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Synthesizing Risk Factors for Child Health: The Case of Mosquito-Borne Diseases in Dakar

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Abstract

In Senegal, mosquito-borne febrile diseases constitute a major burden in terms of child morbidity and mortality. In this context, the current research examines child mosquito-borne disease in an urban environment and aims, firstly, to illustrate a new approach for synthesizing the network of its determinants. Secondly, the paper analyzes the relative role of these determinants in children's febrile disease in Dakar, focusing on protective behaviors, socio-economic characteristics and domestic environment.

The data used comes from a survey conducted in 2008 in Dakar and the statistical analysis consists of two steps: first, several latent variables are estimated, using Latent Class Analysis (LCA). The yielded latent variables subsequently constitute the explanatory part of a multi-level logistic regression, in order to explain the occurrence of a recent febrile episode in children.

Findings indicate that the febrile episodes are influenced primarily by health-related behaviors and – to a lesser extent – by factors relating to the socio-economic status of the family, while environmental factors play a minor role. The paper illustrates the use of LCA for synthesizing a wide array of indicators, in order to create a comprehensive causal image of mosquito-borne disease risks, all the while using parsimonious statistical models.

Keywords: Latent Class Analysis, Sub-Saharan Africa, mosquito-borne diseases, child health

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Introduction

In many developing countries, the burden of infectious diseases in general and of mosquito-borne diseases in particular remains very important and constitutes one of the most significant public health problems. This type of diseases affects children in particular, a vulnerability due in part to young age, but often also to other determinants, such as malnutrition, which weakens the immune system (WHO, 2013). In cities, rapid and often unplanned urban growth has led to very diverse environmental patterns, which add to the diversity in terms of demographic, socio-economic and behavioral characteristics (Mendez et al., 2000; Robert et al., 2003).

In Senegal, malaria – the most prevalent mosquito-borne infection – constitutes one of the main causes of mortality, between 2000 and 2003 being responsible for almost one third (28%) of all deaths among children under five, and for 13% of deaths in the general population, in 2002 (WHO, 2006). Its capital, Dakar, is a relatively rich region with respect to the rest of the country and represents the main area of economic development, attracting businesses and workers from throughout West Africa. This contributes to a relatively high population growth rate, making Dakar the country's most populous city, with nearly a quarter of the total population of Senegal (Service Régional de la Statistique et de la Démographie de Dakar, 2009). This high density means that the population at risk of mosquito-borne infections is, in terms of absolute numbers, very high. Thus, the socio-economic burden (at least in terms of affected individuals and the amount of prescribed treatments) of mosquito-borne diseases is particularly important.

A limitation of most research on mosquito-borne diseases is that studies have generally used an individual-centered approach, neglecting – for example – the sphere of the immediate environment (Mauny et al., 2004). However, the network of determinants for mosquito-borne diseases is complex and certain factors from different spheres may interact, thus rendering unidimensional analyses unreliable.

From this perspective, the first main objective of this paper is to illustrate a new statistical approach, which makes it possible to group a wide range of determinants, synthesizing them into wider dimensions, in order to create a comprehensive causal image, all the while using parsimonious statistical models.

The second main objective of the paper is to analyze the network of determinants for mosquito-borne infections in children, taking into account factors pertaining to the individual, the socio-economic status, as well as aspects of health behavior and of domestic environment.

Methods

Data

The research uses the hierarchical quantitative data of the project ACTU-PALU, conducted in 50 districts of Dakar and its suburbs and coordinated by the Institut de Recherche pour le Développement (IRD) in France, in collaboration with the Cheikh Anta Diop University of Dakar (Lalou, 2008). The survey was done by means of questionnaires, on a representative sample of 2952 households, which include 7416 children aged 2 to 10. The survey took place during and just after the rainy season (from the 15th of September to the 22nd of December) 2008, and covered aspects related to socio-demographic characteristics, behavior, characteristics of the dwelling and area of residence, as well as the occurrence of an episode of fever in children from the household (Lalou, 2008).

This hierarchical data structure allows for a multilevel statistical approach, which takes into account the non-independence of individuals within the same cluster (children from the same household) and permits to distinguish the effect of household-related variables from that of micro level ones.

