Master of Public Health

Master de Santé Publique

Sociodemographic and Environmental Characteristics Influencing Use or Non-Use of Malaria Prevention Tools

A Mother-Child Prospective Cohort in Allada, Benin

Kieran KLEMAN
MPH Candidate 2020-2022

Practicum Host Institution:

Irset – Inserm UMR_S
Team on Exposure Assessment & Epidemiological Research on Environment

Profession & Academic Advisor:

Dr. Florence Bodeau-Livinec, MD, PhD
Professor of Epidemiology, EHESP
Department of Quantitative Methods in Public Health

Acknowledgements

Above all, I would like to thank Florence Bodeau-Livinec for the opportunity to conduct this research and for all of her guidance during this time. Throughout my tenure at EHESP, she has been a constant support and source of inspiration, not only for my present studies, but future dreams as well.

Without the participation of the mothers and children of the EXPLORE cohort, this work would not have been possible. I extend a sincere thank you to each one of them for their willingness to participate in the study.

Thank you also to Philippe Glorennec and Irset Team 9 – ELIXIR for allowing me to work with them and their assistance towards completing this project. Their ideas, support and comradery was indispensable throughout the process.

The statistical analysis performed in this study would have been impossible without the contributions of Nolwenn LeMeur-Rouillard and Nathalie Costet. Thank you both for your unceasing ethusiasm to share your expertise.

My thanks to Roméo Zoumenou and his expert knowledge in the field which made it possible to understand the findings of this research.

Amanda Garrison and Mélanie Bertin were both invaluable resources for this project and I thank both of them for helping me along the way. Thank you also to my fellow Avenue George Sand interns as well as all of the EHESP staff for all their help during these many months together.

These last two years would not have been as great without my friends, near and far. Thank you for making sure I put my computer away for some fun every once in awhile.

To my family; everything I do is possible thanks to your unwavering support and love. Your kindness, selflessness and joie de vivre drives me to be better each and every day. And to Alex, you have been next to me since page one and again now for the final touches, you are the best.

Table of Contents

List of acronyms

EPA	Environmental Protection Agency (U.S.A.)
EXPLORE	The Exposition au Plomb et au manganese et Risques pour l'Enfant
HOME	Home Observation Measurement of the Environment
IRS	Indoor residual spraying
ITN	Insecticide treated net
IPTi	Intermittent preventive treatment of malaria in infants
IPTp	Intermittent preventive treatment of malaria in pregnancy
LLIN	Long-lasting insecticide treated net
LTFu	Lost to follow-up
MCA	Multiple Correspondence Analysis
MiP	Malaria in pregnancy
MiPPAD	Malaria in Pregnancy Preventive Alternative Drugs
MSEL	Mullen Scales of Early Learning
OR	Odds Ratio
RBC	Red blood cell
RITAM	Research Initiative on Tradition Antimalarial Methods
SES	Socioeconomic status
SMC	Seasonal malaria chemoprevention
SSA	Sub-Saharan Africa
VGSC	Voltage-gated sodium channel
WHO	World Health Organization

List of figures

List of tables

Abstract

Introduction: Compared to the global malaria incidence, disproportionate malaria morbidity and mortality occur in communities in Sub-Saharan Africa (SSA). Use of long-lasting insecticide treated nets (LLIN) and indoor residual spraying (IRS) have been fundamental in mitigation of malaria and correlated ancillary outcomes. Other utilization of pyrethroids to prevent malaria exist in the form of mosquito coils and sprays, however, their efficacy is unknown. The objective of this study was to determine the socio-cultural and environmental characteristics influencing the use/non-use of prevention of malaria tools (bednet and coils) in families with children 6 years of age in southern, semi-rural Benin.

Methods: In a birth cohort in Allada, Benin, data collected from 432 mothers at offspring age six, sought to ascertain information concerning: bednet, coil, spray and traditional medicine use, as well as season (wet/dry), number of family members, dwelling type, family wealth and maternal education and literacy. Descriptive statistics illuminated implementation of bednet and use of other tools of malaria prevention. Binary logistic regressions were performed to test the association between sociodemographic factors, family structure, environmental conditions, and use of bednets and coils. Analyses were further stratified by season (wet/dry).

Results: Overall, 82.6% of respondents stated that their child used a bednet the night prior to being surveyed with 100 having used coils (23.1%) and 30 having used sprays (6.9 %) and frequency of use most commonly (26.9%) several times per week. Traditional medicines were used by 87.7% of the population; highest frequency of use was annual (49.5%). Increased bednet use was found with female offspring (OR = 2.15, [95% CI, 1.19 – 3.98]), paternal cohabitation with child (OR = 6.28, [95% CI, 2.43 – 16.17]) and simultaneous use of traditional medicines [OR = 2.54, [95% CI, 1.18 – 5.31]); decreased bednet use when there were 6 or more siblings (OR = 0.36, [95% CI, 0.14 – 0.96]) and when coils were used in the home (OR = 0.26, [95% CI, 0.14 – 0.48]). Use of coils was less likely in the presence of a bednet the night prior to the survey (OR = 0.31, [95% CI, 0.18 – 0.54]), and when there was a stove in the interior of the dwelling (OR = 0.48, [95% CI, 0.29 – 0.79]).

Discussion: Families in southern, semi-rural Benin with children aged six years old were differentially influenced towards use of insecticide treated prevention of malaria tools based on variable socio-cultural and habitation factors.

Introduction

1. Malaria infection in humans

1.1 The disease

Malaria is a vector born disease transmitted to human hosts through the bite of an infected female *Anopheles* mosquito.[1] The *Plasmodium* parasite, a unicellular protozoan parasite and the causative agent of malaria in humans, is transferred from the mosquito vector to the host.[2] *Plasmodium* sporozoites, the motile and infective form of the malaria causing parasite, permeate human liver cells where they then fragment to produce schizont that will ultimately release thousands of merozoites into the human blood stream.[3] After leaving the liver, surface proteins of the merozoite allow formation of a tight junction between the parasite and human red blood cells (RBCs), allowing the parasite to enter.[3] During the asexual reproductive stage in the red blood cell the clinical symptoms of malaria present[4], including, but not limited to: fever, malaise, anorexia, lassitude, dizziness, headache, backache, myalgias as well as nausea and vomiting.[5] RBC infiltration, utilization of cell sources, and destruction of cell membranes during the reproductive cycle of the *Plasmodium* parasite ultimately leads to lysis of RBCs which increases occurrence of anemia, thrombocytopenia (low platelet count[6]) and leukopenia (low leukocyte count[7]) that may lead to more severe malarial disease and possible death.[5]

Studies have found that the *Plasmodium* species *falciparum, vivax,* and *knowlesi* are more likely to cause severe malaria then other species of the parasite and disproportionately affect children under five in stable endemic areas.[5] Severe malaria causes systemic symptoms with severe exacerbation including: altered consciousness (frequently leading to coma), respiratory failure, acute renal failure, jaundice and hepatic dysfunction, and severe anemia.[5] Each of the presenting symptoms of severe malaria increase the likelihood of death with delayed or inadequate treatment.

After infiltrating the human host, the parasite *Plasmodium* has the ability to adapt genetically when encountering human immune responses and evolve and persist in their infectious nature.[2] The genetic elasticity of the organism encourages resistance to therapeutic treatments including antimalarial drugs and vaccines.[2] This attribute of the *Plasmodium* parasite makes it critically important to implement the use of insecticide treated barriers as a key element in the prevention of malaria in endemic areas.

1.2 Burden of malaria

According to the World Health Organization (WHO) world malaria report from 2021, global malaria prevalence increased from 227 million in 2019 to more than 240 million in 2020.[8] A large portion of this amount describes African populations where malaria remains the most common disease and a leading cause of morbidity and mortality among all populations.[2, 8, 9] Vulnerable groups, including pregnant woman and children under five years of age, are at increased risk of malaria.[10] It is estimated that during delivery, 25% of pregnant woman in sub-Saharan Africa will exhibit presence of the *plasmodium* parasite in the placenta.[10] With 25 million pregnant woman at risk for malaria in SSA, the WHO estimates that the disease will lead to an annual death toll of 10,000 and 20,000 for mothers and their infants, respectively.[11] Studies have shown that surviving neonates exposed to malaria in pregnancy (MiP) are likely to be affected by low birth weights and a heightened risk of malaria during childhood.[10]

2. Global malaria prevention methods

2.1 Antimalarial drugs

The WHO Global Technical Strategy for Malaria (2016 – 2030) describes the importance of prioritizing "universal access to quality-assured and appropriate vector control measures, diagnostics and antimalarial medicines" in countries with persistently high rates of malaria transmission in order to achieve the goal of malaria eradication.[12] As of February 2022, the WHO strongly recommends intermittent preventive treatment: administration of antimalaria drugs for pregnant woman (IPTp) during their second trimester and in infants (ITPi) following normal 1-year-old vaccination schedules.[13] Seasonal malaria chemoprevention (SMC) for children less than 6 years of age has been newly recommended in the Sahel subregion of Africa, not including Benin.[13] In regions deemed moderate to high areas of malaria transmission, the WHO strongly recommends the RTS,S/AS01 malaria vaccine for children for prevention of P. falciparum strains of malaria.[13]

2.2 Insecticides in the context of vector-borne control

The WHO strongly recommends populations in areas of ongoing malaria transmission to implement either pyrethroid-only long-lasting insecticidal nets or indoor residual spraying.[13] The organization does not recommend the simultaneous use of the two means of control of malaria vectors for fear that this will encourage overlooking deficiencies in the first method employed.[13]

All WHO anti-malaria recommendations are based on “high certainty of evidence” from available and appropriate research studies and at the advice of independent experts on the topics.[13]

Prevention of malaria tools that utilize insecticides also come in the form of spatial/airborne repellents (coils) and space sprays (sprays). WHO guidelines for malaria vector control conditionally do not endorse the use of sprays due to “very low certainty of evidence” of their efficacy.[13] Evidence supporting the efficacy of coils has been deemed deficient by the WHO and they currently do not have any recommendations concerning the use of these tools.[13] A 2017 study in a suburban village outside of Porto Novo, Benin aimed to compare efficacy of LLIN with mosquito repellent coils in two varying dwelling structure. While both methods were found to be efficacious in consideration of induced mosquito exophily and mortality, ITN proved to be more efficacious. The findings of this study, although relevant, were highly dependent on structure type and therefore not enough evidence exists to confirm the usefulness of coils in all situations.[14] A systematic review published in 2006, sought to answer the question: “do mosquito coils prevent malaria?”[15] Appraisal of 15 studies showed no evidence that use of coils aided study subjects in preventing contraction of malaria. In conclusion, the reviewers state that more investigation is required to determine if coils are beneficial or detrimental to human health.[15]

The U.S. Environmental Protection Agency (EPA) defines pyrethroids as a class of synthetic chemical compounds of pyrethrins, a botanical insecticide derivative of the chrysanthemum flower.[16] The use of pyrethroids and pyrethrins has become more common in agriculture and health treatments mainly through pest control as they are proven to be less toxic to humans and animals than previous methods using organophosphates.[16] The World Health Organization currently endorses the use of pyrethroids for individual protection against malaria and the Zika virus.[17] According to research done in western Kenya in 2014, 40% of all the insecticides used for indoor residual spraying around the world were pyrethroids.[18] As of 2020, pyrethroids were the only class of insecticides used in WHO endorsed mass distribution campaigns of ITNs worldwide.[19]

Pyrethroid treated barriers are effective tools against the spread of malaria as they interrupt the trajectory of the mosquito vector prior to and upon contact with the chemical.[20] Barriers impregnated with pyrethroid chemicals work prior to contact with mosquito vectors by discouraging the vector from coming into proximity with the barrier due to potent repelling properties.[20] Vectors that are able to resist the repellent properties are killed upon contact with

the barrier as the pyrethroids work to disrupt proper functioning of the insect nervous system.[21] These qualities of pyrethroids tools make them a successful intervention towards reduction of mosquito populations that have the potential to spread malaria to vulnerable human populations.

2.3 Traditional medicine

Traditional medicines are also used in parts of Sub-Saharan Africa in order to prevent and alleviate the malaria burden. Several systematic literature reviews conducted by the Research Initiative on Tradition Antimalarial Methods (RITAM) found that in malaria endemic countries, 1/5th of patients use traditional herbal remedies to combat the disease via more than 1200 plant species from 160 biological families.[22] The RITAM explains that although traditional medicines are generally more widely available and more affordable than pharmaceutical drugs in endemic countries, their limitations are not fully understood.[22] More research is needed to comprehend the full risks and benefits of this method of malaria prevention and their potential place among WHO recommended tools and therapies.

3. Malaria and prevention in Benin, Sub-Saharan Africa

3.1 Benin

Benin is a low-income country in Sub-Saharan Africa covering a land area of 112,622 kilometers squared with almost 12 million inhabitants and a poverty rate of 45.9% in 2020 according to the World Bank.[23, 24] The country experiences two wet seasons annually from March to July and September to November, with the remainder of months marking the dry season.[25] Annual wet and dry season are more varying in southern portions of the country, with the wet season generally taking place between April – July and October – November.[26] French is the official language and over half of the population speaks the local languages of Fon, Yoruba, Mina, Bariba and Dendi.[24] The Allada Plateau in southern Benin, locality of the mother-child prospective cohort used in this thesis, is a semi-rural area known for agricultural commerce and proximity to the capital, Porto-Novo, and the major port city of Cotonou.[24, 27] The villages of Sékou and Attogon constitute part of the Allada region and have population sizes of more than 6,500 and 4,000 people, respectively.[28] These were the main villages of interest during data collection.

