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Factors Associated with Mosquito Net Ownership and Use in Haiti, December 2014-February 2015

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Bachelor of Science
The Ohio State University
2016

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An abstract of
A thesis submitted to the Faculty of the
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Abstract

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By Meghan Franczek

Background: As the majority of Haiti's population is at-risk of malaria infection, there is a need to better understand current malaria control strategies in Haiti. Previous studies have highlighted various factors associated with household ownership and utilization of mosquito nets; however, nearly all of these studies were conducted in Africa and many factors appear to be context-specific. Recognizing Haiti's strategic plan to eliminate malaria by 2020, the purpose of this study is to investigate factors associated with household ownership and use of mosquito nets.

Methods: A household-based survey was conducted in all ten departments in Haiti between 2014 and 2015 to assess ownership and use of mosquito nets. In total, 1,755 households were enrolled, and responses were analyzed. Univariate logistic models were developed to investigate household, respondent, and net characteristics associated with mosquito net ownership and use. Net ownership was self-reported. Net use was defined as a household member reporting that someone had slept under the net the previous night. The statistically significant factors identified in the univariate models were evaluated in a final multivariate logistic regression model.

Results: Of 1,755 households, 688 (39%) reported ownership of at least one mosquito net, of which, 477 (69%) reported net use. In adjusted analysis of potential explanatory factors for net ownership, a household member with fever in the previous two weeks, a child under five in the household, and larger household size were associated with net ownership. In adjusted analysis of potential explanatory factors for net use, younger age of the respondent, rural household location, net observation by study staff, if the net was hung to sleep under, and household purchase of the net versus provided for free were associated with net use.

Conclusion: Mosquito net ownership in Haiti is lacking, and not all mosquito net-owning households report using their net in the previous night. Greater health education on the purpose and proper use of mosquito nets is needed in conjunction with improved distribution mechanisms. Further research into additional factors associated with net ownership and use in Haiti will allow for more effective distribution campaigns and more targeted malaria education initiatives.

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CHAPTER I: BACKGROUND/LITERATURE REVIEW

Overview of Mosquito Nets: Ownership, Funding, and Purpose

Mosquito nets are the largest cost in the global malaria control budget [1]. Insecticide-treated nets (ITNs) are the most commonly distributed type of mosquito net. ITNs require annual or biannual re-treatment, one factor hindering their long-term use at the household level. More recently developed, long-lasting insecticide-treated nets (LLINs) alternatively offer an average lifespan of three years or more, depending on how often the net is washed and how well it is cared for [1]. Mosquito nets may also be untreated, although untreated nets do not have nearly the same level of protection against malaria [1]. In conjunction with interventions deployed by national malaria control programs and other partners, household ownership of at least one ITN in malaria endemic settings has increased significantly over the past several years; however, the proportion of households with a sufficient number of nets for the number of members of a household, often termed net density, has not increased at the same rate [2]. Most studies investigating net ownership have compared trends before and after the adoption of various national policies and activities, such as mass distribution, voucher subsidies, and more. All showed understandable increases in household ownership [3-6].

Numerous studies have investigated factors, including individual, household, community, net, and environmental factors, believed to be associated with mosquito net use. Individual factors suggested to be positively associated with net use include age, specifically the youngest or oldest age classifications [7-10], being female [7], higher education levels [11-14], greater malaria knowledge [7, 11, 12, 15-18], greater exposure to anti-malaria messaging [12, 17], perceptions of malaria risk [15], perceived benefits of using the nets [15, 19, 20], and greater knowledge of appropriate net use, care, and hanging practices [15]. Net characteristics found to have been

associated with mosquito net use include decreased net age [7, 11, 15, 21, 22], low degree of net damage [7, 11, 21], net type [12, 21], net shape, color, and low cost [11, 19], and if the net is hung in the household [22]. At the household level, factors previously associated with net use include decreased net density [7, 9, 10, 21], greater wealth [21], decreased household size [12], sleeping arrangements [7, 15, 22], children under five in the household [9, 10, 12], household structure [13], and greater use of indoor residual spraying [12, 15, 21]. Community factors found to have been associated with net use include social norms [23], mechanisms of net distribution, and limited distance to net suppliers [7]. Finally, environmental factors that have been suggested to influence net use include decreasing altitude [7, 12, 21], decreasing temperature [8], and perceived mosquito density [7]. All of these detailed factors, in addition to others, undoubtedly interact with each other in complex ways to determine attitudes towards net use and to influence actual household net use [7].

In 2016 alone, $2.7 billion was invested in malaria control and prevention globally, but this accounts for only 41% of what is estimated to be required to achieve the malaria-related targets of the World Health Organization's (WHO) Sustainable Development Goals (SDGs) and other malaria elimination strategy goals [2]. Further, funding levels per capita have plateaued or decreased across most WHO regions in comparison to the peak years of malaria funding that occurred in 2012 and 2013 [2]. Decreasing funding levels in some areas have raised concerns that household ownership of mosquito nets will decline simultaneously and consequently, rates of malaria infections will increase.

For years, mosquito nets have been one of the hallmarks of malaria prevention and control in low-resource malaria-endemic countries. From the perspective of donors, mosquito nets are a cheap and easy to implement intervention. Moreover, mosquito nets have proven to be effective in preventing malaria morbidity when used correctly and consistently, as they take

advantage of the endophagic, or indoor feeding, and indoor resting behavior of many of the Anopheline mosquitos [24]. As such, mosquito nets are an example of a vector control strategy. Specifically, the nets reduce exposure to infectious mosquito bites, leading to reduced malaria parasite infection prevalence. If a net is treated, the insecticide kills mosquitos seeking a blood meal, thereby reducing indoor vector densities. Additionally, if the person sleeping under a net is already infected, the net can reduce transmission by preventing gametocyte uptake by the mosquito [25].