Concepts and Measures

This research aims to delineate the multidimensional health determinants of mosquito-borne diseases and to analyze their relative role. For this purpose, indicators from different spheres (demographic, socio-economic, behavioral and environmental) and belonging to several levels of statistical analysis (child and household) are considered.

On the one hand, demographic characteristics of the individual (age and sex), of the mother (age, schooling and occupation), as well as anti-mosquito measures at household-level (the use of bednets and other measures, such as insecticide spraying or burning coils) are included in the final logistic regression.

On the other hand, other multi-dimensional concepts also have an impact on the risk of disease. Certain types of behavior, particularly related to preventing the access of the vector inside the compound or to avert potentially infective bites, can influence exposure to the pathogens (Tolle, 2009). General standard of living within the household influences the capacity to afford these preventive measures (Mosley and Chen, 1984). Also, certain housing characteristics and amenities can influence the risk of malaria by facilitating (or impeding) the human-vector contact (Robert et al., 2003). These multi-dimensional concepts were approximated by means of latent variables elaborated prior to the main statistical analysis and subsequently used as covariates in the logistic regression.

For the purpose of this research, mosquito-borne diseases are approximated by the occurrence of an episode of fever, as the most common symptom to most mosquito-borne diseases. In the survey, the head of the household was asked whether or not the child in question had a fever during the previous 30 days, from which (s)he recovered at least 3 days before the survey date. In order to distinguish mosquito-borne fevers from other diseases, only fevers dissociated from teething, open wounds, skin rashes or otitis were recorded.

Statistical Analysis

A possible caveat of including a large set of variables pertaining to different levels is that it may lead to statistical models which are difficult to interpret or even to estimate. Moreover, certain factors are multidimensional and complex notions, such as the case of socio-economic status or health-related behavior. This means that they cannot be directly measured and that no single indicator can express them correctly. However, they can be approximated, by clustering several relevant manifest indicators (variables which can be measured directly). The broader explanatory construct thus yielded is, in fact, the multidimensional concept of interest.

In order to achieve this, the research employs latent variables in the form of latent class analysis (LCA). The principle at the basis of latent variables is conditional independence, which postulates that the observed association between manifest variables is not due to hidden causality, but to the fact that these variables are, actually, indicators of the same underlying concept: the latent variable. This implies that, once controlled for this latent variable, the association between the manifest variables disappears (statistical independence which is conditional upon the latent variable). In the case of categorical data, they are latent classes.

One of the main advantages of using LCA is that this procedure yields parsimonious models: it synthesizes a large quantity of data (manifest variables) into a pre-defined number of categories (called "classes") and subsequently assigns individuals to these classes, based on their respective conditional probabilities.

Compared to other methods of dimension reduction - such as principal component analysis (PCA) or factor analysis - the advantage of latent classes is that they do not assume continuous data. This means that LCA can be used with categorical data, without violating methodological principles of application (McCutcheon, 1987).

Another advantage is that, while PCA uses orthogonal transformation, LCA uses conditional probabilities. Within each latent class, the observed variables are statistically independent. This implies that the association between the observed variables is explained by the classes of the latent variable (McCutcheon, 1987). This aspect – together with the fact that the number of classes is determined by the researcher, based on the scientific literature or exploratory data – yields results that are easier to interpret and to adapt to the theoretical background.

In LCA, the procedure of class estimation aims to maximize the likelihood criterion (Linzer and Lewis, 2011). This is done in an iterative manner, to avoid local maxima (Vermunt and Magidson, 2003). The final model calculates two sets of parameters (probabilities): the first set are the probabilities of latent class membership (whose sum is 1); the second set are the conditional probabilities: those of having a certain value on each of the manifest variables, given the latent class membership (Landale et al., 2013). For example, in a model with 3 manifest variables – A, B and C – with respectively i, j and k modalities, let X be the latent variable estimated, with t classes and let π be the expected probabilities (calculated by the model). The expected/posterior probability for each combination of answers in the manifest variables is then:

$$\eth_{ijk}^{ABC} = \sum_{t=1}^{T} \eth_{t}^{X} * \eth_{it}^{A|X} * \eth_{jt}^{B|X} * \eth_{kt}^{C|X}$$

