on the disease is defined by:

$$ATT_{jk}(X) = \frac{\mathbf{P}(P = j, M_j = 1|X)}{\mathbf{P}(P = j|X)} - \frac{\mathbf{P}(P = j, M_k = 1|X)}{\mathbf{P}(P = j|X)}, \; j \neq k, \tag{3}$$

where j is the observed protection: $j = 1,2$ given the level of protection. $k = 0,1,2$ is the counterfactual. Similarly, we can calculate the potential effect of a level of protection for a child initially unprotected. This involves calculating the effect of the treatment (level of protection) on those not having undergone the treatment (the children living in an accommodation without an ITN). This effect, referred to as Average Treatment on Non Treated, ATNT), is measured by:

$$ATNT_{0k}(X) = \frac{\mathbf{P}(P = 0, M_0 = 1|X)}{\mathbf{P}(P = 0|X)} - \frac{\mathbf{P}(P = 0, M_k = 1|X)}{\mathbf{P}(P = 0|X)}, \; k \neq 0, \tag{4}$$

where $k = 1,2$ is the potential situation of protection. The confidence intervals of the average estimated effects for the protected children (3), or for the unprotected children (4) are obtained by bootstrapping from 1000 iterations. More precisely, from the estimated parameters obtained by maximum likelihood (cf. Table II), predictions of the probabilities defined in equations (3) and (4) have been computed. These predicted probabilities allow to compute average treatment (protection) effects are given in Table III. To measure the significant of these effects we have to compute the standard deviations or the confidence intervals. Because the delta method is not easy to calculate we decide to use bootstrap method. Three steps have been replicated a thousand times: (i) using a random number generator we draw with replacement a sample of size n (2677) from the actual sample; (ii) we estimate the model for this random sample; (iii) we predict and save (3) and (4). Confidence interval (95%) with Efron's bias-corrected method have been computed (for more detail about the method see for example Efron and Tibshirani (1986)).

4. Results

The comments on the findings are made all other things being equal. Taking the level of protection to be endogenous seems appropriate because the correlation coefficient between the terms of errors associated with the two equations is positive and significant. This means that any explanatory variables not observed in the equations affect both probabilities analyzed in the same way.

4.1. The determinants of the level of protection

The effects of the various characteristics under consideration on the level of protection are given in column 1 of Table II. The probability of sleeping regularly under an ITN differs according to the regions. This variable can be considered a more or less close proxy of the climate. It is worth recalling that the seasonality of the entomological inoculation rate is correlated to the climate.