Since malaria accounts for high morbidity and mortality among pregnant women and children under five years of age, these groups are considered the most high-risk groups for malaria infection. Malaria during pregnancy is linked to gestational anemia that can result in low birth weights, abortion, and miscarriage [26]. Children under five have not yet acquired clinical immunity to malaria, which usually occurs during multiple exposures throughout childhood, meaning they often present with severe malaria. In cases of severe malaria, rapid progression to death is common [27]. For these reasons, many malaria prevention and control programs and research initiatives have focused on pregnant women and children under five. For instance, the use of ITNs among pregnant women has been associated with a lower prevalence of malaria infection, fewer premature births, and significant reductions in all-cause maternal anemia [15]. Additionally, it has been suggested that achieving full coverage of ITNs could reduce child mortality by an average of 17% compared to no nets. More simply, it is estimated at least five lives would be saved per year for every 1,000 children under five years of age using an ITN [28].

Malaria in Haiti

Haiti and the Dominican Republic, constituting the island of Hispaniola, are the last locations in the Caribbean where malaria persists. With 17,094 reported cases in 2014 by the Programme National de Contrôle de la Malaria (PNCM), malaria is a serious public health

concern in Haiti. An estimated 80% of the population is at-risk of acquiring infection. Moreover, in patients presenting to clinics with undifferentiated febrile illness, malaria positivity ranged from 3% to 47% in different areas of the country. This wide range not only implies that transmission rates differ geographically, but also possibly elucidates some of the inconsistencies and challenges in malaria diagnostics across Haiti. Malaria infections in Haiti are predominantly caused by *Plasmodium falciparum*. *Anopheles albimanus* is the most common vector, although it is important to note that other malaria vectors have been found in Haiti [29]. While there is geographic heterogeneity, both within a country and regionally, the peak feeding time for these mosquitos occurs closer to sunset and generally earlier in the night than other *Anopheles* species [24]. Haiti's terrain also facilitates opportunities for sustained transmission of malaria. The terrain is mainly rough and mountainous with numerous springs and seepage areas throughout the low-lying areas. Many of these low-lying areas are also farmed and contain irrigation canals. Together, this creates conditions that enable mosquito proliferation. As *Anopheles* prefer to breed in transient pools of water, these conditions also lend to an increase in cases during the rainy season [30].

Malaria control, prevention, and elimination efforts in Haiti have been challenged by the repercussions of the 2010 earthquake. After the earthquake, weakened infrastructure and more densely populated living settlements provided greater reservoirs for transmission of infectious pathogens, such as malaria. Even now, frequent air travel between Haiti and other countries by humanitarian actors poses the risk for rapid dissemination of novel or drug-resistant malaria [29]. It is difficult to approximate the extent to which rates of malaria transmission were altered by the earthquake. Prior to 2010, there was limited published data on malaria in Haiti; however, the data that was available did indicate very low transmission. For example, a health facility survey conducted in 1995 estimated a slide-positivity rate of 4% among patients with suspected malaria [31]. Furthermore, a population-based study completed in the rural Artibonite Valley in 2006

found a malaria prevalence of about 3.1% using PCR [32]. Conversely, post-earthquake studies from the areas near the epicenter of the earthquake found high percentages of malaria infection in febrile patients attending clinics. These percentages ranged from as low as 20.3% to as high as 46.9% [33, 34]. Although comparing the data from before and after the earthquake suggests an increase in malaria in Haiti, these observed differences could be due to increased or improved surveillance after the earthquake. Alternatively, they may be due to increased exposure to mosquito vectors after many Haitians were displaced and left homeless.

History of Mosquito Net Distribution Campaigns in Haiti

Haiti's national malaria program first received external funding during the beginnings of The Global Fund. The first Global Fund grant for malaria in Haiti was approximately $12.8 million and was implemented just prior to the earthquake between 2004 and 2009 [35]. The grant focused mainly on service delivery, departmental infrastructure for case management and microscopy testing, routine reporting, and the sale and distribution of LLINs. In 2009, Haiti and the Dominican Republic developed a bi-national plan to eliminate malaria from Hispaniola by 2020. While this collaboration strengthened future Global Fund applications, progress in long-term advances and investments were ultimately halted by the earthquake. Notably, a few years after the earthquake in 2012, Haiti initiated a national campaign for mass distribution of permethrin-treated nets. During this campaign, an estimated 3 million nets were distributed across all geographic departments in Haiti. Furthermore, from 2011 to 2015, mass distribution of LLINs was a primary intervention funded in the eighth round of funding from The Global Fund [35].

Current Malaria Interventions in Haiti

Currently, malaria control interventions in Haiti mainly include vector control measures, most often the distribution of ITNs with the support of The Global Fund, local non-governmental organization (NGOs), and the U.S. Centers for Disease Control and Prevention (CDC).

Additionally, there is also cooperation to improve surveillance systems and case detection and management, especially with the recent adoption of Rapid Diagnostic Tests (RDTs). Nevertheless, the most common weaknesses cited in Haiti's ability to control malaria include lack of training for health workers, absence of active case detection, and poor communication, including communication of suspected cases versus confirmed cases, feedback from central to local settings, and the absence of dissemination of information to both the community and health workers [29]. Until these are addressed, and equitable and efficacious distribution of mosquito nets occurs, malaria will continue to threaten the health of Haiti's people.