where $\eth_{t}^{X}$ denotes the mixing proportion (the distribution of the estimated classes in the population), while $\eth_{it}^{A|X}$ $\eth_{jt}^{B|X}$ and $\eth_{kt}^{C|X}$ are the conditional probabilities which link each of the indicator/manifest variables to the latent variable. Therefore, in the population, the sum of membership probabilities across all classes is 1:

$$\sum_{t=1}^{T} \eth_{t}^{X} = 1$$

Conditional probabilities are used for analyzing the coherence of results in a latent class model, whereas to use the resulting latent classes in another statistical analysis (such as a multivariate regression), it is the latent class membership probabilities which are used.

The latent variables of interest for this research all pertain to the household level of analysis and have been estimated in R, using the poLCA package (Linzer and Lewis, 2011). They refer to the general standard of living (latent variable WI), to the household environment (latent variable DE) and to health-related behavior (latent variables MB and MPM).

Since LCA is used to create models with a pre-defined number of classes, the researcher is able to make this choice, in order to best fit the theoretical approach adopted. However, among several models with similar explanatory capacities, a general principle would be to use the model with the least number of classes (McCutcheon, 1987). For comparing the fit of multiple models, the 2 most widely used indicators based on the log-likelihood function are the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (Linzer and Lewis, 2011; Sclove, 1987). As a general rule, between several models, the choice is for one that minimizes the BIC and/or AIC value.

In this context, the choice of the number of classes for each estimated latent variable was determined primarily by theoretical considerations and subsequently by analyzing the AIC and BIC values. Between several models with similar fit, the one with the fewest classes was chosen. Thus, the latent variable “household wealth” comprises three classes and was constructed using asset ownership indicators (Filmer and Pritchett, 2001). The two variables pertaining to behavior also have three classes, while the latent variable refers to the household environment and comprises two latent classes. The choice for two classes is based on the hypothesis that the role of environmental factors is less strong and hence a more clear distinction between categories is needed.

Indicators used for estimating these four latent variables are all manifest variables deemed to influence the risk of mosquito-borne diseases, as explained in the following:

Economic Latent Variable: Wealth and Income (WI)

The method chosen for approximating the standard of living within the household is by using the ownership of long-run household assets as proxy (Filmer and Pritchett, 2001). Thus, the indicators used for constructing the latent variable refer to ownership of a radio (WI1), television (WI2), landline (WI3), kitchen stove (WI4), living room (WI5), air conditioning (WI6), computer (WI7), refrigerator (WI8), freezer (WI9) and car (WI10).

Behavioral Latent Variable Medical Behavior (MB)

The latent variable related to general health behavior was constructed using 5 indicators which reflect general knowledge and attitudes towards medication:

- MB1: Ever gave to her child medicine she didn't know, as suggested by a person who was not a health-care professional: (Reference Category: Yes)
- MB2: Generally finds the posology instructions for medicine: (Reference Category: Easy to understand)
- MB3: Follows medical treatment until the end of the prescription: (Reference Category: Always)
- MB4: Ever buys modern medicine from itinerant merchants: (Reference Category: Yes)
- MB5: Ever buys modern medicine at the market: (Reference Category: Yes)

Behavioral Latent Variable Malaria Protection Measures (MPM)

The second behavioral latent variable reflects knowledge and attitudes towards malaria protection and was constructed using four indicators:

- MPM1: Ever assisted to reunions concerning malaria: (Reference Category: Yes)
- MPM2: Sleeps under a mosquito net during the rainy season: (Reference Category: Always)
- MPM3: All her children have mosquito nets: (Reference Category: Yes)
- MPM4: Her children sleep under a mosquito net during the rainy season: (Reference Category: Always)

Environmental Latent Variable: Domestic Environment (DE)

The environmental latent variable used in this research refers to household-level amenities and characteristics which may play a role in favoring or deterring the presence of mosquitoes inside the compound:

- DE1: Water source: (Reference Category: Tap)
- DE2: During the past year, ever had to resort to another water source: (Reference Category: No)
- DE3: Type of toilet: (Reference Category: WC)
- DE4: Wastewater disposal method: (Reference Category: Sewage)