6. For more details about the contributions see for example Body et al. (2014).

TABLE II : Estimation of the probabilities of level of protection and disease

		Protection level coef.		Malaria coef.	
Intercept		−0.232	(0.28)	0.120	(0.27)
Referent's age	max 20 years old	−0.034	(0.09)	0.062	(0.10)
	20 to 25	0.061	(0.07)	0.137*	(0.08)
	25 to 30	−0.012	(0.06)	0.014	(0.07)
	30 to 35	0.07	(0.06)	0.081	(0.07)
	over 35 years old (Ref.)				
Mother of the child?	yes	−0.077	(0.08)	−0.105	(0.08)
Level of education	illiterate	−0.020	(0.05)	0.122**	(0.06)
	literate but no education	0.023	(0.06)	0.010	(0.06)
	has some education (Ref.)				
Preventive treatment during pregnancy	yes	0.111***	(0.03)		
Level of information	watches TV regularly	0.117***	(0.04)		
	listens to the radio regularly	0.013	(0.03)		
	knows the causes of the disease	0.057*	(0.03)		
	knows the symptoms of the disease and can react	0.032	(0.04)		
	has heard messages on ITNs in the last month	0.062	(0.04)		
Confession	catholic	−0.119**	(0.05)		
	protestant	−0.057	(0.05)		
	muslim (Ref.)				
	animist	−0.440***	(0.09)		
	others	−0.274***	(0.07)		
	no religion	−0.193**	(0.09)		
HH's gender	male	0.143***	(0.05)		
HH's age		0.008	(0.01)	0.014	(0.1)
$(\text{HH's age}/10)^2$		−0.008*	(0.01)	−0.014	(0.00)
Number of children less than 6 years old		−0.065***	(0.02)	−0.044**	(0.02)
More than one referent	yes	0.082	(0.06)	0.197***	(0.06)
HH's number of children		−0.004	(0.00)	0.053*	(0.03)
$(\text{HH's number of children}/10)^2$		−0.037	(0.21)	−0.395*	(0.23)
Number of persons per sleeping unit		0.303***	(0.07)	0.266***	(0.07)
$(\text{Number of persons per sleeping unit})^2$		−0.036***	(0.01)	−0.028**	(0.01)
Relationship with the HH	daughter or son (Ref.)				
	grand-daughter or grand-son	−0.067	(0.07)	−0.024	(0.07)
	other	−0.093	(0.07)	0.195**	(0.09)
Age of the child	up to 12 months	0.016	(0.08)	−0.535***	(0.10)
	12 to 18 months	0.120	(0.08)	−0.383***	(0.10)
	18 to 24 months	0.027	(0.08)	−0.351***	(0.09)
	24 to 36 months	0.029	(0.07)	−0.188***	(0.07)
	36 to 48 months	0.023	(0.07)	−0.194***	(0.07)
	48 to 60 months	0.021	(0.07)	−0.064	(0.07)
	over 60 months				
Gender of the child	boy	−0.006	(0.04)	−0.008	(0.04)
The house is	close to a water stream	0.023	(0.04)	0.013	(0.04)
	close to a field	−0.043	(0.05)	0.045	(0.06)
	in a rural area	0.143***	(0.05)	0.356***	(0.06)
Finished housing	zero, no toilet	−0.238**	(0.11)	−0.078	(0.13)
	zero, with latrine	−0.003	(0.08)	0.239***	(0.09)
	very weak, without toilet	−0.391**	(0.17)	−0.062	(0.19)
	very weak, with latrine	0.079	(0.09)	0.244***	(0.09)
	weak	−0.054	(0.05)	−0.073	(0.06)
	intermediate (Ref.)				
	high, with latrine	−0.161**	(0.07)	−0.197**	(0.08)
	high, with flush toilets	−0.032	(0.12)	−0.190	(0.15)
	very high, with latrine	−0.167**	(0.08)	−0.251***	(0.09)
	very high, with flush toilets	−0.381***	(0.12)	−0.355**	(0.14)
Region of residence	Adamaoua	−0.849***	(0.09)	−0.869***	(0.09)
	Centre	0.283***	(0.09)	0.332***	(0.09)
	Douala	0.625***	(0.1)	0.312**	(0.13)
	Est (Ref.)				
	Extreme Nord	−0.268***	(0.09)	−0.676***	(0.09)
	Littoral	−0.522***	(0.1)	−0.762***	(0.1)
	Nord	−0.020	(0.09)	−0.168*	(0.09)

continued on the next page

Table II : *continued*

		Protection level coef.		Malaria coef.	
	Nord Ouest	0.241***	(0.09)	−0.881***	(0.15)
	Ouest	−0.436***	(0.09)	−0.929***	(0.1)
	Sud	−0.228**	(0.1)	−0.170*	(0.1)
	Sud Ouest	−0.639***	(0.1)	−0.902***	(0.1)
	Yaoundé	−0.266***	(0.1)	−1.074***	(0.13)
Does not sleep regularly under an ITN				−0.874***	(0.10)
Sleeps regularly under an ITN				−1.660***	(0.21)
No ITN in the household (Ref.)					
Threshold t_2		0.668***	(0.02)		
σ_{PM}				0.716***	(0.11)

Source: Ministry of Health, EIP 2011. Reading: for every column, the first figure is the estimated parameter (significant at the level * 10%, ** 5%, *** 1% at least) and the figure in brackets is the standard deviation of this parameter.