CHAPTER II: MANUSCRIPT

Abstract

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Introduction

Malaria is a significant public health concern in many low-resource countries, particularly among pregnant women and children under five years [26, 27]. To combat malaria in these settings, mass distribution campaigns have led to marked increases in household ownership of mosquito nets. Oftentimes, these campaigns result in an initial peak in ownership, with ownership then declining with time [7].

Haiti and the Dominican Republic are the last malaria endemic nations in the Caribbean. Although 17,094 cases of malaria were reported in Haiti in 2014, an estimated 220,000 cases may have been present [29]. Given the morbidity and economic impact of malaria, the fact that the majority of Haiti's population is at-risk of acquiring infection is alarming. Recently, a bi-national agreement between the Dominican Republic and Haiti was adopted with the goal of eliminating malaria from Hispaniola by 2020 [29]. In the Dominican Republic, the reported number of malaria cases reached a fifteen-year low of 952 in 2012; however, one-third of these cases were thought to be directly imported from Haiti [29]. Therefore, sufficient malaria control in Haiti will be key to achieving and sustaining elimination of malaria by 2020.

Household ownership of a mosquito net is not synonymous with proper or sustained use of the net [11, 15, 26, 28, 36]. Although challenging to understand, reasons cited for lack of use included discomfort of using the net, perceived low mosquito density, and concerns regarding the potential dangers of the insecticides treatment [11, 15, 26, 28, 36]. Other times, nets were found to have been re-purposed. For instance, nets were used to fish or raise chickens [26] or were being traded as an asset for cash [11]. Together, these examples imply low community education on the purpose of nets, resulting in low perceived importance of the nets as a household malaria prevention strategy.

Almost all studies investigating factors associated with mosquito net ownership and use have been conducted in Africa, highlighting the need for studies of a similar nature in Haiti. Further, studies assessing net use were typically focused on pregnant women and children under five, rather than an entire population more broadly. Recognizing that the last mass distribution of insecticide-treated nets (ITNs) occurred in 2012 and distribution of long-lasting insecticide-treated nets (LLINs) has been the priority from 2011 to 2015 [29], the purpose of this study is to examine household, household respondent, and net characteristics that are significantly associated with mosquito net ownership and use in Haiti.

Methods

Survey Methodology

The data used for this analysis are the result of household surveys administered in the *Tracking Results Continuously (*TRaC*)* Study that was jointly conducted by the CDC and Population Services International (PSI) in Haiti from December 2014 to February 2015. All ten departments in Haiti were sampled. Using a sampling technique proportional to the population density within each department, the departments were first divided into enumeration sections (*site d'enumeration*, SDE). Within each SDE, cluster-based random household sampling by the survey team attempted to visit and enroll all members from 20 households. All residents of a household were eligible to participate in the study except for children under twelve months of age, individuals unable to provide informed consent, individuals under the influence of alcohol, and individuals with a mental illness. Through their survey responses, consenting heads of households provided information on household residents, household assets, and possession and use of mosquito nets. All clinical information obtained was self-reported data. No pregnancy tests were done and there was no evaluation of written medical histories. Malaria rapid diagnostic tests (RDTs) were offered for malaria, upon additional consent from all household members fifteen years of age or older and from caregivers of all children under fifteen years of age. Persons

positive by RDT were treated with appropriate anti-malarial drugs as previously determined by the national malaria control program.

Ethics

Upon review by Emory University's Institutional Review Board (IRB), an IRB exemption (IRB00102028) was approved. The original TRaC study secured written approval from the National Ethics Committee of the Haitian Ministry of Health and CDC Human Subjects Office. All standard ethical research policies and procedures were adhered to during data collection.

Outcomes of Interest

In this analysis, the first outcome investigated was self-reported household mosquito net ownership. The second outcome of interest was self-reported mosquito net use among all households indicating ownership of at least one net. In this study, mosquito net use was defined as the head-of-household respondent reporting that any household member had slept under the mosquito net the night prior to being surveyed.

Covariates of Interest

The factors considered to be potentially associated with mosquito net ownership and use included the dichotomous variables of sex of respondent, pregnancy in the household, a RDT positive result in the household, a child under five years in the household, a household member reporting fever in the previous two weeks to being surveyed, and finally, household location, specifically urban or rural. Categorical variables were created for household respondent age and the number of members of a household, or household size. The factors considered to be potentially associated with mosquito net use included all of the variables described above plus additional net characteristic variables. Specifically, these included the dichotomous variables of

net observation by the survey enumerator, if the net was pretreated with insecticide prior to receipt, if the net was treated with an insecticide since receipt, whether the net was hung to sleep under, and household purchase of the net. Additional categorical variables were created for age of the mosquito net, number of nets in a household, and net condition. A dummy variable coding was used for net source, or where the household obtained the net. For all of the explanatory factors considered in this analysis, prior to the epidemiological modeling, all responses inappropriately entered into the survey database were re-coded as missing responses and were excluded from further analysis.

Analysis

All analyses were performed using SAS (Version 9.4). Two datasets were utilized to create the final dataset for analysis. One dataset contained individual-level data listed by household member. The second dataset contained household-level data. Both sources of data were provided by a single household respondent who was the identified head of household. Individual-level data were linked to the correct household-level response via a unique household identification number that was assigned by the survey enumerators during data collection. In the final dataset, individual responses regarding pregnancy, a household member under five years of age, and a positive RDT result were summarized to create relevant household-level dichotomous variables.