3.2 Malaria burden in Benin

Malaria transmission is seasonal and peak periods of transmission last over eight months in a calendar year. Data from 2020 shows malaria incidence of 388 people per 1,000 at risk in the

country.[29] As reported by the CDC, malaria infection was the leading cause of mortality in children aged five years and younger in Benin in 2019.[29] It has also been found that gross motor skill development is stunted by MiP in populations of interest in Benin.[10] As a preventable and treatable disease, the extensive consequences of malaria, especially in youth and vulnerable populations, is alarming. Prevention of MiP and early childhood malarial infection is essential to disease control and lowering of morbidity and mortality rates in all populations throughout SSA.

3.3 Current insecticide use methods in Benin

Insecticide treated barriers are a proven strategy in the diminution of the global malaria burden.[30] Decreased malaria related morbidity and mortality is largely dependent on widespread use of insecticide treated tools in endemic areas, including the southern region of Benin. Universal coverage of insecticide treated tools throughout Benin is a potential solution to the challenges that malaria presents in the country and possible eradication of the disease. In Benin, ITNs are the main insecticide tools utilized for malaria prevention through regulation of vectors.[31] The quantity of bednets owned by Beninese households has improved over time (Figure 1).

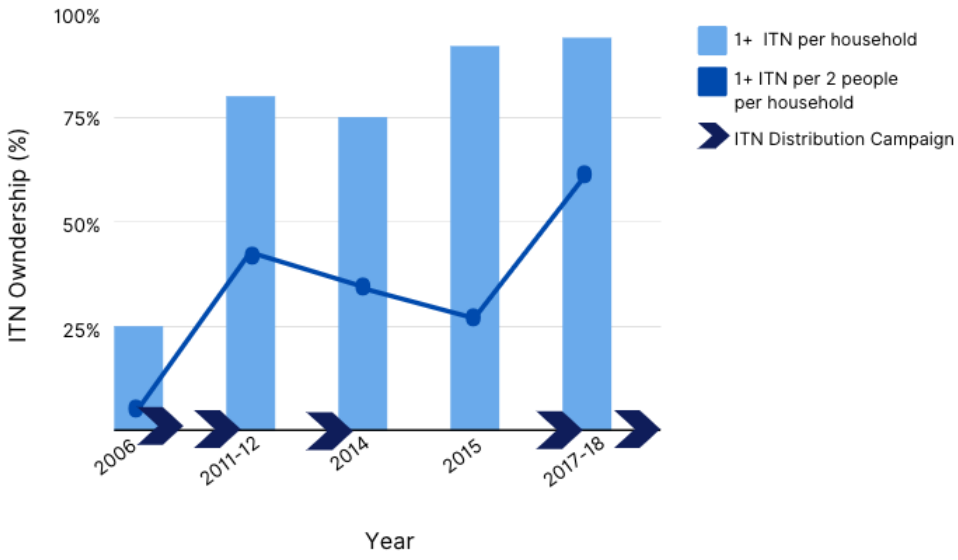


Figure 1. ITN mass distribution campaign in Benin 2020, by region and type of ITN dispensed.[28]

The reason for the rise in bednet ownership between 2006 and 2018 can be attributed to the implementation of a nationwide health program regarding LLIN. In Benin, nationwide health surveys and long-lasting insecticide net mass distribution campaigns have been carried out

frequently during this period.[26] Following the first national health survey in 2006, mass distribution of LLIN took place in October 2007 and ownership of ITN increased from 25% of households owning one or more ITN to 80% of households in 2011-12.[26] Another survey took place in 2014, in which household ownership of at least one ITN had decreased by 5%.[26] In September 2014 and again between August and October 2017, mass distribution LLIN campaigns took place allowing achievement of the highest recorded ITN ownership in Benin with 92% of households owning one or more ITN in 2017-18. During the same years, 61% of households were found to own at least one ITN for every 2 people in the household – an increase from 7% at the beginning of the national survey and mass distribution periods.[26] In 2020, Benin employed a digitalized mass distribution campaign of insecticide treated nets due to the COVID-19 pandemic. There were 7,562,166 ITN's distributed, leading to the protection of more than 94% of the population.[32] In this latest wave of distribution, pyrethroid-only nets as well as the new generation nets, combining insecticide types, were disseminated throughout Benin (Figure 2).[26]

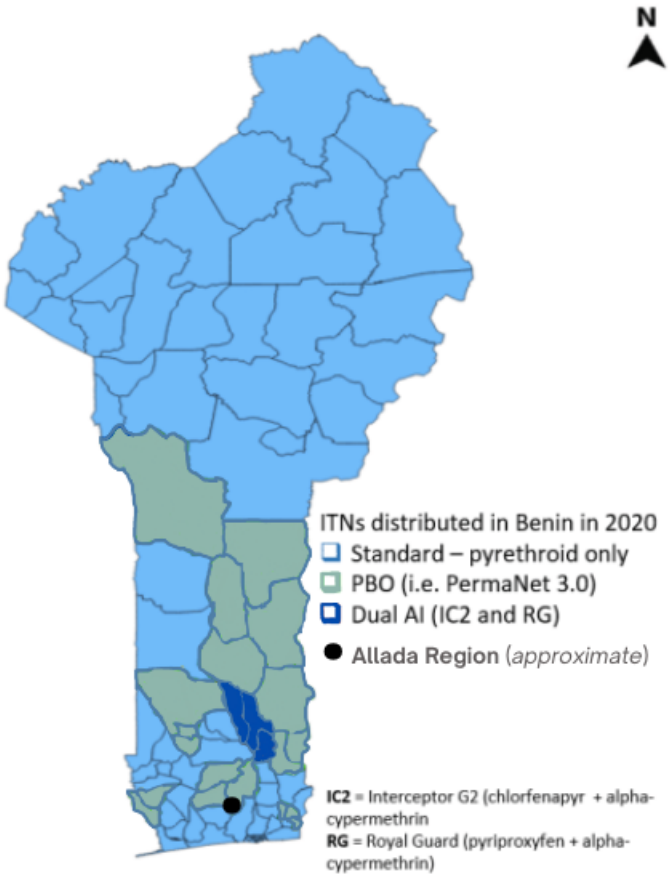


Figure 2. ITN mass distribution campaign in Benin 2020, by region and type of ITN dispensed.[28]

Source: U.S. President's Malaria Initiative, Benin 2022

4. Prior research, SSA

4.1 Prior research on ITN use

In 2021, map and metric statistics were compiled describing ITN coverage in 40 African countries with the highest malaria burden. As one of the most universal tools for malaria prevention, more than 450 million cases of malaria were avoided through use of bednets between 2000 and 2015.[33] Current estimations for net coverage across these 40 coutries should near 364 million

(95% CI, 341 – 383 million) with use rates reaching near 87.1% (95% CI, 83.1% – 90.3%).[33] Peak coverage was reached in 2017, with net ownership near 360 million (95% CI, 345 – 376 million).[33]

Research specific to factors influencing the usage of ITNs and characteristics contributing to the non-use of nets has been conducted in SSA countries. In Ghana, it was found that 97% of households reported ownership of ITNs, but only 65% of the study population reported using that net the evening prior to the survey.[34] This study found reasons associated with non-use of ITNs to include family size of more than 10 members, living in a house with more than 10 rooms and having screened windows in the home.[34] In Cameroon, a country where free distribution of ITNs has occurred since 2003, multistage sampling of 67 communities revealed only 47% of respondents owned at least one bed net.[35] Utilization of the nets was found to be almost 70% with increased likelihood of use when the household was in an urban area and when a pregnant woman lived in plank-louver housing compared to other housing types.[35]

Previous studies largely focus their research on children under the age of 5. In Burkina Faso in 2006, a study of 360 households with children 5 years and younger, were followed for indication of ITN use. All homes in the study possessed an ITN, but varying implementation was found for children residing in the homes.[36] It was discovered that children were more likely to sleep under a bednet during the rainy season than the dry season.[36] Reasons for this were found to be temperature related and due to sleep outdoors away from nets during the dry season.[36] Another study from 2007, conducted in rural Kenya, sought to determine coverage of ITNs in a population of 3,700 children from 0 – 4 years old. Results showed that poorer children benefit more from mass distribution campaigns and children in this economic class showed higher rates of coverage from dissemination of nets.[37]

4.2 Gaps in knowledge

Malarial disease studies in Benin have focused on pregnant woman and infants, signifying need for understanding prevention of malaria tools use in other populations at risk for disease contraction. There also remains a need for information concerning the use of other insecticide treated tools (coils and sprays) and use of traditional medicines as methods of malaria prevention. Further research with the intention to understand insecticide tool use patterns and method preferences as they relate to the dynamic population of southern, semi-rural Benin is imperative.

It is important to reproduce and broaden prior research on use and non-use of prevention of malaria tools in Benin where malaria remains a critical public health problem.

Aim of study

As evidenced by the widespread prevalence of malaria, which remains responsible for large numbers of deaths in Benin, further research is required to understand preventive measures in school age children. The ultimate goal of this thesis research was to determine factors leading to use and non-use of bednets and coils for malaria prevention in families with six year old children in Benin. Investigation also aimed to identify the specific populations, if any, that are more or less likely to employ these methods. Discovering reasons limiting prevention tool coverage could lead to developing specific and suitable guidance relating to vector control methods, ensuring appropriate malaria control and subsequent prevention.

Hypothesis

Increased or decreased use of insecticide tools for malaria prevention (bednets and coils) at child aged 6 in the Allada region of Benin is associated with socioeconomic status, family structure and environmental characteristics.

Main objective

To describe varying means for prevention of malaria (bednets, coils and sprays as well as traditional medicine) and precise which demographic and sociocultural characteristics in addition to family structure and lifestyle are associated with the use of malarial preventive measures.

Methods

Study design

Data was collected in a prospective cohort seeking to describe various sociodemographic as well as health and behavior trends of families in the Allada region, a semi-rural area, of Benin from pre-birth through child age six. Varying times of investigation during the more than six year period (Appendix 1) were focused on differing variables of interest and outcomes. The current study and analysis were designed with an emphasis on the use of bednets and other prevention of malaria tools used within the households included in the cohort at child age six years old. Information which could be valuable to describing why or why not insecticide prevention tools were used was highlighted at this period of exploration.

Data collection

MiPPAD & TOVI studies

MiPPAD, or Malaria in Pregnancy Preventive Alternative Drugs, randomized clinical trials marked the initiation of the prospective cohort. Between the years 2009 and 2013, 1,052 pregnant woman from the Allada region of Benin participated in the clinical trial seeking to describe IPTp and consequences in mother and children from the second trimester of pregnancy through birth until child age 12 months.[38] Criteria for inclusion was based on residency in Allada with less than 28-week gestational age at first antenatal visit and ability to deliver in approved local maternity wards. Inclusion was also dependent on receiving signed informed consent from each participant. As the children from the MiPPAD clinical trial approached age one, mothers were invited to continue in the study through a cross-sectional survey: TOVI. The purpose of TOVI was to uncover possible associations between occurrence of anemia during pregnancy and the potential outcomes of neurological child development from birth to one year old.

EXPLORE

Following TOVI, mothers were again invited to participate in an extension study at child age six: The Exposition au Plomb et au manganese et Risques pour L'Enfant (EXPLORE) between August 2016 and September 2018. In this follow up study, researchers were seeking to describe various sociodemographic and dwelling characteristics as well as health and behavior trends of families with children aged 6 years old in the Allada region of Benin.

Out of 963 livebirths, 87 children died between birth and six years of age. 590 mothers were interviewed by trained assessors (67% of eligible children). Questions related to coil use were added after the start of the study and were available for 432 participants. Therefore, 432 mothers were included in the final population used in the analysis of this project (Appendix 2).

Variables collected at six years of age

Among the extensive data recorded and registered from the EXPLORE questionnaire, the following variables were considered the main exposures of interest at child age 6 and were examined in additional assessment and investigation: 1) offspring gender, 2) maternal age at survey, 3) marital status, 4) quantity of individuals in household, 5) father cohabitation with child, and 6) stove and electricity in the home. Inquiries into insecticide tools for malaria prevention (bednets, coils, indoor residual sprays, and traditional medications) were also part of the

EXPLORE questionnaire (Appendix 3). Factors potentially related to socioeconomic status were probed, including: maternal education level, maternal literacy, village of residency, housing type, family relocation since child was born, proximity to traffic, presence or absence of painted walls as well as building material of walls and flooring (Appendix 4). Seasonal precipitation trends (based on period when questionnaire was supplied) and year of survey was also recorded by the research team.

Outcomes

Malarial preventive measures including ITN, coil, spray (Appendix 5), and traditional medicine were described. Determinants of use were explored for bednet and coil use.

Statistical methods

Description of the population

Univariate analysis was conducted initially with all variables of interest listed above in order to describe the data and detect any existing patterns. Missing data counts (Appendix 6) and prevalence of each characteristic was also calculated. All exposures of interest were transformed to categorical variables for further analysis (Appendix 7). Socioeconomic status was divided into quartiles to describe and analyze the population by four economic levels.

Multiple correspondence analysis (MCA)

Multiple correspondence analysis (MCA) was used to summarize information regarding socioeconomic status (SES) among the population of this study. This type of analysis allowed determination of underlying commonalities between categorical variables as a means of avoiding redundancy in chosen exposures of interest. Potential indicators of SES included in the MCA were the following: maternal ability to read and write, maternal education level, marital status, parental employment status, village of residency, dwelling type, family relocation, dwelling proximity to traffic, painted interior walls and material of dwelling walls and floor. The included 432 observations were found to be random and representative of the entire population without clusters (Appendix 8). The results of MCA computation showed that maternal education, maternal literacy, family wealth score, maternal employment, flooring material, wall material and paint, number of rooms in the home, village of residency, housing type and previous change of dwelling were strongly correlated in the first dimension (Appendix 9,10). Wealthier families were described by maternal literacy, high maternal education, residence in Attogon, maternal employment, 3 or more

rooms in homes with cement flooring and brick and painted walls. Associations were found between less wealthy families and maternal illiteracy, low maternal education, residence in Sekou, maternal unemployment and dwellings consisting of 2 or fewer rooms, non-cement flooring, and non-brick and unpainted walls. These findings were used to generate an economic status indicator variable which defined socioeconomic quartiles of the study population based on the previously listed associations. The first quartile respresenting the least wealthy families in the population, and the fourth quartile representing the wealthiest. The second and third quartiles were defined by families with middle and upper-middle wealth, respectively.