The child's gender and age plays hardly any role in the level of protection. HH's age and to a lesser extent referent's age, even though the referent is the mother of the child, fails to significantly affect the level of protection. The children without a direct family tie with the HH, such as grandchildren do not sleep regularly under one. The messages that households and referent may receive through the media on the ways to fight against malaria, or its symptoms or vectors, have a positive impact on the child sleeping regularly under an ITN. The probability that the child sleeps regularly under an ITN soars especially if the referent reports having heard messages on the ITN during the last month. The referent's religion seems to have a significant impact on the level of protection. Children having a referent of Protestant or Muslim confession have a higher probability of sleeping regularly under the ITN than those having an animist, Catholic and other confession. The size of the household has a significant impact on the level of protection. The probability that the child sleeps regularly under an ITN, shrinks with an increase in the number of children under six years old present in the household. On the other hand, this probability surges with the average number of people sleeping in a single bed. Housing features are discriminatory: children living in badly finished housing without a toilet have fewer chances than the others of sleeping regularly under an ITN. It may be supposed that these children live in very poor families who cannot afford an ITN, or in houses where an ITN would be utterly ineffective. Finally, the household location plays a crucial role: the house being in a rural area reduces the probability that it is protected, while living close to a stream or a field has no significant impact.

4.2. The determinants of disease

To measure the probability that the RDT is positive (the child is ill) special attention was paid to the level of protection. The estimation results are given in column 2 of Table II. The child's gender is not significant: girls are no more liable to disease than boys but the child's age does have an impact: the older the child, the higher the probability that he or she may be ill. As the child grows up he or she becomes more autonomous and increasingly hard to keep under protection. Household size influences the probability of being ill: the higher the number of people sharing a single sleeping place, the higher the probability of being ill. Overcrowding may be at the root of this finding. Housing features are discriminatory: i) a child living in a poorly finished house with latrines has a stronger chance of being ill, ii) a child living in a house finished to a high or very high level has fewer chances of being ill. Living in a rural area increases the probability of testing positive, whilst the proximity to a stream or to a field has no significant impact.

Looking at protection, the results show that in both cases (more or less regular use of an ITN), the chance of being ill is lower but the effectiveness of an ITN is stronger if the ITN is used on a regular basis. The average treatment effects on the treated (the protected children) and the untreated (the unprotected children) have been estimated in Table III.

TABLE III : Average effect of protection on disease

	Level of protection		
	$k=0$	$k=1$	$k=2$
$ATNT_{0k}$ (40.2)		26.2 [14.2;32.4]	34.0 [17.6;40.0]
ATT_{1k} (36.2)	-35.4 [-48.1;-16.7]		23.1 [9.8;30.2]
ATT_{2k} (33.7)	-51.2 [-62.6;-27.9]	-28.1 [-42.2;-10.7]	

Source: calculations made by the authors. Reading: the value 0 is associated with an absence of protection, the value 1 with an intermittent protection and the value 2 with a regular protection. Figures given in brackets are the Efron's bias-corrected confidence intervals (95%). A child unprotected by an ITN would see his probability of being ill, percentage between hooks, decreased by 34.0 points if he slept regularly under an ITN.

These effects are significant. The average probability that an unprotected child is ill is 0.4. The estimation of the ATNT shows that this probability would decrease on average by 0.26 if the child did not sleep regularly under an ITN and 0.34 if he slept regularly under an ITN. The estimates of these three average probabilities of being ill are lower than the average probabilities of being ill observed in protected children.
Similarly, the average probability that a child living in a home with an ITN is ill is 34.6%. The ATT estimation shows that children sleeping regularly under an ITN would see their probability of being ill multiplied by approximately 2.5 if they were not protected and by 1.8 if they slept occasionally under an ITN. For children not sleeping regularly under an ITN, not sleeping at all under the ITN would multiply their probability of being ill by two, while sleeping regularly under it would reduce this probability by two thirds.
It is possible that the effects of the protection may be overestimated and that having additional data available might improve the accuracy of our results. Nevertheless, these findings show that the children who are best protected are likely to be those at the greatest risk due to their health conditions, and/or those living in a high-risk area of transmission. At any rate, our results show that households have a "good" perception of the risk of disease. They are not in an uncertain universe but in a "risky" one, to use Knight's word.