Descriptive statistics were conducted on household responses collected between 2014 and 2015 across the ten departments sampled in Haiti. Missing responses were excluded from analyses. A Wald Chi-Square Test (or Fisher's Exact Test when 20% of expected cell counts were less than 5) was conducted to assess potential statistical differences between categorical

covariates, stratified by the outcomes of interest. All analyses were also stratified by rural or urban household location.

Logistic regression models identified factors associated with mosquito net ownership and use. As part of the predictive modeling strategy, the explanatory factors were tested independently in univariate logistic models to determine their significance in relation to the outcomes. Crude prevalence odds ratios (cOR), 95% confidence intervals, and p-values were calculated. Factors with a p-value <0.05 were retained for inclusion in the multivariate logistic regression models after assessing them for collinearity. Collinearity was diagnosed if a condition index (CI) was greater than 30 and if two or more variance decomposition proportions (VDPs) were greater than 0.50. Adjusted prevalence odds ratios (aOR), 95% confidence intervals, and p-values were calculated.

Results

Descriptive Analyses

A total of 1,755 household responses were enrolled in the TRaC survey. Table 1 provides descriptive statistics. Of the total analyzed households, 585 (33%) were rural and 1,170 (67%) were urban. In total, 688 households reported owning at least one mosquito net (39%). Among households that owned a net, 477 (69%) reported that a household member had slept under the net the previous night. In assessing overall statistical differences between rural and urban households, several factors were statistically significant at an alpha level of 0.05: sex of household respondent (p-value <0.0001), with rural households having a larger proportion of female respondents; age of household respondent (p-value <0.0001), with urban households having a higher proportion of elderly respondents older than 60 years of age; if someone in the household had slept under the net the previous night (p-value=0.0098), with a larger proportion of rural households reporting a household member sleeping under the net; whether the net was paid

for the by the household (p-value <0.0001), with a higher proportion of rural households having paid for their net; net condition (p-value=0.0459), with a slightly higher proportion of good nets with no holes in urban households and a slightly higher proportion of rural households having reasonable nets with a few holes; and net source (p-value <0.0001), with a larger proportion of urban households obtaining their nets from a mass campaign and a larger proportion of rural households securing their net from a store or retailer.

Rural/Urban Stratification

Initially, the analysis was conducted using an urban versus rural household stratification. Since household location did not appear to modify the effect of the explanatory factors on either of the outcomes (Appendix A), household location was alternatively considered as a potential explanatory factor for the outcomes in this analysis

Analysis of Potential Explanatory Factors for Mosquito Net Ownership

The univariate analyses resulted in several significant associations between household respondent characteristics and household characteristics and household ownership of a mosquito net (Table 2). Households with a child under five years of age had nearly 1.5 times higher odds of owning a mosquito net than households without a child under five years of age (crude odds ratio, cOR=1.42, 95% CI: 1.11-1.82, p-value=0.0054). Notably, households where a member reported a fever in the previous two weeks had almost two times higher odds of owning a mosquito net in comparison to households where no fever was reported (cOR=1.85, 95% CI: 1.37-2.50, p-value <0.0001). Finally, the size of the household was significantly associated with mosquito net ownership (p-value=0.0023) with a positive trend towards greater household size and greater odds of owning a net. A household with 5 to 9 people had an odds of owning a mosquito net that was nearly double (cOR=1.82, 95% CI: 1.24-2.68) and households with 10 or more people had an

odds of owning a mosquito net almost 2.5 times (cOR=2.46, 95% CI: 1.38-4.40) that of the referent of 1 to 4 people.

Among the abovementioned significant factors, collinearity was not diagnosed. All of the significant ($p<0.05$) factors from Table 2 were included in the final multivariate logistic regression model (Table 3). Households with a member reporting fever in the previous two weeks had nearly twice the odds of ownership (adjusted odds ratio, aOR=1.82, 95% CI: 1.34-2.47, p-value=0.0001) in comparison to households without reports of fever. The size of a household was further significantly associated with ownership of a mosquito net (p-value=0.0110). Using 1 to 4 people as the referent, households with 5 to 9 people (aOR=1.69, 95% CI: 1.13-2.54) and households with 10 or more people (aOR=2.20, 95% CI: 1.20-4.04) had greater odds of owning a mosquito net. Households with a child under five years of age had almost 1.5 times higher odds of owning a net (aOR=1.29, 95% CI: 1.00-1.66) versus households without a child under five years of age, however this result was on the border of being statistically significant at an alpha level of 0.05 (p-value=0.0528).

Analysis of Potential Explanatory Factors for Mosquito Net Use

Among households reporting ownership of at least one mosquito net, the results of the univariate logistic regression analyses of the factors associated with net ownership and net use are conveyed in Table 4. One factor that was significantly associated with net use was younger age of the household respondent (p-value=0.0016). With 15 to 30 years as the referent, the odds of net use decreased when the respondent was 31 to 45 years of age (cOR=0.54, 95% CI: 0.37-0.79). The odds decreased further when the respondent was 46 to 60 years of age (cOR=0.40, 95% CI: 0.37-0.79) and when the respondent was greater than 60 years of age (cOR=0.30, 95% CI: 0.14-0.63). Additionally, urban mosquito net owning households had a lower odds of reporting net use the previous night (cOR=0.46, 95% CI: 0.22-0.97, p-value=0.0408) compared to rural

households. Observation of the net by the survey enumerator was also associated with reported net use. Notably, observation by the enumerator simply refers to the observation of the net in the household. The net might not necessarily be hung over the sleeping area. Households where a net was observed had an odds of reported net use approximately 1.8 times that of households where the net was not observed (cOR=1.81, 95% CI: 1.29-2.53). Moreover, if the net was hung to sleep under versus not hung, the odds of net use the previous night were extremely high (cOR=63.47, 95% CI: 22.79-176.80, p-value <0.0001). Households that paid for their net had over twice the odds of reporting that a household member had slept under the net the previous night (cOR=2.20, 95% CI: 1.43-3.39, p-value=0.0003) in comparison to households that did not pay for their net.