Bivariate analysis

Preliminary associations between relevant exposures and outcomes of interest were analyzed using Chi Square tests.

Logistic regression

Multivariate analysis was conducted using binary logistic regression. Variables with a p-value of less than 0.20 during bivariate analyses were included in the full regression models. The SES indicator variable generated from MCA results was also included in the full multivariate model regardless of chi square results. Secondary models were built with variables associated with the outcome at $p < 0.05$. The two regression models tested associations between significant exposures of interest and the two outcomes: use of bednet the night prior to delivery of the EXPLORE survey and use of insecticide treated coils in the interior of the household.

Stratification by precipitation season

In exploration of prior literature, seasonal data showed varying patterns of insecticide use based on wet or dry conditions.[39] This can be explained by mosquito density and temperate changes caused by seasonal variation in rainfall.[39] Malaria is also more prevalent during the rainy season, potentially causing changes in methods employed to prevent the disease during this period. Therefore, because it was hypothesized that behaviors may vary according to the season (dry/wet), analyses were further stratified according the season using conditional binary logistic regressions.

Software statement

The statistical analysis was completed using R Core Team (2009 - 2021) version 1.4.1717. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. UR: http://www.R-project.org/.

Ethical declaration

Approval and consent for use of all data analyzed in this thesis collected from the previously mentioned studies is given by: Comité d'Éthique de La Recherche de l'ISBA (Benin) and the Comité Consultatif de Déontologie et d'Éthique of the Institut de Recherche pour le Développement (France).

Results

Demographic, family & dwelling Characteristics

More than four hundred respondents were described during analysis (Table 1). Survey included 203 female (47.0%) and 229 male (53.0%) offspring with most mothers being older than 30 years of age. The lowest quartile of the socioeconomic groups included 11.2% of the population. Many families had between five and seven members (64.4%) with three to five siblings (52.4%) for the offspring of interest. Interior stoves were found to exist in 172 homes (39.8%) and 141 were equipped with electricity (32.6%). Respondents surveyed in the wet season constituted 52.8% of the population.

Table 1. Summarization of demographic characteristics of study population at completion of *EXPLORE*

	N = 432	
	n	(%)
Sociodemographic Characteristics		
Gender (female)	203	(47.0%)
Maternal age at survey		
Less than 22 years old	10	(02.3%)
22 - 25	53	(12.3%)
26 - 30	102	(23.7%)
31 years old and older	266	(61.7%)
Socioeconomic status		
1st quartile	47	(11.2%)
2nd quartile	190	(45.2%)
3rd quartile	132	(31.4%)
4th quartile	51	(12.1%)
Family Structure Characteristics		
Number of family members		
Less than 5 people	97	(22.5%)
5 - 7 people	278	(64.4%)
8 or more people	57	(13.2%)
Number of siblings		
1 or 2	163	(39.4%)
3 to 5	217	(52.4%)
6 or more	34	(08.2%)
Dwelling Characteristics		
Interior stove (yes)	172	(39.8%)
Electricity (yes)	141	(32.6%)
Temporal Characteristics		
Precipitation season (wet)	228	(52.8%)

The types of prevention of malaria tools and frequency of use was summarized for the overall population (Table 2). Over 80% of respondents had used an ITN the night prior to survey (more people reported ITN use in general, but not the previous night). Coils had been used by 100 families (23.1%) and 30 (23.1%) had used sprays. Most families (26.9%) who had used insecticides in the home previously, were using them at a frequency of 1-3 times per week. More than three hundred mothers confirmed the use of tradition medicines, mainly used in the context of malaria.

Table 2 Description of bednet use and insecticide use at 6 year follow-up; missing values are not included in the calculations

(% of Yes responses displayed)

	N = 432	
	n	%
Bednet use previous night	357	(82.6%)
Coil use in household	100	(23.1%)
Spray use in household	30	(06.9%)
Frequency of insecticide use		
Less than once per month	19	(16.0%)
1-3 times per month	26	(21.8%)
1-3 times per week	32	(26.9%)
4-6 times per week	22	(18.5%)
Daily	18	(15.1%)
Use of traditional medicines	377	(87.7%)
Daily	39	(10.5%)
Weekly	74	(20.0%)
Monthly	73	(19.7%)
Annually	183	(49.5%)

Bivariate analysis

Bivariate analysis tested the significant associations between offspring gender, maternal age at survey, SES level, number of total family members and number of siblings, child cohabitation with their father, presence of a stove in the interior of the home, use of other malaria prevention methods, and season (wet/dry) according to the two outcomes: bednet use the night prior to survey and insecticide use in the household (Table 3).

Table 3 Distribution of sociodemographic and familial characteristics according to use of various prevention of malaria tools at offspring age of 6 years (Allada, Benin); missing values are not included in the calculations

	Bednet use the night prior to survey				**Insecticide coils used in the interior of household**			
	n = 357 (82.6 %)				n = 100 (23.1 %)			
	n	N	**%**	p	*n*	N	%	p
Sociodemographic Charateristics								
Offspring sex								
Male	180	229	78.6%	0.026	59	229	25.8%	0.210
Female	177	203	87.2%		41	203	20.2%	
Maternal age at survey								
Less than 22 years	8	10	80.0%	0.602	3	10	30.0%	0.322
22 - 25 years old	43	53	81.1%		16	53	30.2%	
26 - 30 years old	89	102	87.3%		18	102	17.6%	
31 years or older	217	266	81.6%		62	266	23.3%	
SES status								
1st quartile	35	47	74.5%	0.278	7	47	14.9%	0.569
2nd quartile	160	190	84.2%		46	190	24.2%	
3rd quartile	107	132	81.1%		32	132	24.2%	
4th quartile	45	51	88.2%		12	51	23.5%	
Family Structure Characteristics								
Number of family members								
Lessthan 5 people	84	97	86.6%	0.494	16	97	16.5%	0.071
5 - 7 people	226	278	81.3%		74	278	26.6%	
8 or more people	47	57	82.5%		10	57	17.5%	
Number of siblings								
1 or 2	135	163	82.8%	0.144	41	163	25.2%	0.237
3 to 5	183	217	84.3%		52	217	24.0%	
6 or more	24	34	70.6%		4	34	11.8%	
Paternal cohabitation								
Yes	330	393	84.0%	0.009	90	393	22.9%	0.794
No	22	34	64.7%		9	34	26.5%	
Dwelling Characteristics								
Interior stove								
Yes	150	172	87.2%	0.056	26	172	15.1%	0.002
No	207	260	79.6%		74	260	28.5%	
Electricity								
Yes	121	141	85.8%	0.281	38	141	27.0%	0.237
No	236	291	81.1%		62	291	21.3%	
Tools for Malaria Prevention								
Bednet use previous night								
Yes					67	357	18.8%	0.000
No					33	75	44.0%	
Coil use in home								
Yes	67	100	67.0%	0.000				
No	290	332	87.3%					
Use of traditional medicines								
Yes	319	377	84.6%	0.013	83	377	22.0%	0.251
No	37	53	69.8%		16	53	30.2%	
Temporal Characteristics								
Season								
Wet	202	228	88.6%	0.001	53	228	23.3%	1.000
Dry	155	204	76.0%		47	204	23.0%	

Significant associations were found between bednet use the night before EXPLORE and offspring gender, number of siblings, paternal cohabitation with child, presence of stove in the interior of the home, coil use in the home, use of traditional medicine, and season (wet/dry). Female offspring were more likely to sleep under bednets than male offspring. Paternal cohabitation and use of traditional medicine was associated with greater use of bednets. Bednet use was less likely when there were high numbers of siblings, when coils were also used and during the dry season.

Significant associations were found between insecticide use in the home at child age six and number of family members, presence of stove in the interior of the home, bednet use the night prior to survey and year surveyed. Use of coils was more likely with households of 5-7 members, no stove in the home and no use of bednet the night prior to survey.

Multivariate analysis

The first regression model tested associations between significant exposures of interest and the use of bednet the night prior to delivery of the EXPLORE survey (Table 4).

Table 4 Binary logistic egression model on associations with bednet use the night prior to survey according to variables of interest based on bivariate analysis results with significant p-value > 0.20 (N= 432)

	Full Model			**Simplified Model**		
	OR	CI	*p*	OR	CI	*p*
Predictor						
Female offspring	2.16	[1.20 - 3.99]	**0.012**	2.15	[1.19 - 3.98]	**0.012**
SES status						
2nd quartile	2.80	[1.17 - 6.54]	**0.018**	2.88	[1.20 - 6.72]	**0.015**
3rd quartile	2.15	[0.88 - 5.15]	0.086	2.23	[0.92 - 5.32]	0.072
4th quartile	6.94	[1.89 - 30.92]	**0.006**	7.17	[1.95 - 31.89]	**0.005**
Number of siblings						
3 to 5	1.08	[0.58 - 2.01]	0.799	1.07	[0.57 - 1.98]	0.831
6 or more	0.36	[0.14 - 0.96]	**0.037**	0.36	[0.14 - 0.96]	**0.036**
Paternal cohabitation	6.13	[2.36 - 15.88]	**< 0.001**	6.28	[2.43 - 16.17]	**< 0.001**
Use of traditional medicine	2.45	[1.14 - 5.13]	**0.019**	2.54	[1.18 - 5.31]	**0.014**
Interior stove	1.30	[0.70 - 2.46]	0.411			
Coil use in home	0.27	[0.15 - 0.50]	**< 0.001**	0.26	[0.14 - 0.48]	**< 0.001**

In both the full and simplified models, use of bednet the night prior to being surveyed was strongly associated with female offspring (OR = 2.15 [95% CI, 1.19 – 3.98]), being in the 2nd (OR = 2.88 [95% CI, 1.20– 6.72]) or 4th (OR = 7.17 [95% CI, 1.95 – 31.89)) quartiles of the socioeconomic class, having six or more siblings (OR = 0.36 [95% CI, 0.14 – 0.96]), paternal cohabitation with child (OR = 6.28 [95% CI, 2.43 – 16.17]), use of traditional medicine (OR = 2.45 [95% CI, 1.18 – 5.31]) and coil use in the home (OR = 0.26 [95% CI, 0.14 – 0.48]) (Appendix 11).

The second regression model tested associations between significant exposures of interest and the use of coils in the household at child aged 6 years old (Table 5).

Table 5 Binary logistic regression model on associations with coil use in the home according to variables of interest based on bivariate analysis results with significant p-value > 0.20 (N= 432)

	Full Model			**Simplified Model**		
	OR	CI	*p*	OR	CI	*p*
Predictor						
SES status						
2nd quartile	2.36	[1.01 - 6.25]	0.062			
3rd quartile	2.38	[0.98 - 6.47]	0.680			
4th quartile	2.54	[0.89 - 7.79]	0.088			
Number of family members						
5 - 7 people	1.63	[0.88 - 3.20]	0.134			
8 or more people	1.08	[0.42 - 2.67]	0.868			
Interior stove	0.47	[0.27 - 0.79]	**0.005**	0.48	[0.29 - 0.79]	**0.005**
Bednet use the previous night	0.30	[0.17 - 0.53]	**< 0.001**	0.31	[0.18 - 0.54]	**< 0.001**

In both the full and simplified models, use of insecticides in the household was strongly associated with possession of a stove in the interior of the home (OR = 0.48 [95% CI, 0.29 – 0.79) and use of bednet the night before the survey took place (OR, 0.31 [95% CI, 0.18 – 0.54]) (Appendix 12).

Seasonal stratification (Appendix 13)

Factors associated with malarial preventive measures varied slightly based on season of rainfall and seasonal stratification of logistic regression models (wet/dry) was executed (Tables 6 and 7).

Table 6. Conditional logistic regression on associations between ITN use the night prior to survey according to exposures of interest based on bivariate analysis results with significant p-value > 0.20, by precipitation season.

	Dry Season n = 204			Wet Season n = 228		
	OR	CI	*p*	OR	CI	*p*
Predictor						
Female offspring	2.16	[1.00 - 4.91]	0.056	2.68	[0.92 - 8.71]	0.082
SES status						
2nd quartile	1.30	[0.40 - 3.93]	0.650	8.68	[1.79 - 44.16]	**0.007**
3rd quartile	1.81	[0.53 - 5.99]	0.335	2.34	[0.54 - 9.76]	0.241
4th quartile	2.39	[0.42 - 19.44]	0.356	30.97	[2.68 - 656.31]	**0.013**
Number of siblings						
3 to 5	1.04	[0.46 - 2.29]	0.931	1.28	[0.40 - 4.06]	0.670
6 or more	1.09	[0.25 - 5.88]	0.914	0.14	[0.03 - 0.60]	**0.009**
Paternal cohabitation	2.95	[0.81 - 10.22]	0.090	37.51	[5.70 - 310.09]	**< 0.001**
Use of traditional medicine	4.04	[1.52 - 10.80]	**0.005**	1.06	[0.19 - 4.50]	0.941
Interior stove	1.85	[0.80 - 4.53]	0.162	0.96	[0.34 - 2.80]	0.945
Coil use in home	0.27	[0.12 - 0.60]	**0.002**	0.15	[0.04 - 0.44]	**0.001**

During the dry season use of traditional medicines was strongly associated with bednet use (OR = 4.04, [95% CI, 1.52 – 10.80]). During the wet season, use of bednet the night prior to delivery of the EXPLORE questionnaire was strongly associated when the family was in the 2nd (OR = 8.68, [95% CI, 1.79 – 44.16]) or 4th (OR = 30.97, [95% CI, 2.68 – 656.31]) socioeconomic quartile, when there were six or more siblings (OR = 0.14, [95% CI, 0.03 – 0.60]) and when the father lived with the child (OR = 37.51, [95% CI, 5.70 – 310.09]). Use of coils in the home was strongly associated with bednet use regardless of precipitation season. (Dry: OR = 0.27, [95% CI, 0.12 – 0.60], Wet: OR = 0.15, [95% CI, 0.04 – 0.44]) (Appendix 14).