- DE5: Garbage disposal: (Reference Category: Private bin with collection service)
- DE6: Roof material: (Reference Category: Cement)
- DE7: Windows: (Reference Category: Frame with glass window)

Improper or irregular water supply means that families are forced to store water inside or around the compound for longer periods of time and the recipients used may become breeding sites for mosquitoes (Padmanabha et al., 2010). Having a tap (DE1) and not having to resort to other water sources (DE2) limits the need for water storage inside the compound. Similarly, having proper sanitation (DE3, DE4) and garbage disposal (DE5) facilities may limit the risk of wastewater for the vector (mosquitoes) to breed (Sutherst, 2004).

In terms of house construction, roofs made of alternative materials, other than cement (DE6), such as thatch or earth, as well as traditional windows which cannot be properly closed (DE7) may create openings and cracks through which mosquitoes can enter the compound (Ghebreyesus et al., 2000).

Once a model is chosen, the individuals are then assigned to latent classes, according to their calculated membership probabilities. Thus, the yielded latent classes can be used in other types of statistical analysis. In this case, they will be included as explanatory part in a logistic regression, to analyze their impact on the dependent variable of interest: the occurrence of a febrile episode in children.

Results and Discussion

Latent Variables

The latent variables estimated group indicators related to the household's general Wealth and Income – WI, Medical Behavior – MB (both based on indicators collected from the head of the household), as well as to Malaria Protection Measures – MPM and Domestic Environment – DE (both based on indicators collected from the mother or tutor of a child from the household).

The manifest variables used for creating these latent variables are all relevant determinants for mosquito-borne diseases. Thus, classes resulted after LCA were considered to pose different levels of risk for mosquito-borne diseases. The decision as to which latent classes pose higher risk is based on the analysis of the conditional probabilities, which connect each class to its manifest indicators (Tables 1 to 4)[1].

As the latent variables estimated are not connected to each other in any way, belonging to one class in one latent variable is not an indicator of class membership in another latent variable. Thus, a household can belong to Class LR (low risk) for one latent variable, but to Class MR (moderate risk) or HR (high risk) for another.

1 As all indicators used for elaborating the latent variables are dichotomous, conditional probabilities associated with only one of the two possible responses per indicator are presented (as the probability of its complement can be calculated, by deduction from 1)

Economic Latent Variable: Wealth and Income (WI)

An estimation with three latent classes was chosen: the class estimated to be at low risk from the economic point of view (WI-LR) has high probabilities of ownership for all items, while the classes estimated to be at moderate (WI-MR) and high (WI-HR) risk levels, have lower probabilities of ownership for these items (Table 1).

Table 1. *Conditional Probabilities of the WI Latent Variable*

	WI1	WI2	WI3	WI4	WI5	WI6	WI7	WI8	WI9	WI10
Class WI-LR	0.95	1.00	0.78	0.43	0.98	0.27	0.60	0.81	0.40	0.56
Class WI-MR	0.90	1.00	0.32	0.06	0.67	0.01	0.09	0.63	0.07	0.11
Class WI-HR	0.69	0.70	0.01	0.01	0.07	0.01	0.00	0.08	0.01	0.02

Behavioral Latent Variable Medical Behavior (MB)

The latent variable thus created distinguishes three classes in the population: the first class is estimated to be at low risk of disease (MB-LR) and has lower probabilities, than the other two classes, of giving unknown and unprescribed medicine to children or buying medicine outside the pharmacy or hospital (Table 2). It has the highest probabilities of following medication until the end of the prescription and of understanding the instructions related to the medical treatment. The class estimated at moderate risk (MB-MR) has lower probabilities for protective behaviors (indicators MB2 and MB3), while the class estimated at high risk (MB-HR) has the lowest probabilities among the three classes, for indicators MB2 and MB3, but the highest probabilities for indicators MB1, MB4 and MB5 (the manifest variables considered to indicate health-risk behaviors).