Due to the low prevalence of RDT positivity in the survey, logistic regression models did not produce interpretable results for this factor, giving confidence intervals of 0 to infinity.

Among the abovementioned significant factors, collinearity was not identified. All of the significant ($p<0.05$) factors from Table 4 were tested in the final logistic regression multivariate model, the results of which are included in Table 5. Households where the net was readily observed in the household by the survey enumerator had over two times higher odds of net use the previous night (aOR=2.14, 95% CI: 1.34-3.41, p-value=0.0014) in comparison to households where the net was not observed. Having the net hung above a sleeping area, versus not hung, was associated with an extremely high odds of net use (aOR=48.64, 95% CI: 16.38-144.40, p-value=0.0014). Additionally, households that paid for their net had nearly 2.5 times higher odds of reporting someone sleeping under the net the previous night compared to households that did not pay for their net. Rural versus urban household location and age of the household respondent were non-significantly associated with the outcome of net use.

Discussion

This analysis highlighted that from a survey of 1,755 households in Haiti from December 2014 to February 2015, only 39% of households owned a mosquito net. The proportion of ownership was modestly higher in urban versus rural settings (41% versus 36%), suggesting there may have been logistical challenges affecting distribution mechanisms in rural areas. Distributing nets to remote markets is often hindered by impassable roads during the rainy season and lack of transportation for health workers [17]. The low percentage of net ownership seen in this study is surprising given the number international aid and humanitarian organizations operating in Haiti. An article in the lay press suggests that low net ownership could be due to lack of coordination among the various international and national organizations or could just be due to the overall state of poverty in Haiti [37]. Haitians may be selling or trading their nets for more basic resources like food and water, something that has been explored in the literature [11].

Of the 688 households in this study that reported owning a net, 69% of the households also reported that someone had slept under the net the previous night, adding to the evidence that ownership of a net is not necessarily associated with use. Universal coverage with ITNs is defined as use by greater than 80% of the individuals in populations at risk [38]. With the limitation that net ownership in this study could refer to either treated or untreated nets, the percentage of net use observed in this survey is far below this target. Previously identified barriers to net utilization include concerns about the perceived negative effects of insecticides, feelings of suffocation when using the net, lack of sufficient nets to accommodate the number of household members and sleeping areas, perceived lack of privacy due to net construction, and distrust of the delivery system used and associated agencies [29]. Although not further explored in this study, these factors may be contributing to the lack of net utilization seen in this study. Notably, a theoretical model estimates that ITN use by at least 35% to 65% of the total population is necessary to achieve the benefit of the community effect equal to that of personal protection [39]. While this

does depend on malaria transmission dynamics, the net usage rates in this study would imply some degree of community protection.

Considering the recent history of treated net distribution in Haiti, it is surprising that in the descriptive analyses, only 17% of households reported that their net was pretreated with an insecticide prior to receipt. Of note, most respondents did not know the treatment status of their net. During the mass distribution in 2012 in Haiti, it was noted that educational messages about ITN and LLIN use were communicated to net recipients and pictorial brochures on how to use the nets were also given [24]. If this education was equally prioritized at all of the distribution points, it could imply inadequate messaging or point to an issue of health literacy.

Interestingly, this study found that having a child under five years of age in the household was associated with greater net ownership. Yet, the same was not true of having a pregnant woman in the household, despite both being the most high-risk groups. There is the potential that health education disseminated to net recipients was more focused on the importance of nets for children under five, rather than for pregnant women. In Nigeria, limited uptake of malaria prevention measures, including mosquito nets, by pregnant women was described to be due to the lack of knowledge on malaria infection during pregnancy and the consequent effects on the mother and the fetus [40]. Similarly, insufficient knowledge of pregnant women as a high-risk group may also be contributing. As seen in Ethiopia, there were greater rates of knowledge of under fives (55.7%) as a high-risk group for malaria infection compared to pregnant women (18.5%) [41].

Opposite of expectations, this study showed that a household reporting a member with fever during the previous two weeks was associated with an increased odds of net ownership. Most simply, this is probably due to the large number of other endemic diseases in Haiti, like

vaccine preventable diseases, other vectorborne diseases, and diarrheal diseases, that could be causing fever symptomology [42]. Rather than malaria, these diseases could responsible for the reports of febrile patients in the analyzed households.

In this study, number of members in household appeared to be associated with net ownership. Specifically, the greater the size of a household, the greater the odds of net ownership. This does not necessarily mean that there is adequate net density in the household. As most respondents in this study received their net from a mass distribution or through government assistance, households may have been eligible to receive more nets based on their household size.

In assessing net use among households owning a net, this study identified that as the age of the household respondent increased, there was a decreased odds of household net use. Other studies have showed both the same and the opposite relationship [8-10, 14, 43], suggesting that this might be context- or location-specific. More research is warranted.