Table 7 Conditional logistic regression on associations between coil use in the home according to exposures of interest based on bivariate analysis results with significant p-value > 0.20, by precipitation

	Dry Season n = 204			Wet Season n = 228		
	OR	CI	*p*	OR	CI	*p*
Predictor						
SES status						
2nd Quartile	1.24	[0.41 - 4.33]	0.714	5.67	[1.40 - 39.14]	**0.033**
3rd Quartile	1.26	[0.38 - 4.64]	0.710	4.63	[1.11 - 32.25]	0.062
4th Quartile	1.34	[0.27 - 6.44]	0.716	5.47	[1.12 - 41.60]	0.055
Number of family members						
5 - 7 people	2.46	[0.91 - 7.86]	0.095	1.31	[0.58 - 3.19]	0.528
8 or more people	2.82	[0.76 - 11.18]	0.125	0.37	[0.07 - 1.52]	0.197
Interior stove	0.66	[0.29 - 1.47]	0.323	0.39	[0.18 - 0.79]	**0.011**
Bednet use the previous night	0.32	[0.15 - 0.68]	**0.003**	0.18	[0.07 - 0.48]	**0.001**

During the wet season, there was a strong association between coil use and second socioeconomic quartile (OR = 5.67, [95% CI, 1.11 – 32.25]) and when there was a stove present in the interior of the home (OR = 0.19, [95% CI, 0.07 – 0.51]). Coil was strongly associated with bednet use the night prior to survey regardless of precipitation season. (Dry: OR = 0.32, [95% CI, 0.15 – 0.68], Wet: OR = 0.18, [95% CI, 0.07 – 0.48]) (Appendix 15).

Discussion

Bednet use was found to be more likely for female offspring, with the father living in the home, when the family implemented traditional medicine practices and in families in higher SES class while use was less common with households of six or more siblings and when coils were used in the home. Coils were less likely to be used among the study population if the family possessed a stove inside the home and if an ITN was used the night prior to the survey. Bednet use was more likely with herbal medicine use during the dry season. During the wet season, middle class families (2nd SES class) were more likely to use coils.

Bednet coverage

Current estimations for bednet use rates reaching near 87.1% (95% CI, 83.1% – 90.3%).[33] Use of bednets in this thesis was defined by use of a bednet the night prior to survey, which was achieved by 82.6% of the population, slightly lower than the expected estimation of use in SSA. In Burkina Faso in 2006, a study of 360 households with children 5 years and younger found all

homes in the study possessed an ITN. [36] Ownership was not assessed independently of use in this thesis, so the previous findings in similar populations in Burkina Faso cannot be confirmed.

Bednet use patterns

Use of bednets was hypothesized to be influenced by sociodemographic characteristics and family structure. The lowest socioeconomic class was found to be using bednets the least. Lower SES status was defined in part by lower education attainment and may explain lower bednet use as knowledge concerning anti-malaria information and practices would be reinforced during more years of education. Fathers living with children increased the use of bednets the night prior to survey. Field experts explain that this is likely due to sociocultural values of the region that place paternal authority in high respect. The experts explained that female offspring were also more likely to follow instructions given to them to use the nets when compared to male offspring. Lower usage rates of bednet with higher sibling numbers, can be explained by ownership trends. National health surveys indicate that even currently, when ownership numbers are at their highest, only 61% of homes had one ITN per every two family members. There is clearly success in increased ITN coverage due to mass distribution campaigns in recent years, but improvements can continue to be made. Higher bednet use in the occurrence of traditional medicine consumption may result from increased health consciousness among users. Reduced bednet use when coils were used in the home can be explained by redundancy. Families employing one means of insecticide tool for malaria prevention may be less inclined to use a second method.

Coil use patterns

Results indicate that sociodemographic and environmental conditions influence use of coils as discussed in the hypothesis. Families who possessed a stove in the home were less likely to use coils. Field experts explain that this may be due to a desire to limit the amount of airborne smoke produced when cooking on the stove and through burning of coils concurrently. As stated previously, findings of decreased coil use in the presence of a bednet show that families are likely to use one method of malaria prevention over the other.

Bednet and coil use

The relationship between decreased use of one malaria prevention tool in the presence of the other has not been studies in detail in existing research. According to WHO 2022 malaria

prevention guidelines, the use of two insecticide prevention tools simultaneously is not recommended, perhaps offering an explanation to these findings.[13]

Precipitation season and use of malaria prevention tools

Variations in use of tools to prevent malaria between wet and dry season is recorded in a multitude of prior research.[39] Stratification of logistic regression models generally maintained the findings described above. However, during the dry season, bednet use was even more likely with herbal medicine use during this period in the study population. Potential explanation of this is that people employing traditional anti-malaria strategies are more concerned for their health and therefore implement all methods for malaria prevention even during the dry season when the perceived risk of malaria contraction is lower.[39] Future qualitative studies could confirm this hypothesis. Interior stove possession is significantly associated with coil use during the wet season. During this season, stoves in the home are used more when outdoor cooking is not possible, explaining the association found here. Wet season incidcated more coil use in middle wealth families. Further investigation into socioeconomic class use pattern variations depending on season is needed to understand this result.

Gender & prevention of malaria tools

Increased bednet use when the offspring was female was found. In another study in Liberia during 2016, men and older children were found to be less likely to sleep under bednets than woman and children under the age of 5.[40] A second study, comparing age and gender ITN usage trends in 29 African countries, found that discrepencies between gender and age use was minimized when ITN ownership was higher.[41] This again reinforces the need for improvement in the already successful ITN distribution campagins. Woman and children are often the targets of prevention of malaria tool guidelines.[42] which may lead to the gender gap in usage, notable from age 6 in this these.

Family size & prevention of malaria tool use

Outside of ownership, several past studies indicated variations in bednet use based on the size of the family unit. In 2021, a study in Ghana concluded that non-use of bednets was associated with family size of more than 10 members.[34] Studies conducted in surrounding countries discovered trends indicative of use and non-use of bednets specifically relating to families with young children. In 2011 in Equatorial Guinea, where ITN mass distribution has been implemented in a similar fashion to Benin, one study found that bednet use was higher in households with fewer

children under 5 years.[43] In Nigeria in 2013, where bednet ownership was found to be 45.5% of the population, ITN use declined when more than three other children under the age of 5 lived in the home and when there was a total of 7 or more family members.[44] The findings in this thesis also showed varying degrees of bednet use depending on size of the family. Larger family units (with more siblings) were found to use bednets less.

Socioeconomic status & prevention of malaria tool use

In Equatorial Guinea, one study from 2011 showed higher bednet use when the head of the household had reached a high level of education.[43] A prior 2014 study in Cameroon found bednet usage increased when the household was in an urban area and when a pregnant woman lived in plank-louver housing compared to other housing types.[35] The variables discussed in these studies (education level, housing material) were combined to create a socioeconomic indicator for the purposes of this thesis. Based on this indicator, there was significant association between family economic status and the use of bednets. It was found that families outside of the lowest wealth class were more likely to use bednets. Bivariate results indicate that in the EXPLORE cohort, the families making up the lowest SES quartile were the least likely to use either bednets or coils. Conversely, In Nigeria, a 2013 study reported higher use of bednets in poorer families.[44]

Reasons for use of coils as a means of prevention of malaria through vector control and their efficacy has not been studied in depth.

Antimalaria uses of traditional medicine

RITAM found that an average of 20% of people in SSA used traditional herbal remedies to avoid malaria contraction.[22] In the EXPLORE population, more than 80% of participants used traditional medicine, much higher than the RITAM estimate.

Factors influencing self-treatment of malaria at home with herbs, known as traditional medicines, was described by a study in Benin in 2020. Researchers in Cotonou, an urban region, found 5.34% of households used traditional medicine exclusively to prevent malaria, while in the rural village of Lobogo, 4% used this method exclusively.[45] In Cotonou, 60.96% of the population used both traditional and pharmaceutical medicines, and in Lobogo, a majority of participants (89.22%) reported using both types.[45] Use of traditional medications was associated with the age of respondent, local traditional financial saving schemes, and low family socioeconomic status [45]

However, the study did not explore use of bednets or coils in conjunction with traditional medications. The analysis performed in this thesis noted increased use of bednets when used in conjunction with traditional medicines.

Novel results

When the father lived in the same home as the child, bednet use was found to increase. Information from field experts indicates that these are likely trends that reflect cultural values of the community and suggests more investigation is required to better comprehend these inclinations.

Usefulness of Insecticide Tools for Malaria Prevention

The latest WHO guidelines for malaria prevention focus on use of pyrethroid treated bednets, with recommended use at night (indoors or outdoors) aimed at avoidance of sun exposure that could alter the insecticidal properties of the net.[13] According to the CDC, long-lasting insecticide treated nets remain efficacious for up to three years.[46]

Insecticide Resistance in Malaria Vectors

Although pyrethroid treated tools have been an effective intervention in the ultimate goal of malaria eradication, using pyrethroids as the sole chemical compound in large bednet distribution campaigns globally has allowed increased vector resistance to the chemical.[19] In an effort to reverse the developed resistance to the currently used chemical compounds, development of a new generation of nets combining novel chemistries has been developed.[19] New chemical cocktails for the purpose of management of disease vectors will not necessarily be restricted to LLIN[19] These concoctions may be impregnated into the other insecticide treated tools, including but not limited to coils and personal sprays.[19]

Insecticide Use Dangers to Humans

The addition of pyrethroids and other chemical compounds used in the control of malaria vectors may pose some threat to human health and safety and therefore their utilization and the results of their use must be properly studied to ensure appropriate management. The benefits of pyrethroids as a source of lowering the mosquito density in malaria endemic areas is accompanied by inevitable risks to the humans utilizing impregnated tools. Exposure to pyrethroids can cause an inundation of sodium particles into human nerve cells through voltage-

gated sodium channels (VGSC).[17] VGSC, one type of family of sodium channels, are located throughout the human body, allowing chemicals to have access to multiple cell types.[47] Influx of sodium ions into cells results in permanent depolarization of cells leading to potential destabilized functioning.[17] Pyrethroids are lipid soluble and therefore can enter the human body through contact with the dermis and the digestive or respiratory systems.[17] Speed of entry into human cells is dependent on the absorptivity of the contact site.[17] It has been found that pregnant woman and children of young ages are at a higher risk of rapid absorption of pyrethroids into the body.[17] Once inside the body, the chemical compound largely affects enzymes functioning in nerve and liver cells.[17] Careful use of pyrethroid treated tools for malaria prevention is required to prevent the potential harms of exposure to pyrethroids in humans.

According to the WHO, pyrethroid treated bednets pose no threat to human health and bodily function.[48] When used within proper bounds, studies show that rare side effects of skin irritation, headache, burning sensation of the eyes and nausea are possible but are negligible and fleeting.[48] It has even been argued that these symptoms may be a benefit by allowing early indication of adverse pyrethroid exposure and early elimination of the object to minimize further reaction[49], however studies in SSA are rare.

Though insecticide treated tools were used by the population in this theis, possible affects from their implementation was not assessed. A study using mother-child cohort data at child age 6 in France between 2002 and 2006, found that exposure to pyrethroids may negatively impact neurodevelopment of children. Higher levels of pyrethroid metabolities in mother and child urinalysis indicated an increased risk for internalizing and externilizaing difiiculties and abnormal or borderline social behavior.[50]

Strengths

Distinguishable from prior research, this study took both bednets and coils into consideration of malaria prevention tools, which were found to have an inverse impact on the usage of the other. Additonally, this study was strengthed through characterization of prevention of malaria regardless of method used. Children age 6 years old are an under studied population concerning malaria prevention, making this study unqiuely advantageous. Inclusion of a large number of variables in the MCA indicating socioeconomic status also strengthened the analysis performed.

Limitations

The study was limited by non-assessment of mosquito density causing lack of knowledge of definitive exposure to mosquito vectors and the level of that exposure. Condition and placement of prevention of malaria tools was also not assessed in this research. Bednets and coils may have been in place but information concerning their confirmed and appropriate usage by respondents remains unknown. Declaration of bednet and coil use was the only indicator of usage of prevention of malaria tools by respondents but was unobserved by researchers in the field. Possible overreporting of bednet use in order to prevent malaria is feasible due to the current WHO guidelines in Benin instructing bednet use and making access to bednets possible for the local population by means of mass distribution campaigns.[13, 26] Sprays could not be studied due to the low number of participants using this means of malaria prevention.

Participants were asked about traditional medicine use and most of them reported using them for malaria, usually in the form of an herbal tea. However, this variable may include traditional medicine for other reasons, and/or for treatment of malaria and not only preventive measure. Therefore, our results may overestimate the use of traditional medicine for malarial preventive measures. Information on screened windows was not available.

Although aiding in full understanding of malarial preventive measures used by the population, stratification of logistic regression models by season in which participants were surveyed is marked by decreased power. Very large confidence intervals in the outcome of the conditional logistic regression models denote lower precision of inferences drawn from their outputs.

Recommendations

Current WHO recommendations for prevention of malaria focus mainly on the use of long-lasting insecticide nets and indoor residual spraying. LLIN have been the main prevention of malaria tool used in Benin since the early 2000's with the initiation of nationwide distribution campaigns.[13] Our findings that varying demographic, sociocultural and environmental elements influence whether bednet and other prevention of malaria tools are used in southern, semi-rural Benin confirms the necessity for expansion of the recommended malaria prevention tools following future research understanding all anti-malaria methods. If coils are found to be inefficacious, or even harmful, guidelines need to be updated to educate populations requiring this information.