Table 2. *Conditional Probabilities of the MB Latent Variable*

	MB1	MB2	MB3	MB4	MB5
Class MB-LR	0.12	0.81	0.77	0.04	0.05
Class MB-MR	0.68	0.77	0.35	0.17	0.15
Class MB-HR	0.50	0.73	0.48	1.00	0.83

Behavioral Latent Variable Malaria Protection Measures (MPM)

Table 3 presents the conditional probabilities associated with each specific item-class modality, for the latent variable expressing anti-malarial measures:

Table 3. *Conditional Probabilities of the MPM Latent Variable*

	MPM1	MPM2	MPM3	MPM4
Class MPM-LR	0.39	0.91	1.00	1.00
Class MPM-MR	0.34	0.61	0.46	0.47
Class MPM-HR	0.23	0.00	0.08	0.00

The women from the class estimated at low risk (MPM-LR) have higher probabilities of answering "Yes" regarding participation in reunions concerning malaria and of declaring that they and all their children always use a bednet during the rainy season. Conversely, the women from the class estimated at high risk (MPM-HR) have the lowest probabilities.

Environmental Latent Variable: Domestic Environment (DE)

The latent variable expressing household conditions distinguishes two classes within the sample of households, with the class estimated at high risk (DE-HR), having lower probabilities of proper infrastructures and amenities (Table 4)

Table 4. *Conditional Probabilities of the DE Latent Variable*

	DE1	DE2	DE3	DE4	DE5	DE6	DE7
Class DE-LR	0.97	0.35	0.86	0.58	0.69	0.67	0.33
Class DE-HR	0.78	0.28	0.48	0.03	0.63	0.18	0.01

The other component of LCA, the mixing proportion, shows the distribution of the estimated classes in the population, for each latent variable. Figures 1 to 4 present the memberships of households to the different classes, for the four latent variables estimated:

Figure 1. *Class Memberships for the WI Latent Variable (%)*

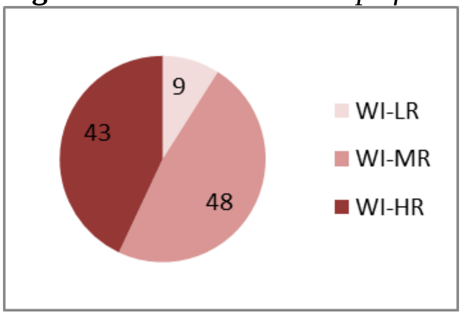


Figure 2. *Class Memberships for the MB Latent Variable (%)*

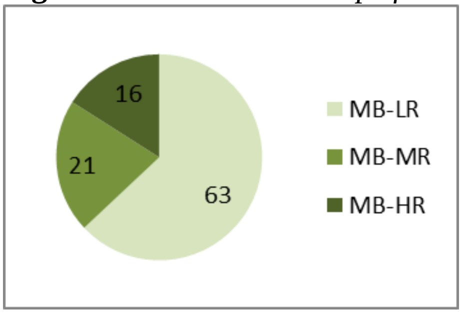


Figure 3. *Class Memberships for the MPM Latent Variable (%)*

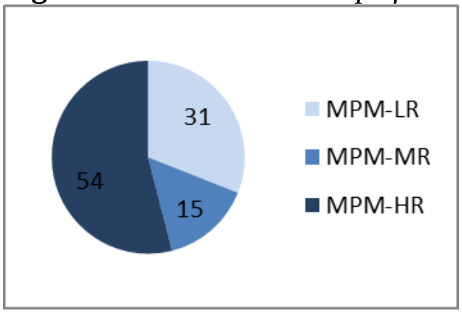
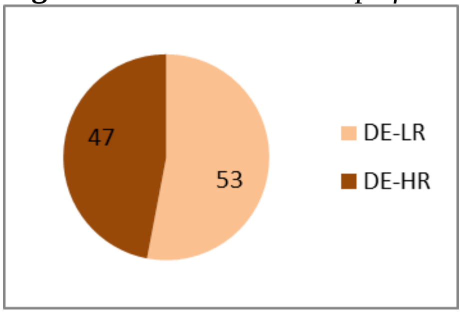


Figure 4. *Class Memberships for the DE Latent Variable (%)*



The distribution of the three latent classes for the Wealth and Income (WI) variable shows a population with few wealthy households (9% of the households in the WI-LR class), whereas the other two classes (WI-MR and WI-HR) have similar shares in the sample of households (48% and 43%). The two behavioral variables show somewhat opposite tendencies: if in the Medical Behavior (MB), the highest share of households (63%) is in the class estimated at lowest risk (MB-LR), in the Malaria Protection Measures (MPM), the largest share (54%) belongs to the class estimated at highest risk (MPM-HR). Finally, the Domestic Environment latent variable splits the sample of households into two similarly sized classes (53% with better sanitary infrastructure and amenities, and respectively 47% with inferior conditions in these aspects).