Not surprisingly, net observation in the household was associated with greater odds of net use. Interestingly, of the 477 households that reported someone sleeping under a net the previous night, the enumerator observed the net in only 50% of households; yet, 99% of households reported having the net hung above a sleeping area. One reason could be that the enumerator simply did not observe the sleeping areas. Alternatively, this result could be indicative of social desirability bias in that the respondents knew that the nets were meant to be hung above a sleeping area and responded accordingly. If so, this type of responding at least highlights a basic understanding of how a net should be used. However, it also points to the need for further research into why a household is not using a net, despite proper knowledge.

Also not surprisingly, this study found that households reporting having the net hung above a sleeping area had a greater odds of net use. Other studies have highlighted the logistical challenges of households having to hang their own nets [29]. In this way, net distribution campaigns could be more effective if mass distribution was complemented with additional home-based distribution and follow-up to assist in the hanging of the nets. This has been suggested to make net distribution campaigns more cost-effective [44]. It may additionally combat the net ownership and non-use observations seen in this study, especially in regards to the nets reported to still being in their packaging.

Notably, urban households in this study had a greater odds of net ownership but a lower odds of net use. Other studies have demonstrated that net use is greater in urban areas as urban dwellers are normally wealthier and more educated, both strong factors influencing health behaviors [49]. One explanation for the difference seen in this study could be lingering repercussions from the 2010 earthquake. The earthquake caused population movement and devastation of homes and schools, which may have negatively affected the wealth and education levels of some urban respondents in this study. An additional explanation could be related to where respondents obtained their nets. A larger percentage of respondents from rural areas obtained their net from a store or retailer. Most people from urban areas received their net from a mass campaign or government assistance, where there are normally greater opportunities for health education. These opportunities may not have been exploited in favor of achieving higher distribution numbers. Conversely, when people buy their net, they may recognize its importance in preventing malaria and be more likely to use the net, as observed in this study and noted in other studies in Ghana and Ethiopia [7, 19]. Understandably, in many low-income settings, cost is often cited as deterrent to net ownership. However, notably, a study in Ethiopia found that 68.5% of study participants were willing to buy an ITN if it was available in the market. While this type of willingness is undoubtedly context- and cost-specific, many of the factors associated with

willingness to pay are also known to be associated with health seeking behaviors: being female, education history, and higher income [43].

Important limitations of this study include that most of the data used in this study was self-reported and bias may have been introduced. For instance, social desirability bias could have lent to over-reporting of known positive behaviors, such as net ownership, net use, number of nets owned, and more. A further limitation is that net use was only reported for the night prior to being surveyed. As such, it does not reflect long-term or consistent patterns of net use, which is what makes mosquito nets effective in reducing malaria morbidity and mortality. Similarly, one cannot ascertain patterns of net use, such as whether only certain individuals in the household sleep under the net, if the net is rotated between household members, and other potential factors.

The study fills a research gap as there are few studies investigating net ownership and use in Haiti. Additionally, this study had a large number of geographically diverse responses, highlighting the study's power, internal validity, and representativeness. As several statistically significant factors associated with mosquito net ownership and use resulted, this study ultimately provides a foundation to further explore these factors. Moreover, other factors associated with mosquito net ownership and use in the literature, such as education and household income levels, should be examined in the context of Haiti. Further research will enable the development and implementation of more effective net distribution and malaria education campaigns as Haiti strives to eliminate malaria by 2020.

REFERENCES

1. Acharya, I., Acharya, J.P., *A Study on Efficacy of LLINS As Compared To In-Use ITNs Amongst Troops in a Malaria Endemic Area.* Journal of Tropical Diseases & Public Health, 2015. **3**(175).
2. WHO, *World Malaria Report: 2017*. 2017.
3. Wanzira, H., et al., *Long lasting insecticidal bed nets ownership, access and use in a high malaria transmission setting before and after a mass distribution campaign in Uganda.* PLoS One, 2018. **13**(1): p. e0191191.
4. Noor, A.M., et al., *Increasing coverage and decreasing inequity in insecticide-treated bed net use among rural Kenyan children.* PLoS Med, 2007. **4**(8): p. e255.
5. Ntuku, H.M., et al., *Long-lasting insecticidal net (LLIN) ownership, use and cost of implementation after a mass distribution campaign in Kasai Occidental Province, Democratic Republic of Congo.* Malar J, 2017. **16**(1): p. 22.
6. West, P.A., et al., *Evaluation of a national universal coverage campaign of long-lasting insecticidal nets in a rural district in north-west Tanzania.* Malar J, 2012. **11**: p. 273.
7. Graves, P.M., et al., *Factors associated with mosquito net use by individuals in households owning nets in Ethiopia.* Malar J, 2011. **10**: p. 354.
8. Alaii, J.A., et al., *Factors affecting use of permethrin-treated bed nets during a randomized controlled trial in western Kenya.* Am J Trop Med Hyg, 2003. **68**(4 Suppl): p. 137-41.
9. Baume, C.A. and M.C. Marin, *Intra-household mosquito net use in Ethiopia, Ghana, Mali, Nigeria, Senegal, and Zambia: are nets being used? Who in the household uses them?* Am J Trop Med Hyg, 2007. **77**.
10. Eisele, T.P., et al., *Assessment of insecticide-treated bednet use among children and pregnant women across 15 countries using standardized national surveys.* Am J Trop Med Hyg, 2009. **80**.

11. Baume, C.A. and A.C. Franca-Koh, *Predictors of mosquito net use in Ghana.* Malaria Journal, 2011. **10**(1): p. 265.

12. Hwang, J., et al., *Knowledge of malaria and its association with malaria-related behaviors--results from the Malaria Indicator Survey, Ethiopia, 2007.* PLoS One, 2010. **5**(7): p. e11692.