Future Research

Based on the findings in the thesis study, it is apparent that populations of southern, semi-rural Benin use insecticide treated coils as a method of controlling mosquitoes, the most common vector of malaria. The efficacy of this method has largely not been studied and is not currently recommended by the WHO as an adequate means to prevent malaria through vector control.[13] Populations utilizing such methods may be exposed to chemical insecticides through these methods.[50] Preliminary urinalysis of subjects within the study population (N = 15) signifies some abnormal chemical levels in the presence of insecticide treated tools for malaria prevention. Further research is indicated to better assess coils efficacy on the risk of malaria, and to study exposure levels of pyrethroids among participants using coils.

Future studies would benefit from inclusion of mosquito density and conditions of bednets and coils being used by respondents for prevention of malaria. More research is indicated in order to have complete awareness of the potential risks and benefits other methods of malaria prevention. The fulfillment of this need will enable populations afflicted by malaria to reach higher levels of coverage against vectors causing perpetuation of the disease.

Conclusion

Families in southern, semi-rural Benin with children aged six years old were differentially influenced towards use of insecticide treated prevention of malaria tools based on variable socio-cultural and environmental factors. The diverse population of Benin and Sub-Saharan Africa causes unique family and home conditions that require accessibility to and education concerning equally diverse prevention of malaria tools. Future studies understanding appropriate usage of prevention of malaria tools must also be considered.

References

1. Talapko J, Škrlec I, Alebić T, Jukić M, Včev A. Malaria: The Past and the Present. Microorganisms. 2019 Jun 21;7(6):179.
2. Sato S. Plasmodium—a brief introduction to the parasites causing human malaria and their basic biology. Journal of Physiological Anthropology. 2021 Jan 7;40(1):1.
3. Belachew EB. Immune Response and Evasion Mechanisms of Plasmodium falciparum Parasites. J Immunol Res. 2018 Mar 25;2018:6529681.
4. Tan MSY, Blackman MJ. Malaria parasite egress at a glance. J Cell Sci. 2021 Mar 8;134(5):jcs257345.
5. Bartoloni A, Zammarchi L. Clinical Aspects of Uncomplicated and Severe Malaria. Mediterr J Hematol Infect Dis. 2012 May 4;4(1):e2012026.
6. Gupta NK, Bansal SB, Jain UC, Sahare K. Study of thrombocytopenia in patients of malaria. Trop Parasitol. 2013;3(1):58–61.
7. Shetty GM, Bhandary NM. LEUCOCYTE COUNT AS A MARKER OF SEVERITY IN MALARIA. International Journal of Biomedical Research. 2012 Mar 1;3(2):88–90.
8. World malaria report 2021 [Internet]. Geneva: World Health Organization; [cited 2022 Mar 1]. Available from: https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2021
9. Rowe AK, Onikpo F, Lama M, Osterholt DM, Deming MS. Impact of a Malaria-Control Project in Benin That Included the Integrated Management of Childhood Illness Strategy. Am J Public Health. 2011 Dec;101(12):2333–41.
10. Garrison A, Boivin MJ, Fiévet N, Zoumenou R, Alao JM, Massougbodji A, et al. The Effects of Malaria in Pregnancy on Neurocognitive Development in Children at 1 and 6 Years of Age in Benin: A Prospective Mother–Child Cohort. Clinical Infectious Diseases. 2021 Jul 23;ciab56
11. Schantz-Dunn J, Nour NM. Malaria and Pregnancy: A Global Health Perspective. Rev Obstet Gynecol. 2009;2(3):186–92.
12. Global Malaria Programme. Global Technical Strategy for Malaria 2016-2030 [Internet]. World Health Organization; Available from: https://www.who.int/docs/default-source/documents/global-technical-strategy-for-malaria-2016-2030.pdf
13. WHO Guidelines for malaria, 18 February 2022. Geneva: World Health Organization; 2022 (WHO/UCN/GMP/ 2022.01). License: CC BY-NC-SA 3.0 IGO.

14. Oumbouke WA, Fongnikin A, Soukou KB, Moore SJ, N'Guessan R. Relative performance of indoor vector control interventions in the Ifakara and the West African experimental huts. Parasites Vectors. 2017 Dec;10(1):432.
15. Lawrance CE, Croft AM. Do Mosquito Coils Prevent Malaria? A Systematic Review of Trials. Journal of Travel Medicine. 2006 Mar 10;11(2):92–6.
16. US EPA O. EPA Addresses Human Health and Ecological Risks Posed by 13 Pyrethroids [Internet]. 2020 [cited 2022 May 2]. Available from: https://www.epa.gov/pesticides/epa-addresses-human-health-and-ecological-risks-posed-13-pyrethroids
17. Hołyńska-Iwan I, Szewczyk-Golec K. Pyrethroids: How They Affect Human and Animal Health? Medicina (Kaunas). 2020 Oct 30;56(11):582.
18. Kawada H, Ohashi K, Dida GO, Sonye G, Njenga SM, Mwandawiro C, et al. Insecticidal and repellent activities of pyrethroids to the three major pyrethroid-resistant malaria vectors in western Kenya. Parasites & Vectors. 2014 May 2;7(1):208.
19. Paaijmans KP, Huijben S. Taking the 'I' out of LLINs: using insecticides in vector control tools other than long-lasting nets to fight malaria. Malaria Journal. 2020 Feb 14;19(1):73.
20. Bowman NM, Akialis K, Cave G, Barrera R, Apperson CS, Meshnick SR. Pyrethroid insecticides maintain repellent effect on knock-down resistant populations of Aedes aegypti mosquitoes. PLOS ONE. 2018 May 15;13(5):e0196410.
21. CDC. Adulticides | CDC [Internet]. Centers for Disease Control and Prevention. 2020 [cited 2022 May 2]. Available from: https://www.cdc.gov/mosquitoes/mosquito-control/community/adulticides.html
22. Willcox ML, Bodeker G. Traditional herbal medicines for malaria. BMJ. 2004 Nov 13;329(7475):1156–9.
23. Overview [Internet]. World Bank. [cited 2022 May 3]. Available from: https://www.worldbank.org/en/country/benin/overview
24. Facts About the Republic of Benin: Official Document [Internet]. [cited 2022 May 3]. Available from: https://www.africa.upenn.edu/Country_Specific/benin_EDoc.html
25. World Bank Climate Change Knowledge Portal [Internet]. [cited 2022 May 3]. Available from: https://climateknowledgeportal.worldbank.org/
26. U.S. President's Malaria Initiative Benin Malaria Operational Plan FY 2022. :96. https://d1u4sg1s9ptc4z.cloudfront.net/uploads/2022/01/FY-2022-Benin-MOP.pdf
27. Tossou CC, Floquet AB, Sinsin BA. SPATIO-TEMPORAL DYNAMICS OF LAND OCCUPATION, URBANIZATION AND URBAN AGRICULTURE ON THE ALLADA PLATEAU IN SOUTHERN BENIN. In: Acta Horticulturae [Internet]. International Society

for Horticultural Science (ISHS), Leuven, Belgium; 2014. p. 91–100. Available from: https://doi.org/10.17660/ActaHortic.2014.1021.8

28. RGPH_Cahier des villages et quartiers de ville - Benin Data Portal [Internet]. [cited 2022 May 3]. Available from: https://benin.opendataforafrica.org/iidseh/rgph-cahier-des-villages-et-quartiers-de-ville
29. Incidence of malaria (per 1,000 population at risk) - Benin | Data [Internet]. [cited 2022 May 3]. Available from: https://data.worldbank.org/indicator/SH.MLR.INCD.P3?locations=BJ
30. Cdc.gov. 2019. *CDC in Benin Factsheet*. [online] Available at: <https://www.cdc.gov/globalhealth/countries/benin/pdf/Benin_Factsheet.pdf> [Accessed 2 March 2022].
31. Djègbè I, Boussari O, Sidick A, Martin T, Ranson H, Chandre F, et al. Dynamics of insecticide resistance in malaria vectors in Benin: first evidence of the presence of L1014S kdr mutation in Anopheles gambiae from West Africa. Malar J. 2011 Dec;10(1):261.
32. Aïkpon R, Affoukou C, Hounpkatin B, Eclou DD, Cyaka Y, Egwu E, et al. Digitalized mass distribution campaign of insecticide-treated nets (ITNs) in the particular context of Covid-19 pandemic in Benin: challenges and lessons learned. Malaria Journal. 2020 Nov 25;19(1):431.
33. Bertozzi-Villa A, Bever CA, Koenker H, Weiss DJ, Vargas-Ruiz C, Nandi AK, et al. Maps and metrics of insecticide-treated net access, use, and nets-per-capita in Africa from 2000-2020. Nat Commun. 2021 Jun 11;12(1):3589.
34. Akuffo R, Wilson M, Sarfo B, Dako-Gyeke P, Adanu R, Anto F. Insecticide-treated net (ITN) use, factors associated with non-use of ITNs, and occurrence of sand flies in three communities with reported cases of cutaneous leishmaniasis in Ghana. PLOS ONE. 2021 Dec 16;16(12):e0261192.
35. Kimbi, Helen Kuokuo, et al. “Socio-Demographic Factors Influencing the Ownership and Utilization of Insecticide-Treated Bed Nets among Malaria Vulnerable Groups in the Buea Health District, Cameroon.” *BMC Research Notes*, vol. 7, no. 1, Sept. 2014, pp. 624–624, https://doi.org/10.1186/1756-0500-7-624.
36. Frey C, Traoré C, De Allegri M, Kouyaté B, Müller O. Compliance of young children with ITN protection in rural Burkina Faso. Malaria Journal. 2006 Aug 14;5(1):70.

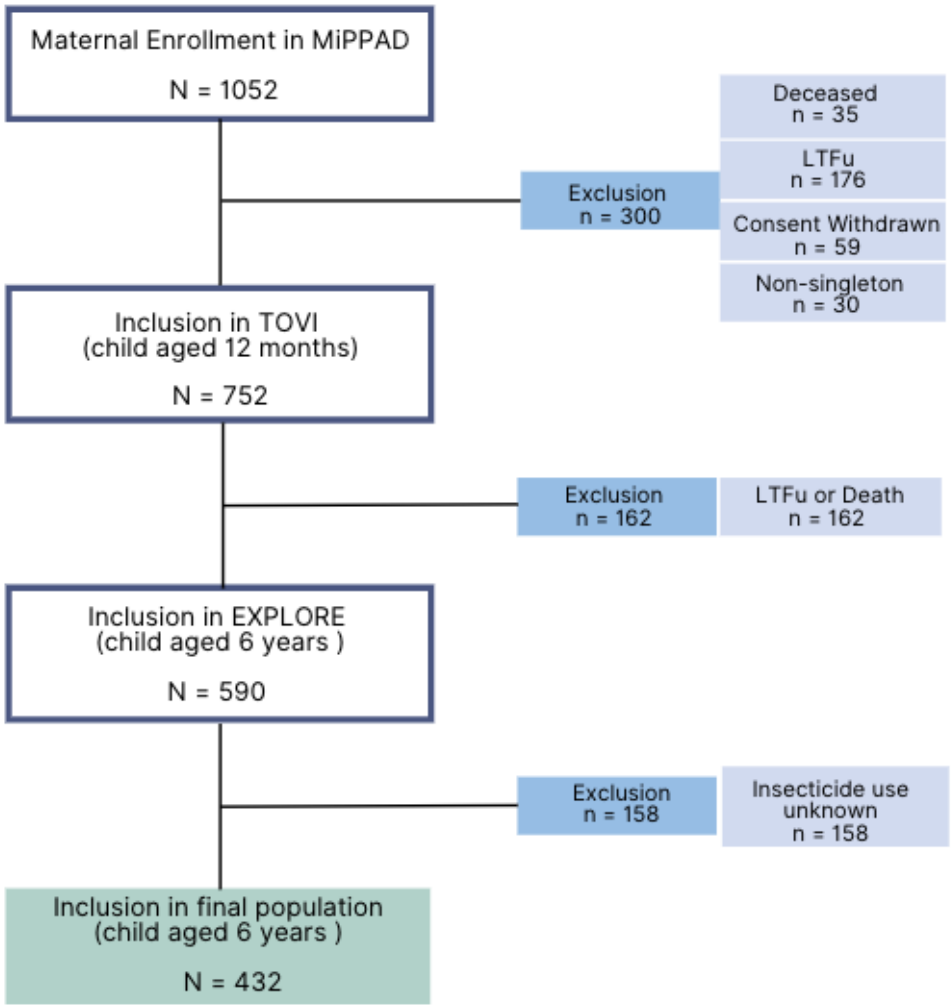
37. Noor AM, Amin AA, Akhwale WS, Snow RW. Increasing Coverage and Decreasing Inequity in Insecticide-Treated Bed Net Use among Rural Kenyan Children. PLOS Medicine. 2007 Aug 21;4(8):e255.
38. Garrison A, Khoshnood B, Courtin D, Milet J, Garcia A, Massougbodji A, et al. Blood lead level in infants and subsequent risk of malaria: A prospective cohort study in Benin, Sub-Saharan Africa. Carvalho LH, editor. PLoS ONE. 2019 Jul 18;14(7):e0220023.
39. Koenker H, Taylor C, Burgert-Brucker CR, Thwing J, Fish T, Kilian A. Quantifying Seasonal Variation in Insecticide-Treated Net Use among Those with Access. Am J Trop Med Hyg. 2019 Aug;101(2):371–82.
40. Babalola S, Ricotta E, Awantang G, Lewicky N, Koenker H, Toso M. Correlates of Intra-Household ITN Use in Liberia: A Multilevel Analysis of Household Survey Data. PLOS ONE. 2016 Jul 12;11(7):e0158331.
41. Olapeju B, Choiriyyah I, Lynch M, Acosta A, Blaufuss S, Filemyr E, et al. Age and gender trends in insecticide-treated net use in sub-Saharan Africa: a multi-country analysis. Malaria Journal. 2018 Nov 14;17(1):423.
42. Garley AE, Ivanovich E, Eckert E, Negroustoueva S, Ye Y. Gender differences in the use of insecticide-treated nets after a universal free distribution campaign in Kano State, Nigeria: post-campaign survey results. Malaria Journal. 2013 Apr 10;12(1):119.
43. García-Basteiro AL, Schwabe C, Aragon C, Baltazar G, Rehman AM, Matias A, et al. Determinants of bed net use in children under five and household bed net ownership on Bioko Island, Equatorial Guinea. Malaria Journal. 2011 Jun 29;10(1):179.
44. Osuorah DC, Ezeudu CE, Onah SK, Anyabolu OT. Household bed net ownership and use among under-5 children in Nigeria. Res Rep Trop Med. 2013 Jul 24;4:15–27.
45. Damien BG, Baxerres C, Apetoh E, Le Hesran JY. Between traditional remedies and pharmaceutical drugs: prevention and treatment of “Palu” in households in Benin, West Africa. BMC Public Health. 2020 Dec;20(1):1425.
46. Prevention CC for DC and. CDC - Malaria - Malaria Worldwide - How Can Malaria Cases and Deaths Be Reduced? - Insecticide-Treated Bed Nets [Internet]. 2019 [cited 2022 Jun 10]. Available from: https://www.cdc.gov/malaria/malaria_worldwide/reduction/itn.html
47. Hernandez CM, Richards JR. Physiology, Sodium Channels. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 [cited 2022 May 3]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK545257/