Determinants of Mosquito-Borne Diseases

The statistical analysis was performed on 7416 children, aged 2 to 10, from 4031 mothers/tutors, living in 2952 households, located in 50 neighborhoods in Dakar and its suburbs. Out of the 7416 children, 3665 were boys and 3751 were girls. Table 5 shows the incidence of mosquito-borne fevers in these children, which is used as the response variable in the present work.

Table 5. *Incidence of Mosquito-Borne Fevers in the Study Population*

	Frequency	Percentage
No	5581	75
Yes	1742	24
N/A	93	1
Total	7416	100

A quarter of children were declared to have experienced a febrile episode of mosquito-borne origin, over the month preceding the survey. The risk factors associated with these febrile episodes were analyzed by means of a two-level logistic regression (child and household level), using the latent variables created and indicators related to the child and his/her mother or tutor (Table 6).

Table 6. *Odds Ratios from Multilevel Logistic Regression Predicting Child Febrile Episodes*

Predictor	OR
Sex (male)	
female	1.01
Age	0.89 ***
Mother's Age (under 25)	
between 25 and 49	0.98
50 or more	0.96
Mother's Schooling (no)	
yes	1.21 **
Mother's Occupation (housewife)	
employed	1.13 *
other	0.92
Medical Behavior (MB-LR)	
MB-MR	1.4 ***
MB-HR	1.08
Malaria Protection Measures (MPM-LR)	
MPM-MR	1.41 ***
MPM-HR	1.01
Domestic Environment (DE-LR)	
DE-HR	0.94

Anti-mosquito Measures (none)	
at least bednet	1.89 ***
other(s), except bednet	2.07 ***
Wealth and Income (WI-LR)	
WI-MR	1.4 **
WI-HR	1.33

CI: * 90% ** 95% *** 99%

As general tendency, febrile episodes seem to be influenced by a high number of determinants, which exert each a moderate impact, rather than by few determinants which exert, each, a high individual impact. This supports the hypothesis of a wide array of factors from different spheres contributing to the risk of infection.

Of the two demographic variables, only age has an impact on mosquito-borne fevers. This is unsurprising, as age is generally considered to be a protective factor against the onset of mosquito-borne disease (Mauny et al., 2004).

Concerning the mother or guardian of the child, having formal education is associated with significantly higher odds of developing the disease. This could be due to two aspects: one hypothesis is that higher levels of education are likely to be associated with higher importance placed on health. Thus, educated mothers are more likely to pay attention to febrile episodes in their children than mothers without schooling, which would induce reporting bias.

A second hypothesis is related to the rather common practice in Dakar, of hiring a carer ("nounou") for one's children. Women or families with higher education levels are more likely to have the financial means to hire a carer. However, usually the carer is a young girl (often a distant relative from the countryside) with no formal education and little knowledge concerning health aspects. This latter hypothesis is also suggested by the results concerning the mother's/tutor's occupation: being employed is associated with significantly higher odds of developing febrile diseases than in the case of stay-at-home mothers.

Behavioral factors seem to exert a relatively stronger influence than other factors: being in the moderate risk class for the Medical Behavior or Malaria Protection Measures latent variables (MB-MR or MPM-MR) is associated with significantly higher odds of developing fever. Slightly higher odds are also observed in the high risk class (MB-HR or MPM-HR), but the association is not statistically significant. The same tendency can be noted with regard to the standard of living in the household: being in the low risk class (WI-LR) is connected with lower odds of mosquito-borne febrile illness in children.