4.3. Robustness tests

The analysis above was refined by testing the models on sub-samples. The estimated coefficients are given in Table IV. Most of the sub-samples continue to show a positive effect of bed net regular use on the child's chance of remaining healthy. For children living in households with a high to very high income level, the effect of the protection is lower. Factors other than protection related to a higher income might be just as powerful, or more powerful, in explaining their better health status, such as higher-quality sanitation in and around the house, improved access to health care services, and better nutrition. In the same way, for children living in rural areas, protection effects are noticeably weaker than for their urban counterparts. Factors such as poor environmental sanitation, poor availability of primary health care and poor nutrition have an adverse effect on morbidity, canceling out the positive effect of protection, which means that a wider range of policy measures are required to effectively fight rural malaria. It would also appear that living in a household with more than one person in charge weakens to some extent the effect of protection, as does the fact of having two or more children under 6 years old. Finally, when the HH is a female, the regular use of an ITLN does not seem to have a statistically significant effect on the probability of being taken ill.

TABLE IV : Effect of level of ITN use on malaria

Sleep regularly under an ITN	no	yes	σ_{PM}
Whole sample	-0.87^{***} (0.10)	-1.66^{***} (0.21)	0.72^{***} (0.11)
Housing in a rural area	-0.75^{***} (0.22)	-1.41^{***} (0.43)	0.60^{***} (0.23)
Housing in a urban area	-0.91^{***} (0.11)	-1.80^{***} (0.31)	0.75^{***} (0.17)
Mother of the child	-0.88^{***} (0.10)	-1.66^{***} (0.22)	0.72^{***} (0.12)
The child has one referent	-0.90^{***} (0.09)	-1.78^{***} (0.21)	0.79^{***} (0.12)
The child has more than one referent	-0.82^{***} (0.18)	-1.41^{***} (0.32)	0.56^{***} (0.15)
The HH is a male	-0.88^{***} (0.09)	-1.71^{***} (0.18)	0.72^{***} (0.10)
The HH is a female	0.25 (0.51)	−0.15 (0.30)	0.00 (0.47)
One child less than 6 years old	-0.96^{***} (0.10)	-1.83^{***} (0.28)	0.86^{***} (0.17)
Two children less than 6 years old	-0.81^{***} (0.18)	-1.56^{***} (0.37)	0.62^{***} (0.20)
More than two children less than 6 years old	-0.74^{***} (0.23)	-1.38^{***} (0.40)	0.52^{***} (0.20)
Very low or low household income	-0.99^{***} (0.08)	-1.98^{***} (0.12)	0.86^{***} (0.07)
Middle household income	-1.01^{***} (0.14)	-1.65^{***} (0.32)	0.77^{***} (0.18)
High or very high household income	-0.84^{***} (0.17)	-1.64^{***} (0.41)	0.69^{***} (0.21)

Source: Ministry of Health, EIP 2011. Reading: the first figure is the estimated parameter associates with the level of protection. Figures given in brackets are the standard deviations of the estimated effects. The effect is significant at the: * 10% level, ** 5% level, *** 1% level at least.

5. Conclusion

To highlight the effect of protection on disease prevalence among children, we assume that anti-vectorial protection against malaria is endogenous. This enables us, on one hand, to explain more rigorously the probability of a Cameroonian child under six years old being ill, and on the other, to evaluate the effect of protection. Our results show that households seem to have a relatively good perception of the risk of disease. Indeed, if the children protected by an ITN had not been protected, their probability of being ill would have been almost twice as great as the probability of disease among unprotected children.

It seems that households are therefore "well aware" of the causes of the disease and have clearly understood that protection is effective. The survey of the literature in the introduction often suggests the opposite. Given that the ITN is distributed free of charge and, if it is not, it is relatively inexpensive, why do all households not protect themselves? Correctly perceiving a risk does not entail undertaking to protect oneself. Additional data would be needed in order to highlight a link between protection and risk aversion, for example.

Any future model to be constructed should take into account the theoretical results on risk aversion from both an individual and, above all, a collective point of view. To do so, a household utility function should be characterized with due regard to the dynamic aspect of the issue. The decision to protect oneself or not comes prior to the onset of the disease. It would be even more daunting to estimate such a structural model.