48. Treated mosquito nets are safe and effective [Internet]. WHO | Regional Office for Africa. [cited 2022 Jun 10]. Available from: https://www.afro.who.int/news/treated-mosquito-nets-are-safe-and-effective
49. Zaim M, Aitio A, Nakashima N. Safety of pyrethroid-treated mosquito nets. Med Vet Entomol. 2000 Mar;14(1):1–5.
50. Viel JF, Rouget F, Warembourg C, Monfort C, Limon G, Cordier S, et al. Behavioural disorders in 6-year-old children and pyrethroid insecticide exposure: the PELAGIE mother–child cohort. Occup Environ Med. 2017 Apr;74(4):275–81.

List of Appendices

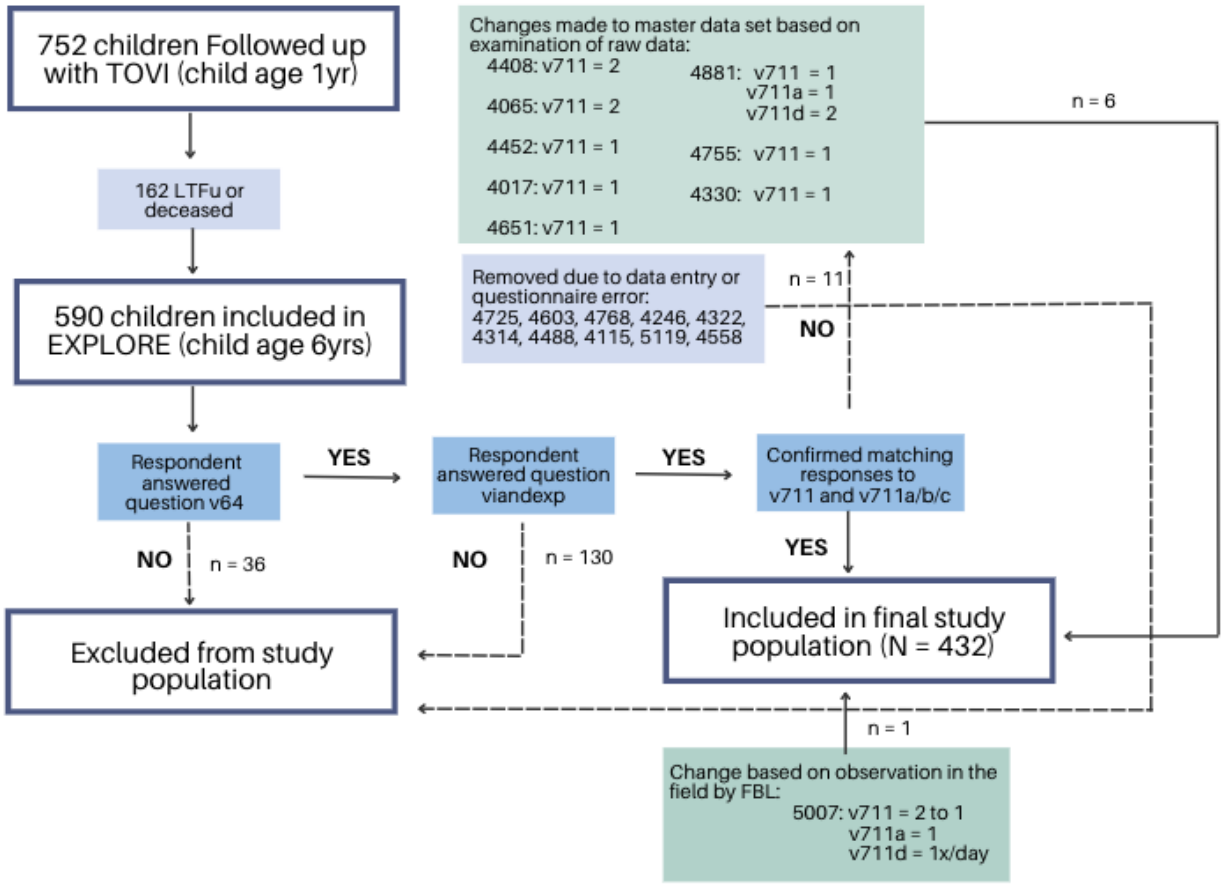
Appendix 1

Summarization of cohort population from MiPPAD through final study population.



Appendix 2

Descriptive flow chart of population selection from onset TOVI until current study analysis following the EXPLORE questionnaire.



Appendix 3

Interview questions from EPXLORE questionnaire used to create study outcomes.

3a. Original questionnaire was given to participants in French.

Section 4. Aliementation de l'Enfant		
4.1.A	Est-ce que votre enfant mange de la viande de bêtes tuées par un fusil ?	{1 - Oui, 2 - Non) | __ |
Section 6. La Maison		
6.4	Votre enfant a-t-il dormi sous la moustiquaire la nuit dernière ?	{1 - Oui, 2 - Non) | __ |
Section 7. Environnement et Habitat		
7.11	Avez-vous déjà utilisé des insecticides à l'intérieur de votre maison?	{1 - Oui, 2 - Non) | __ |
7.11A	Pulvérisation	{1 - Oui, 2 - Non) | __ |
7.11B	Spirale	{1 - Oui, 2 - Non) | __ |
7.11C	Autre	| _____ |

3b. Translation in English is included for clarity of outcome creation for study purposes.

Section 4. Child's Food Habits		
4.1.A	Has your child eaten meat resulting from hunting using a gun?	{1 - Yes, 2 - No) | __ |
Section 6. The Home		
6.4	Did your child sleep under a bednet last night?	{1 - Yes, 2 - No) | __ |
Section 7. Environment & Habit		
7.11	Have you used insecticides in your home before?	{1 - Yes, 2 - No) | __ |
7.11A	Space Spray	{1 - Yes, 2 - No) | __ |
7.11B	Coil	{1 - Yes, 2 - No) | __ |
7.11C	Other	| _____ |

Appendix 4

Descriptive summarization of population characteristics included for creation of socioeconomic indicator variable.

	N = 432	
	n	(%)
Sociodemographic Characteristics		
Maternal Education (High)	62	(14.4%)
Maternal Literacy (Yes)	113	(26.4%)
Family Structure Characteristics		
Marital status		
Single	18	(04.3%)
Monogamous	209	(49.4%)
Polygamous	192	(45.4%)
Number of Family Members		
Less than 5 people	97	(22.5%)
5 - 7 people	278	(64.4%)
8 or more people	57	(13.2%)
Number of Siblings		
1 or 2	163	(39.4%)
3 to 5	217	(52.4%)
6 or more	34	(08.2%)
Paternal Cohabitation (Yes)	393	(92.0%)
Paternal Employment (Yes)	407	(95.1%)
Maternal Employment (Yes)	270	(63.5%)
Dwelling Characteristics		
Village of Residency		
Attogon	125	(28.9%)
Sekou	307	(70.6%)
Housing Type		
Communal	326	(75.8%)
Individual	104	(24.2%)
Change of Dwelling (Yes)	87	(20.1%)
Proximal to Traffic (Yes)	354	(82.5%)
Floor Material		
Cement	314	(72.7%)
Other	118	(27.3%)
Wall Material		
Brick	188	(43.5%)
Other	244	(56.5%)
Painted Walls (Yes)	48	(11.4%)

Appendix 5

Sub-population distribution describing respondents who have previously used insecticide sprays in the interior of the home.

	N = 30	
	n	(%)
Sociodemographic Chacracteristics		
Gender (female)	15	(50.0%)
Maternal age at survey		
Less than 22 years old	0	(00.0%)
22 - 25	5	(17.2%)
26 - 30	10	(34.5%)
31 years old and older	14	(48.3%)
Maternal education (high)	12	(40.0%)
Maternal literacy (yes)	13	(46.4%)
Socioeconomic status		
1st quartile	2	(07.1%)
2nd quartile	7	(25.0%)
3rd quartile	12	(42.9%)
4th quartile	7	(25.0%)
Family Structure Characteristics		
Marital status		
Single	1	(03.4%)
Monogamous	18	(62.1%)
Polygamous	10	(34.5%)
Number of family members		
Less than 5 people	8	(26.7%)
5 - 7 people	20	(66.7%)
8 or more people	2	(06.7%)
Number of siblings		
1 or 2	10	(37.0%)
3 to 5	13	(48.1%)
6 or more	4	(14.8%)
Paternal cohabitation (yes)	26	(89.7%)
Paternal employment (yes)	29	(96.7%)
Maternal employment (yes)	18	(62.1%)
Dwelling Characteristics		
Village of residency		
Attogon	15	(50.0%)
Sekou	15	(50.0%)
Housing type		
Communal	23	(76.6%)
Individual	7	(23.3%)
Proximal to traffic (yes)	22	(73.3%)
Interior stove (yes)	10	(33.3%)
Electricity (yes)	9	(30.0%)
Prevention of Malaria Tools		
Bednet use the prior night	23	(76.7%)
Coil use in home	8	(26.7%)
Uses traditional medicine	28	(93.3%)
Temporal Characteristics		
Precipitation season (wet)	17	(56.7%)

Appendix 6

Missing values in exposures of interest.

		N = 432
	n	**% of missing**
Sociodemographic Charateristics		
Offspring sex	0	0.0%
Maternal age at survey	1	0.2%
Maternal literacy	4	0.9%
Maternal education level	1	0.2%
SES status	12	2.8%
Family Structure Characteristics		
Martial status	0	0.0%
Household size	0	0.0%
Number of siblings	18	4.2%
Paternal cohabitation	5	1.2%
Maternal employment	7	1.6%
Paternal employment	4	0.9%
Dwelling Characteristics		
Village of residency	0	0.0%
Housing type	2	0.5%
Moved since child was born	0	0.0%
Number of rooms	0	0.0%
Proximity to traffic	3	0.7%
Wall material	0	0.0%
Floor material	0	0.0%
Painted interior walls	10	2.3%
Stove in the house	0	0.0%
Presence of electricity	0	0.0%
Prevention of Malaria Tools		
Bednet use previous night	0	0.0%
Insecticide use	1	0.2%
Coil use in home	0	0.0%
Spray use	0	0.0%
Use of traditional medicine	2	0.5%
Temporal Characteristics		
Precipitation season	0	0.0%
Year surveyed	0	0.0%

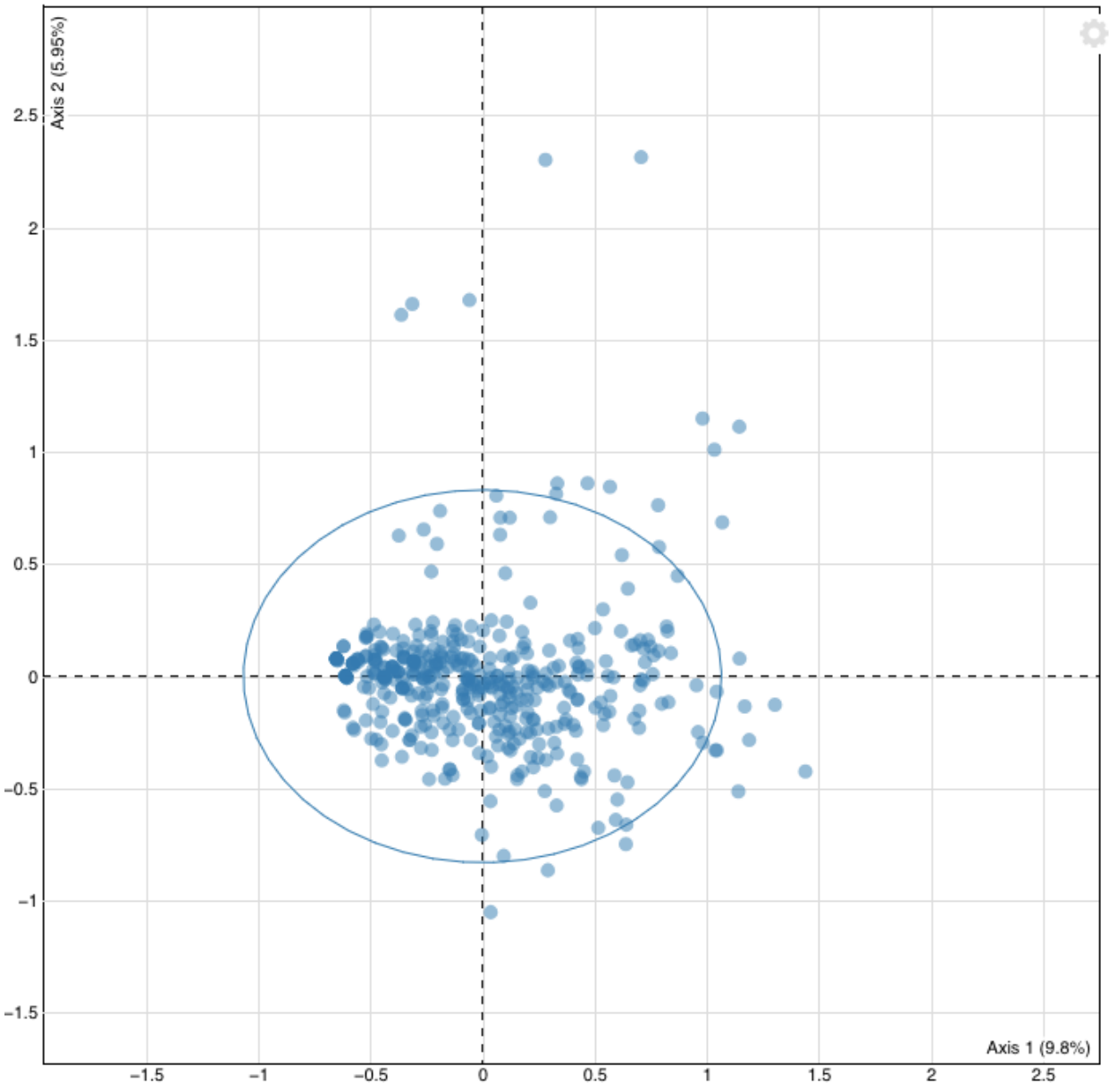
Appendix 7

Dictionary of variable names used in R-studio scripts. Further appendix tables and figures will use these names instead of full descriptive variable names as seen previously.