The aspect of anti-mosquito measures may seem surprising: the odds of the child experiencing a mosquito-borne febrile episode are significantly higher where these measures are taken. This seems counter-intuitive, but the association is probably due to an interaction between behavior (at household level) and vector presence (at neighborhood level). It seems reasonable to state that the use of anti-mosquito measures strongly depends on the nuisance of mosquitoes inside the compound, which is – in turn – a function of the vector density in the neighborhood: households living in areas with high mosquito density are at higher risk of disease transmission, but at the same time are more inclined to use measures to avert mosquitoes. Hence, the use of protective measures is unequally distributed in the whole population and neglecting this association could lead to biased results concerning the role of mosquito protective measures.

Analyzing the relationship between the usage of protective measures and the perceived nuisance of mosquitoes in the area confirms this hypothesis, as Tables 7 and 8 show a strong association between the two aspects.

Table 7. *Agreement that "There are Few Mosquitoes in this Neighborhood" and Usage of Anti-Mosquito Measures (Column Percentages)*

	None	At least bednet	Other(s), except bednet	Total
Agree	66 (57)	431 (28)	492 (39)	989 (34)
Disagree	49 (42)	1113 (72)	776 (61)	1958 (66)
N/A	1 (1)	3 (0)	1 (0)	5 (0)
Total	116 (100)	1567 (100)	1269 (100)	2952 (100)

When asked whether they agree with the statement "There are few mosquitoes in this neighborhood" (Table 7), mothers from households which use anti-mosquito measures are much more likely to disagree with the statement (that is, to consider that in their neighborhood there are many mosquitoes). The same relationship is observed when asked whether they consider that "Malaria constitutes an important problem in this neighborhood" (Table 8).

Table 8. *Agreement that "Malaria Constitutes an Important Problem in this Neighborhood" and Usage of Anti-Mosquito Measures (Column Percentages)*

	None	At least bednet	Other(s), except bednet	Total
Agree	76 (66)	1338 (85)	996 (78)	2410 (82)
Disagree	33 (28)	173 (11)	203 (16)	409 (14)
N/A	7 (6)	56 (4)	70 (6)	133 (4)
Total	116 (100)	1567 (100)	1269 (100)	2952 (100)

Both of the associations are strong and statistically significant (the value of the Chi2 test being 73.9 and respectively 45.4, with a significance level sig. = 0.000). This shows that indeed, there is a strong association between the use of anti-mosquito measures and the perceived presence of mosquitoes (mosquito nuisance), which explains the higher odds of fever associated with anti-mosquito measures.

Conclusions

The two main objectives of this study were – firstly – to illustrate the usefulness of LCA in elaborating models which are exhaustive, yet easy to estimate and to interpret. Secondly, it aimed to analyze the network of risk factors, under the assumption that only taking into account several spheres and levels of analysis can yield robust and reliable results. To this end, a two-step statistical analysis was performed: initially four latent variables were created, using LCA; consequently, these latent variables were used as co-variates in a two-level logistic regression, in order to explain recent mosquito-borne fevers in children.

The results obtained confirm the hypothesis that mosquito-borne fevers are influenced by a wide array of factors, in agreement with other hierarchical analyses (Mauny et al., 2004; Van Benthem et al., 2005).

Findings also suggest that interactions between behavior (anti-mosquito measures) and the wider environment (mosquito nuisance) play an important role. This aspect – although relatively little studied – has however been briefly mentioned in other papers (Binka and Adongo, 1997; Thomson et al., 1994). It implies that campaigns to increase bednet usage should target specific areas with higher environmental risk, in order to be effective.

Results also show that LCA is a useful method for incorporating measures of demographic, socio-economic, behavioral and environmental characteristics, in order to create a comprehensive causal image of disease risks, all the while using parsimonious statistical models. It thus permits to identify key dimensions, not measurable as such, which influence the risk of diseases.

As vector density seems to be an important factor, further research needs to be conducted with regard to the interactions of the environment and individual behavior and its impact on vector-borne diseases in general.

References

Binka, F. N. and Adongo, P. (1997) 'Acceptability and Use of Insecticide Impregnated Bednets in Northern Ghana', Tropical Medicine & International Health, 2, 499–507.

Filmer, D. and Pritchett, L. (2001) 'Estimating Wealth Effects Without Expenditure Data--Or Tears: An Application to Educational Enrollments in States of India', Demography, 38, 115–132.