13. Keating, J., et al., *Self-reported malaria and mosquito avoidance in relation to household risk factors in a Kenyan coastal city.* J Biosoc Sci, 2005. **37**(6): p. 761-71.

14. Rashed, S., et al., *Determinants of the Permethrin Impregnated Bednets (PIB) in the Republic of Benin: the role of women in the acquisition and utilization of PIBs.* Soc Sci Med, 1999. **49**(8): p. 993-1005.

15. Baume, C., R. Reithinger, and S. Woldehanna, *Factors associated with use and non-use of mosquito nets owned in Oromia and Amhara Regional States, Ethiopia.* Malar J, 2009. **8**.

16. Adongo, P.B., B. Kirkwood, and C. Kendall, *How local community knowledge about malaria affects insecticide-treated net use in northern Ghana.* Trop Med Int Health, 2005. **10**(4): p. 366-78.

17. Chuma, J., et al., *Towards achieving Abuja targets: identifying and addressing barriers to access and use of insecticides treated nets among the poorest populations in Kenya.* BMC Public Health, 2010. **10**: p. 137.

18. Widmar, M., et al., *Determining and addressing obstacles to the effective use of long-lasting insecticide-impregnated nets in rural Tanzania.* Malar J, 2009. **8**: p. 315.

19. Ng'and'a, P., et al., *Bed net use and associated factors in a rice farming community in Central Kenya.* Malar J, 2009. **8**.

20. Dye, T.D., et al., *"Before we used to get sick all the time": perceptions of malaria and use of long-lasting insecticide-treated bed nets (LLINs) in a rural Kenyan community.* Malar J, 2010. **9**: p. 345.

21. Ngondi, J.M., et al., *Which nets are being used: factors associated with mosquito net use in Amhara, Oromia and Southern Nations, Nationalities and Peoples' Regions of Ethiopia.* Malar J, 2011. **10**: p. 92.

22. Iwashita, H., et al., *Sleeping arrangement and house structure affect bed net use in villages along Lake Victoria.* Malar J, 2010. **9**: p. 176.

23. Dunn, C.E., A. Le Mare, and C. Makungu, *Malaria risk behaviours, socio-cultural practices and rural livelihoods in southern Tanzania: implications for bednet usage.* Soc Sci Med, 2011. **72**(3): p. 408-17.

24. Steinhardt, L.C., et al., *Effectiveness of insecticide-treated bednets in malaria prevention in Haiti: a case-control study.* Lancet Glob Health, 2017. **5**(1): p. e96-e103.

25. Larsen, D.A., et al., *Community coverage with insecticide-treated mosquito nets and observed associations with all-cause child mortality and malaria parasite infections.* Am J Trop Med Hyg, 2014. **91**(5): p. 950-8.

26. Taremwa, I.M., et al., *Knowledge, attitude and behaviour towards the use of insecticide treated mosquito nets among pregnant women and children in rural Southwestern Uganda.* BMC Public Health, 2017. **17**(1): p. 794.

27. *Malaria in children under five*. 2018; Available from: http://www.who.int/malaria/areas/high_risk_groups/children/en/.

28. Desrochers, R.E., et al., *Effectiveness of post-campaign, door-to-door, hang-up, and communication interventions to increase long-lasting, insecticidal bed net utilization in Togo (2011-2012): a cluster randomized, control trial.* Malar J, 2014. **13**: p. 260.

29. Boncy, P.J., et al., *Malaria elimination in Haiti by the year 2020: an achievable goal?* Malar J, 2015. **14**: p. 237.

30. Frederick, J., et al., *Malaria vector research and control in Haiti: a systematic review.* Malar J, 2016. **15**(1): p. 376.

31. Kachur, S.P., et al., *Prevalence of malaria parasitemia and accuracy of microscopic diagnosis in Haiti, October 1995.* Rev Panam Salud Publica, 1998. **3**(1): p. 35-9.

32. Eisele, T.P., et al., *Prevalence of Plasmodium falciparum infection in rainy season, Artibonite Valley, Haiti, 2006.* Emerg Infect Dis, 2007. **13**(10): p. 1494-6.

33. Neuberger, A., et al., *Malaria among patients and aid workers consulting a primary healthcare centre in Leogane, Haiti, November 2010 to February 2011 - a prospective observational study.* Euro Surveill, 2011. **16**(13).

34. Townes, D., et al., *Malaria survey in post-earthquake Haiti--2010.* Am J Trop Med Hyg, 2012. **86**(1): p. 29-31.

35. Lemoine, J.F., et al., *Haiti's Commitment to Malaria Elimination: Progress in the Face of Challenges, 2010-2016.* Am J Trop Med Hyg, 2017. **97**(4_Suppl): p. 43-48.

36. Inungu, J.N., et al., *Use of Insecticide-Treated Mosquito Net among Pregnant Women and Guardians of Children under Five in the Democratic Republic of the Congo.* Malar Res Treat, 2017. **2017**: p. 5923696.

37. Zervos, J.M. *Where are the Mosquit Nets in Haiti?* 2013.

38. Willey, B.A., Paintain, L.S., Mangham, L., Car, J., & Schellenberg, J.A. *Strategies for delivering insecticide-treated nets at scale for malaria control: a systematic review*. Bulletin of the World Health Organization, 2012. 674-684E DOI: 10.2471/BLT.11.094771.

39. Killeen, G.F., et al., *Preventing childhood malaria in Africa by protecting adults from mosquitoes with insecticide-treated nets.* PLoS Med, 2007. **4**(7): p. e229.