Descriptive Variable Name	R-Studio Equivalent	Levels
Sociodemographic Characteristics		
Offspring sex	gender	Female, Male
Maternal age at survey	age	Less than 22 years old
		22 - 25 years old
		26 - 30 years old
		31 years and older
Maternal iteracy	literacy	Yes, No
Maternal education level	edmother	High, Low
SES status	SES	Quartiles
Family Structure Characteristics		
Martial status	marriage	Single
		Monogomous
		Polygamous
Household size	size	Less than 5 people
		5 - 7 people
		8 or more people
Number of siblings	siblings	1 or 2
		3 to 5
		8 or more
Paternal cohabitation	lif	Yes, No
Maternal employment	momworks	Yes, No
Paternal employment	dadworks	Yes, No
Dwelling Characteristics		
Village of residency	village	Sekou
		Attogon
Housing type	housetype	Individual
		Communal
Moved since child was born	moved	Yes, No
Number of rooms	rooms	1 or 2
		3 to 5
		6 or more
Proximity to traffic	traffic	Yes, No
Wall material	wall	Brick, Other
Floor material	floor	Cement, Other
Painted interior walls	paint	Yes, No
Stove in the house	stove	Yes, No
Presence of electricity	electic	Yes, No
Insecticide Specific Characteristics		
Bednet use previous night	itnp	Yes, No
Insecticide use	insect	Yes, No
Coil use in the home	coil	Yes, No
Spray use	spray	Yes, No
Frequency of insecticide use	freq	Daily - Annually
Use of traditional medicine	meds	Yes, No
Frequency of medicine use	fremed	Daily - Annually
Temporal Characteristics		
Year surveyed	year	Yes, No
Precipitation season	season	Wet, Dry

Appendix 8

MCA individual plot. Representative cloud of all individuals included in MCA analysis compared to dimensions one and two. More similar individuals are grouped more closely to each other; discriminant individuals are plotted further from each other. Plot indicates that all people within the study are similar enough to each other to consider as one population without need for clustering.



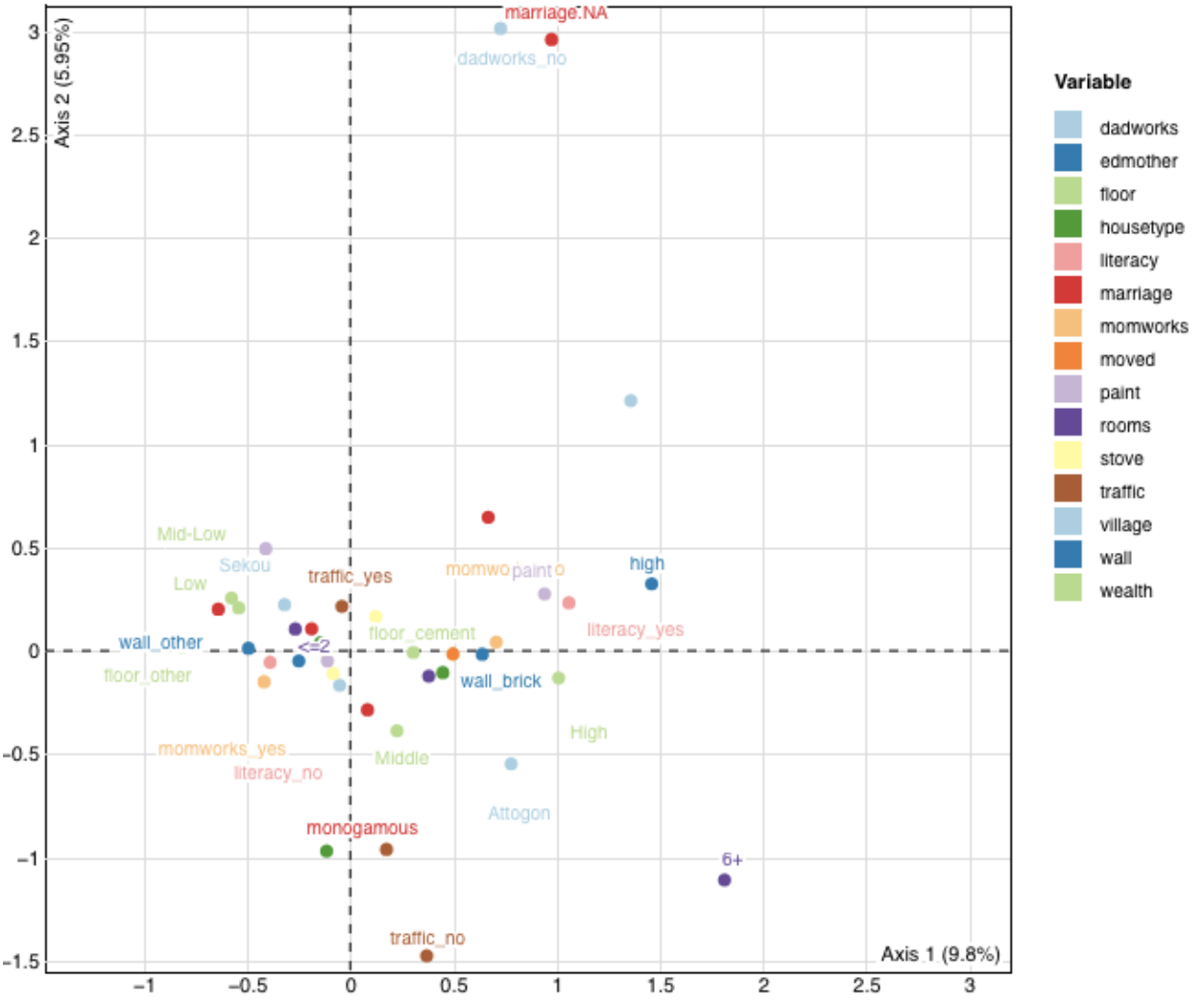
Appendix 9

MCA Variable data results. Ordered by highest contribution to dimension 1. Positive coordinates indicate association with higher SES status, negative coordinates indicate the opposite. Information used to create new SES indicator variable for further use in multivariate analysis. Variables with contributions less than 1.0 were not considered to be significant contributors to SES status.

Variable	Level	Coord	Contrib	Cos2	Count
edmother	high	1.461	10.78	0.358	62
literacy	literacy_yes	1.060	10.35	0.398	113
wealth	High	1.010	8.73	0.328	105
floor	floor_other	-0.815	6.38	0.249	118
momworks	momworks_no	0.708	6.33	0.280	155
wall	wall_brick	0.640	6.28	0.316	188
village	Attogon	0.780	6.20	0.248	125
wall	wall_other	-0.493	4.84	0.316	244
wealth	Low	-0.575	4.09	0.179	152
literacy	literacy_no	-0.388	3.85	0.404	315
momworks	momworks_yes	-0.417	3.83	0.290	270
paint	paint	0.942	3.47	0.111	48
rooms	6+	1.814	2.95	0.086	11
village	Sekou	-0.318	2.52	0.248	307
floor	floor_cement	0.306	2.40	0.249	314
edmother	low	-0.249	1.86	0.362	369
wealth	Mid-Low	-0.540	1.80	0.062	76
moved	moved	0.498	1.76	0.063	87
housetype	individual	0.449	1.71	0.064	104
rooms	3-5	0.381	1.68	0.071	142
rooms	<=2	-0.266	1.60	0.129	279

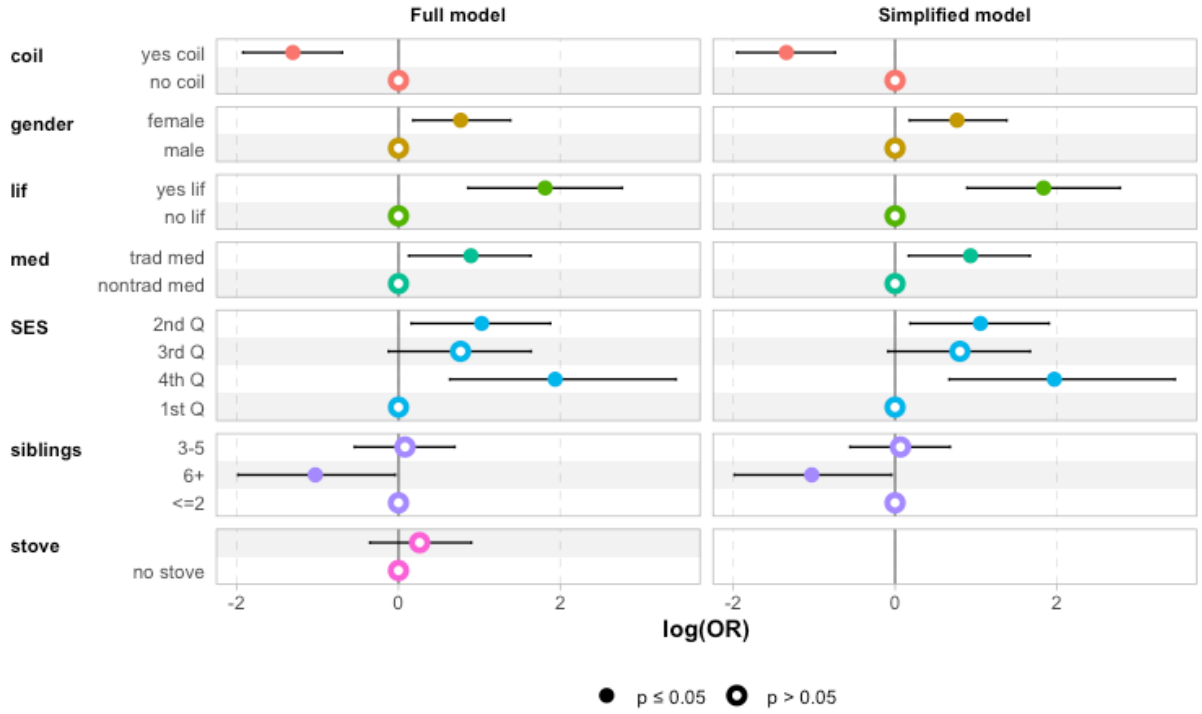
Appendix 10

Variable plot of MCA results. NA categories with less than contribution = 1.0 in dimension one did not influence results of SES variable creation based on this dimension. Point labels only exist when contribution is greater than or equal to 2.0 in either dimension 1 or dimension 2.



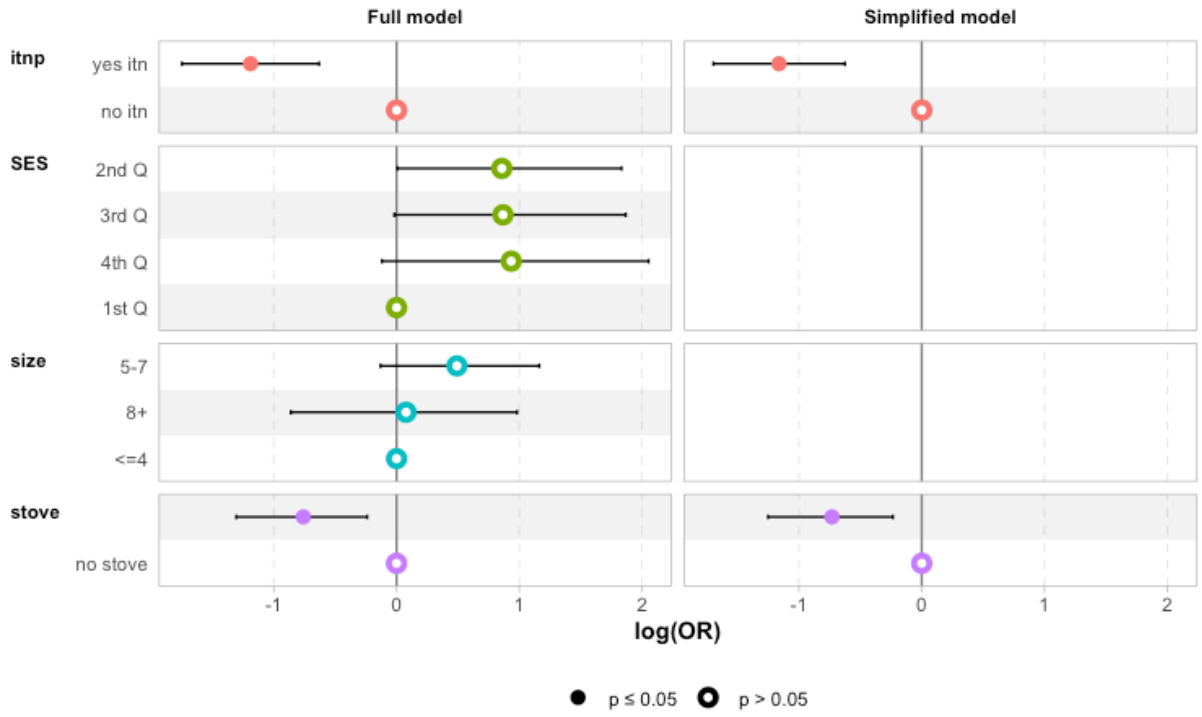
Appendix 11

Odds ratio plot of results from logistic regression models comparing bednet use the night before the EXPLORE survey and exposures of interest. Non-significant findings were removed between the full and simplified models. Interpretation: Use of bednet the night prior to survey was more likely when (1) offspring gender was female, (2) the father lived in the same home as the child, (3) with socioeconomic status in the 2nd or 4th quartile, (4) with simultaneous use of traditional medicines were used, and (5) when a stove was present in the household. Bednet use the night prior to survey was less likely when (1) coils were used in the home, and (2) the child had more than 6 siblings.