Ghebreyesus, T. A., Haile, M., Witten, K. H., Getachew, A., Yohannes, M., Lindsay, S. W. and Byass, P. (2000) 'Household Risk Factors for Malaria among Children in the Ethiopian Highlands', Transactions of the Royal Society of Tropical Medicine and Hygiene, 94, 17–21.

Lalou, R. (2008) Rapport Scientifique d'Etape, Available at http://en.calameo.com/read/0001329037be93e1ded73 [Accessed 04.03.2014]

Landale, N., Lanza, S., Hillemeier, M. and Oropesa, R. S. (2013) 'Health and Development among Mexican, Black and White Preschool Children: An Integrative Approach Using Latent Class Analysis', Demographic Research, 28, 1302–1338.

Linzer, D. A. and Lewis, J. B. (2011) 'poLCA: An R Package for Polytomous Variable Latent Class Analysis', Journal of Statistical Software, 42, 1–29.

Mauny, F., Viel, J. F., Handschumacher, P. and Sellin, B. (2004) 'Multilevel Modelling and Malaria: A New Method for an Old Disease', International journal of epidemiology, 33, 1337-1344.

McCutcheon, A. L. (1987) Latent Class Analysis, Newbury Park, Calif., Sage Publications.

Mendez, F., Carrasquilla, G. and Muñoz, A. (2000) 'Risk Factors Associated with Malaria Infection in an Urban Setting', Transactions of the Royal Society of Tropical Medicine and Hygiene, 94, 367–371.

Mosley, W. H. and Chen, L. C. (1984) 'An Analytical Framework for the Study of Child Survival in Developing Countries', Population and Development Review, 10, 25–45.

Padmanabha, H., Soto, E., Mosquera, M., Lord, C. C. and Lounibos, L. P. (2010) 'Ecological Links Between Water Storage Behaviors and Aedes Aegypti Production: Implications for Dengue Vector Control in Variable Climates', EcoHealth, 7, 78–90.

Robert, V., Macintyre, K., Keating, J., Trape, J.-F., Duchemin, J.-B., Warren, M. and Beier, J. C. (2003) 'Malaria Transmission in Urban Sub-Saharan Africa', The American Journal of Tropical Medicine and Hygiene, 68, 169–176.

Sclove, S. L. (1987) 'Application of Model-Selection Criteria to Some Problems in Multivariate Analysis', Psychometrika, 52, 333–343.

Service Régional de la Statistique et de la Démographie de Dakar (2009) Situation Économique et Sociale de La Région de Dakar de L'année 2008, Available at http://www.ansd.sn/publications/annuelles/SES_Region/SES_Dakar_2008.pdf [Accessed 11.03.2014].

Sutherst, R. W. (2004) 'Global Change and Human Vulnerability to Vector-Borne Diseases', Clinical Microbiology Reviews, 17, 136-173.

Thomson, M. C., d' Alessandro, U., Bennett, S., Connor, S. J., Langerock, P., Jawara, M., Todd, J. and Greenwood, B. M. (1994) 'Malaria Prevalence Is Inversely Related to Vector Density in The Gambia, West Africa', Transactions of the Royal Society of Tropical Medicine and Hygiene, 88, 638–643.

Tolle, M. A. (2009) 'Mosquito-Borne Diseases', Current Problems in Pediatric and Adolescent Health Care, 39, 97–140.

Van Benthem, B. H. ., Vanwambeke, S. O., Khantikul, N., Burghoorn-Maas, C., Panart, K., Oskam, L., Lambin, E. F. and Somboon, P. (2005) 'Spatial Patterns of and Risk Factors for Seropositivity for Dengue Infection', The American journal of tropical medicine and hygiene, 72, 201-208.

Vermunt, J. K. and Magidson, J. (2003) 'Latent Class Analysis', The SAGE Encyclopedia of Social Science Research Methods, Sage Publications, 549–553.

WHO (2006) Country Health System Fact Sheet 2006 Senegal, Available at http://www.afro.who.int/index.php?option=com_docmanandtask=doc_downloadandgid=1278 [Accessed 19.12.2012].

WHO (2013) World Malaria Report 2013, Geneva, Switzerland, WHO Press.