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Appendix: Descriptive statistics

TABLE V : Housing features based on the degree to which the house is finished

		Degree to which the house is finished					
		very high	high	intermediate	weak	very weak	zero
Number		400	467	1413	1094	349	742
Housing features							
Finished roof		100	99.1	99.9	82.4	0	0
Finished ground		100	97.4	71.5	7.2	2.9	0
Finished walls		100	100	91.8	20.6	11.6	0
Windows	glass	100	65.5	4.3	3	0	0
	wood	0	34.5	74.7	57.2	48.5	0
	others	0	0	15.7	24.6	29.4	2.9
	none	0	0	5.3	15.2	22.1	97.1
Toilets	with flush	34.7	22.3	5.4	1.6	0	0
	latrine	65.3	77.5	92.9	94.2	84.9	77.2
	others	0	0.2	1.7	4.2	15.1	22.8

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Table V : *continued*

very high	high	intermediate	weak	very weak	zero

Source: Ministry of Health, EIP 2011. Reading: 400 children live in an accommodation finished to a very high degree. Among houses finished to a very high degree, 100% have a finished roof.
Finished roof: sheet zinc, steel or iron, tiles, cement; unfinished roof: no roof, thatch, straw, lawn, bamboo, wooden boards, cardboard.
Finished ground: wooden floor, asphalt, tile, cement; unfinished ground: soil, sand, manure, bamboo.
Finished walls: cement, stones with lime / cement, bricks, cement blocks; unfinished walls: palm leaves, bamboo, stones, mortar, cardboard, plywood, no wall.

TABLE VI : Household descriptive statistics

	Mean	Standard deviation	Min	Max
Number of children less	2.15	1.22	1	9
HH's number of children	4.11	2.51	1	18
HH's age	43.37	13.63	18	99
Household size	8.05	4.2	2	30
Number of sleeping places	4.35	2.89	1	24

Source: Ministry of Health, EIP 2011. Reading: there are on average 2.15 children less than 6 years old by household.

TABLE VII : Descriptive statistics on protection

		Total	The child lives in a house with at least an ITN		The child sleeps regularly under an ITN	
			no	yes	no	yes
Referent's features						
Referent's age	max 20 years old	11.9	13	11.1	10.6	11.5
	20 to 25	24	22.5	25	26.7	23.8
	25 to 30	28.1	28	28.1	28	28.2
	30 to 35	17.1	16.3	17.6	17.3	17.9
	over 35 years old	18.9	20.2	18.2	17.4	18.6
Level of education	illiterate	53	54.9	51.7	57.6	47.8
	literate but no education	15.5	14.6	16.3	16.1	16.5
	has some education	31.5	30.5	32	26.3	35.7
Preventive treatment during pregnancy		62.3	60.3	63.5	58.8	66.8
Level of information	watches TV regularly	45.7	43.6	47.1	41.8	50.7
	listens to the radio regularly	36.8	36.5	37	30.2	41.6
	knows the causes of the disease	65.4	63.4	66.8	66.2	67.2
	knows the symptoms of the disease and can react	74.9	72	76.9	78.4	75.9
	has heard messages on ITNs in the last month	80	77.6	81.7	79.7	83
Confession	catholic	34.7	32.3	36.3	31.7	39.4
	protestant	27.7	28.3	27.3	24.6	29.1
	muslim	24.9	25.1	24.8	29.1	21.9
	animist	3.5	4.4	2.8	4.5	1.7
	other	6.4	6.9	6.1	6.9	5.5
	no religion	2.8	3	2.7	3.2	2.4
Household's features						
HH is a man		83.7	80.9	85.6	86.8	84.7
Household's size	at most 4 members	15.6	14.9	16.1	12.4	18.6
	4 to 6	26.5	26.2	26.7	25.2	27.7
	6 to 8	23.9	25	23.2	24.7	22.2
	over 8 members	34	33.9	34	37.7	31.5
Household's income	very weak	21.7	20.9	22.2	28.6	17.9
	weak	23.5	24	23.1	20.7	24.7
	intermediate	23.9	26.1	22.6	20.4	24
	high	18.6	16.7	19.8	18.1	20.9
	very high	12.3	12.3	12.3	12.1	12.5
Housing features						
The house is	close to a water stream	51	52.8	49.8	47.7	51.2
	close to a field	81.3	82.6	80.4	80.4	80.4
	in a rural area	61.2	61.7	60.8	60.8	60.8
Finished housing	zero	16.6	16.6	16.6	21.1	13.6