Appendix 12

Odds ratio plot of results from logistic regression models comparing insecticide treated coil use in the home and exposures of interest. Non-significant findings were removed between the full and simplified models. Interpretation: The likelihood of coil use was lower when (1) bednet was used the night prior to survey, and (2) when a stove was present in the home.



Appendix 13

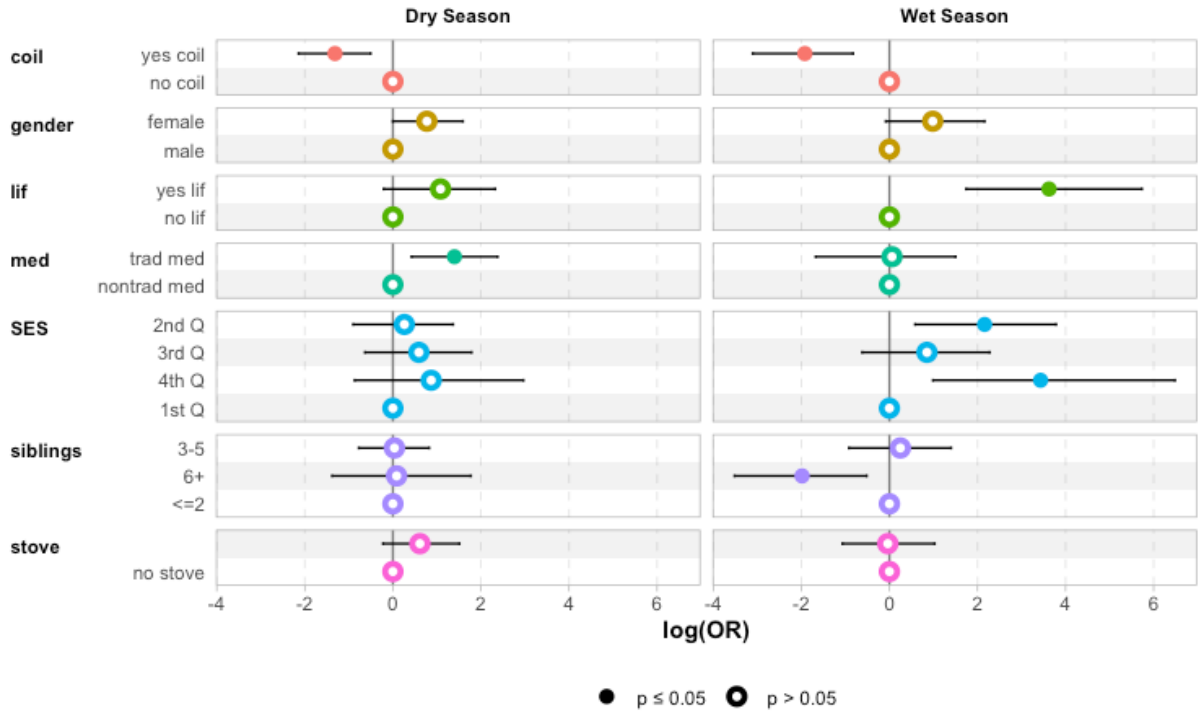
Description of population when stratified by season.

Table Distribution of sociodemographic and familial characteristics according to season in which survey took place (Allada, Benin); (N= 432)

	Dry Season n = 204 (47.2 %)		Wet Season n = 228 (52.8 %)	
	n	**%**	*n*	%
Sociodemographic Characteristics				
Offspring sex				
Male	110	(53.9%)	119	(52.2%)
Female	94	(46.1%)	109	(47.8%)
Maternal age at survey				
Less than 22 years	9	(04.4%)	1	(40.0%)
22 - 25 years old	21	(10.3%)	32	(14.1%)
26 - 30 years old	51	(25.0%)	51	(22.5%)
31 years or older	123	(60.3%)	143	(63.0%)
SES Status				
1st quartile	24	(12.2%)	23	(10.3%)
2nd quatile	93	(47.2%)	97	(43.5%)
3rd quartile	61	(31.0%)	71	(31.8%)
4th quartile	19	(09.6%)	32	(14.3%)
Family Structure Characteristics				
Martial status				
Single	4	(02.0%)	14	(06.3%)
Monogamous marriage	107	(53.5%)	102	(45.7%)
Polygamous marriage	86	(43.0%)	106	(47.5%)
Number of family members				
Less than 5 people	49	(24.0%)	48	(21.1%)
5 - 7 people	126	(61.8%)	152	(66.7%)
8 or more people	29	(14.2%)	28	(12.3%)
Number of siblings				
1 or 2	76	(38.6%)	87	(40.1%)
3 to 5	106	(53.8%)	111	(51.2%)
6 or more	15	(07.6%)	19	(08.8%)
Paternal cohabitation				
Yes	187	(92.1%)	206	(92.0%)
No	16	(07.9%)	18	(08.0%)
Dwelling Characteristics				
Proximal to traffic				
Yes	161	(79.7%)	193	(85.0%)
No	41	(20.3%)	34	(15.0%)
Interior stove				
Yes	76	(37.3%)	96	(42.1%)
No	128	(62.7%)	132	(57.9%)
Electricity				
Yes	61	(29.9%)	80	(35.1%)
No	143	(70.1%)	148	(64.9%)
Prevention of Malaria Tools				
Bednet use previous night				
Yes	155	(76.0%)	202	(88.6%)
No	49	(24.0%)	26	(11.4%)
Coil use in home				
Yes	47	(23.0%)	53	(23.2%)
No	157	(77.0%)	175	(76.8%)
Use of traditional medicine				
Yes	175	(86.6%)	202	(88.6%)
No	27	(13.4%)	26	(11.4%)

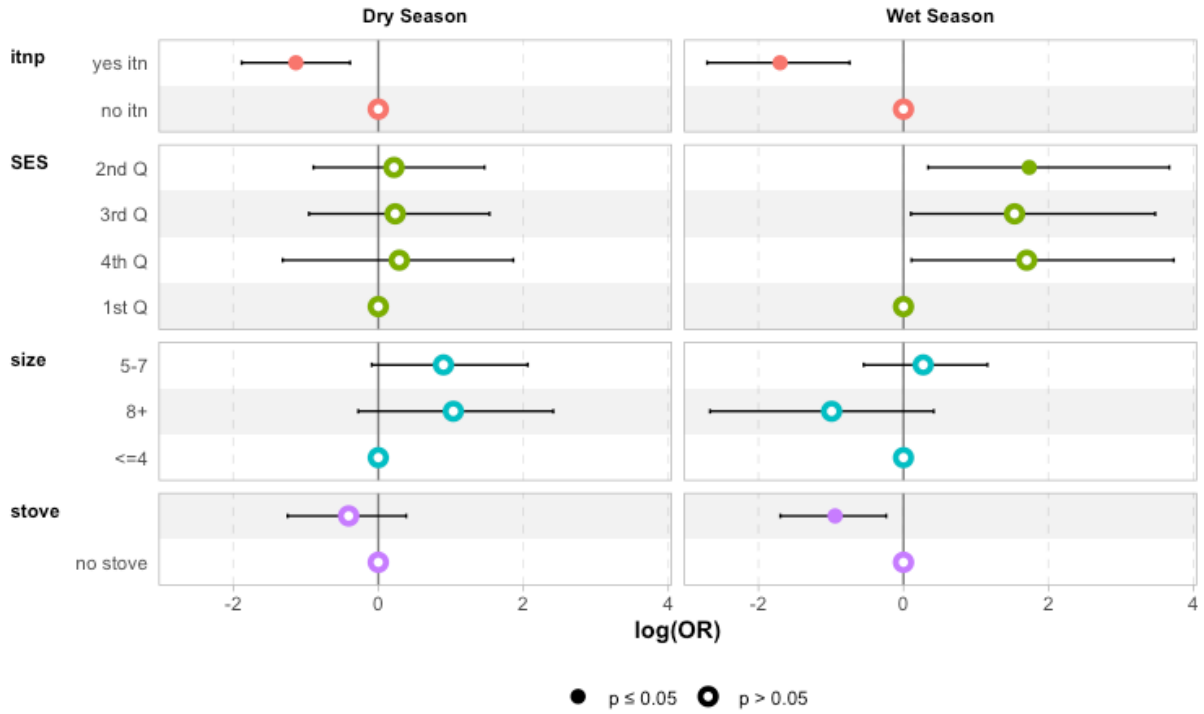
Appendix 14

Odds ratio plots of conditional logistic regression describing exposures of interest with bednet use the night prior to survey by precipitation season. Interpretation: bednet use was more likely in the wet season if the family was in the 2nd or 4th socioeconomic quartile and if the father lived in the home. Bednet use was less likely in the wet season with 6 or more siblings and when coils were used in the home. These findings are consistent with unstratified results.



Appendix 15

Odds ratio plots of conditional logistic regression describing exposures of interest with coil use in the interior of the home by precipitation season. Interpretation: Coil use was more likely in the wet season if the family was in the 2nd socioeconomic quartile. Interior stove presence indicated lower likelihood of coil use. Coil use was less likely in the wet and dry season when bednet was used the night prior to survey. These findings are consistent with multivariate results.



Résumé

Caractéristiques sociodémographiques et familiales influençant sur l'utilisation et la non-utilisation de moyens de prévention du paludisme (Benin, SSA)

Introduction : Le paludisme continue de sévir avec une mortalité plus élevée en Afrique subsaharienne. Des moustiquaires imprégnées d'insecticide à longue durée d'action (MILD), des pulvérisations intradomiciliaires, des spirales et des pulvérisations à base de pyréthrinoïdes sont utilisées dans la prévention du paludisme. Les déterminants des l'utilisation de moustiquaires et des spirales sont mal connus. Les objectifs de cette étude étaient de déterminer les caractéristiques socioculturelles et environnementales influençant l'utilisation des moustiquaires et des spirales pour prévenir le paludisme () dans des familles avec un enfant de 6 ans dans le sud du Bénin semi-rural.

Méthodes : Dans une cohorte mère-enfant dans le district d'Allada, au Bénin, la collecte de données était basée sur les réponses à un questionnaire détaillé de 432 mères quand l'enfant avait 6 ans. Les informations recherchées comprenaient : l'utilisation des moustiquaires, des spirales, de l'utilisation de sprays dans la maison, la saison (humide/sèche), le nombre d'enfants dans le ménage, le type de logement, le richesse de la famille ainsi que l'éducation de la mère. Une Analyse des Correspondances Multiples (ACM) a permis de synthétiser le niveau de vie de la famille sous forme d'un indicateur global de richesse. Une régression logistique binaire a été effectuée pour tester l'association entre l'utilisation de moyens de prévention du paludisme (moustiquaire et spirales) et le niveau de vie, les facteurs sociodémographiques et socio-culturelles, la structure familiale, et les conditions environnementales.

Résultats : 82,6 % des personnes interrogées ont déclaré que leur enfant avait utilisé une moustiquaire la nuit précédant l'enquête, 23.1% utilisé des spirales et 6.9% des sprays, la fréquence d'utilisation la plus courante (26,9 %) étant plusieurs fois par semaine. Les médicaments traditionnels étaient utilisés par 87,7% de la population ; la fréquence d'utilisation la plus élevée était annuelle (49,5%). Une plus grande utilisation de la moustiquaire a été trouvée avec les filles (OR = 2,15, [95% CI, 1,19 - 3,98]), la cohabitation paternelle avec l'enfant (OR = 6,28, [95% CI, 2,43 - 16,17]) et l'utilisation simultanée de médicaments traditionnels [OR = 2. 54, [IC 95 %, 1,18 - 5,31]) ; diminution de l'utilisation des moustiquaires lorsqu'il y avait 6 frères et sœurs ou plus (OR = 0,36, [IC 95 %, 0,14 - 0,96]) et lorsque des spirales étaient utilisés à la maison (OR = 0,26, [IC 95 %, 0,14 - 0,48]). L'utilisation des spirales était associée à une utilisation plus faible de moustiquaire la nuit précédent l'enquête l'enquête (OR = 0,31, [IC 95%, 0,18 - 0,54]), et quand il y avait un poêle à l'intérieur du logement (OR = 0,48, [IC 95%, 0,29 - 0,79]).

Discussion : Les moustiquaires imprégnées sont largement utilisées dans les familles avec des enfants de 6 ans dans le sud du Bénin semi-rural, ainsi que les spirales.