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Table VII : *continued*

		Total	The child lives in a house with at least an ITN		The child sleeps regularly under an ITN	
			no	yes	no	yes
	very weak	7.9	7.2	8.2	9.4	7.4
	weak	24.5	23.7	25	22.3	26.9
	intermediate	31.5	33.3	30.7	28.3	32.1
	high	10.5	10.2	10.6	10.1	11
	very high	9	9	8.9	8.8	9
Number of sleeping places	at most 2	25.5	24.8	26	19.1	30.5
	2 to 4	40	37.8	41.4	41.9	41.2
	4 to 8	27.2	28.7	26.2	29.7	23.8
	over 8	7.3	8.7	6.4	9.3	4.5
Child's features						
Boy		51.0	51.5	50.6	50.7	50.6
Relationship with the HH	daughter or son	72.8	71.3	73.8	75.7	72.5
	grand-daughter or grand-son	18.3	18.7	18	16.5	19.1
	other	8.9	10	8.2	7.8	8.4
Age of the child	up to 12 months	11.6	12.3	11.1	10.5	11.6
	12 to 18 months	10.9	9.4	11.8	12.8	11.2
	18 to 24 months	9	9.1	9	8	9.7
	24 to 36 months	20.5	20.4	20.6	19.7	21.2
	36 to 48 months	18.5	18.5	18.6	19.7	17.9
	48 to 60 months	18.9	19.2	18.7	20	17.9
	over 60 months	10.6	11.1	10.2	9.3	10.5
Positive RDT		36.9	40.2	34.8	36.2	33.7
Total		4465	1772	2693	1087	1606

Source: Ministry of Health, EIP 2011. Reading: in our sample, 11.9% of the people taking care of the children are maximum 20 years old. There are 13% of them if the house is not protected.

TABLE VIII : Descriptive statistics associated with the RDT

		Total	Test	
			negative	positive
Features of the person in charge of the child				
Age	max 20 years old	11.9	11.8	12
	20 to 25	24	24.1	23.9
	25 to 30	28.1	29	26.5
	30 to 35	17.1	16.9	17.5
	over 35 years old	18.9	18.2	20.1
Level of education	illiterate	53	45.6	65.6
	literate but no education	15.5	17.1	12.8
	has some education	31.5	37.3	21.6
Preventive treatment, pregnancy		62.3	67.1	54.0
Household's features				
Household's size	at more 4 members	15.6	17.7	12.1
	4 to 6	26.5	28.7	22.7
	6 to 8	23.9	23.2	25.2
	over 8 members	34	30.4	40.0
Housing features				
The house is	close to a water stream	51	49.7	53.3
	close to a field	81.3	76.9	88.8
	in a rural area	61.2	51.9	77
Finished housing	zero	16.6	12	24.6
	very weak	7.9	5	12.6
	weak	24.5	24.5	24.5
	intermediate	31.5	33.9	27.6
	high	10.5	13.1	6.0
	very high	9	11.5	4.7
Chid's features				
Boy		51	51.1	50.7
Relationship with the HH	daughter or son	72.8	73.3	72
	grand-daughter or grand-son	18.3	18.9	17.3
	other	8.9	7.8	10.7
Age	up to 12 months	11.6	13.7	8.0

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Table VIII : *continued*

	Total	Test	
		negative	positive
12 to 18 months	10.9	12.8	7.7
18 to 24 months	9	10	7.4
24 to 36 months	20.5	19.9	21.4
36 to 48 months	18.5	17.9	19.7
48 tot 60 months	18.9	17	22.2
over 60 months	10.6	8.7	13.6
Presence of an ITN	60.3	62.4	56.7
The child sleeps in a protected house	36	37.8	32.9
Total	4465	2819	1646

Source: Ministry of Health, EIP 2011. Reading: in our sample, 11.9% of the people taking care of the children are maximum 20 years old. There are 11.8% of them if the test of malaria prevalence is negative.