40. Mens, P.F., et al., *Peer education: the effects on knowledge of pregnancy related malaria and preventive practices in women of reproductive age in Edo State, Nigeria.* BMC Public Health, 2011. **11**: p. 610.

41. Aleme, A., E. Girma, and N. Fentahun, *Willingness to pay for insecticide-treated nets in Berehet District, Amhara Region, Northern Ethiopia: implication of social marketing.* Ethiop J Health Sci, 2014. **24**(1): p. 75-84.

42. Gracia, J.N., Brown, C.M., Sampson, D.M., & Ejike-King, L., *CDC Yellow Book 2018*. 2018, Centers for Disease Control and Prevention.

43. Toé, L.P., et al., *Decreased motivation in the use of insecticide-treated nets in a malaria endemic area in Burkina Faso.* Malar J, 2009. **8**.

44. Smith Paintain, L., et al., *Evaluation of a universal long-lasting insecticidal net (LLIN) distribution campaign in Ghana: cost effectiveness of distribution and hang-up activities.* Malar J, 2014. **13**: p. 71.

45. Fuge, T.G., S.Y. Ayanto, and F.L. Gurmamo, *Assessment of knowledge, attitude and practice about malaria and ITNs utilization among pregnant women in Shashogo District, Southern Ethiopia.* Malar J, 2015. **14**: p. 235.

46. Wiseman, V., et al., *Determinants of bed net use in the Gambia: implications for malaria control.* Am J Trop Med Hyg, 2007. **76**(5): p. 830-6.

TABLES

Table 1. Characteristics of the Sample Population

	Total HH *(N=1755)*		***Rural*** *(N=585)*		***Urban*** *(N=1170)*		**p-value for**
HH Characteristics	n	%	n	%	n	%	**difference**
HHs owning at least 1 net							
Yes	688	39%	210	36%	478	41%	0.0508
No	1065	61%	373	64%	692	59%	
Pregnant woman in HH							
Yes	77	4%	25	4%	52	5%	0.8777
No	1639	96%	546	96%	1093	95%	
Child U5 in HH							
Yes	314	18%	97	17%	217	19%	0.2996
No	1426	82%	484	83%	942	81%	
Size of HH							
1-4 persons	1200	68%	397	68%	803	69%	0.1997
5-9 persons	536	31%	178	30%	358	31%	
≥ 10 persons	19	1%	10	2%	9	1%	
HH member with fever in the past 2 weeks							
Yes	192	11%	75	13%	117	10%	0.0729
No	1522	89%	496	87%	1026	90%	
RDT positive result in HH							
Yes	22	1%	6	1%	16	1%	0.5839
No	1650	99%	541	99%	1109	99%	
HH Respondent Characteristics							
Sex							
Male	567	42%	137	34%	430	46%	<0.0001
Female	774	58%	269	66%	505	54%	
Age							
15-30 years	267	20%	92	23%	175	19%	<0.0001
31-45 years	432	32%	156	38%	276	30%	
46-60 years	369	28%	105	26%	264	28%	
> 60 years	273	20%	54	13%	219	23%	

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, CHW= Community Health Worker

Table 1. Characteristics of the Sample Population (*continued)*

	Total HH *(N=1755)*		***Rural*** *(N=585)*		***Urban*** *(N=1170)*		**p-value for difference**
	n	%	n	%	n	%	
Characteristics Among HHs Owning at Least 1 Net							
Age of the net							
< 1 year	151	22%	50	24%	101	21%	0.1283
1-2 years	75	11%	29	14%	46	10%	
2-3 years	73	11%	16	8%	57	12%	
≥ 3 years	252	37%	69	33%	183	38%	
Unknown	137	20%	46	22%	91	19%	
Net observed in HH							
Yes	315	46%	85	40%	230	48%	0.0640
No	373	54%	125	60%	248	52%	
Number of nets in HH							
1 net	341	50%	103	50%	238	50%	0.9121
2-3 nets	309	45%	94	46%	215	45%	
4-6 nets	30	4%	8	4%	22	5%	
Net pretreated with insecticide prior to receipt							
Yes	118	17%	32	15%	86	18%	0.4890
No	102	15%	37	18%	65	14%	
N/A	105	15%	30	14%	75	16%	
Unknown	363	53%	111	53%	252	53%	
Net treated with insecticide since receipt							
Yes	87	13%	30	14%	57	12%	0.3157
No	193	28%	49	23%	144	30%	
N/A	58	8%	19	9%	39	8%	
Unknown	350	51%	112	53%	238	50%	
Net hung to sleep under							
Yes	611	89%	184	88%	427	89%	0.5120
No	77	11%	26	12%	51	11%	
Someone in HH slept under the net the previous night							
Yes	477	69%	156	74%	321	67%	0.0098
No	209	30%	52	25%	157	33%	
Unknown	2	0%	2	1%	0	0%	

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, CHW= Community Health Worker

*Due to low cell counts for the '4-6 nets' response for number of nets in household, '2-3 nets' and '4-6' nets were combined into a single response category prior to the epidemiological modeling.

Table 1. Characteristics of the Sample Population (*continued)*

	Total HH *(N=1755)*		***Rural*** *(N=585)*		***Urban*** *(N=1170)*		**p-value for difference**
	n	%	n	%	n	%	
Characteristics Among HHs Owning at Least 1 Net							
Net paid for by HH							
Yes	164	24%	73	35%	91	19%	<0.0001
No	517	75%	132	63%	385	81%	
Unknown	7	1%	5	2%	2	0%	
Net Condition							
Good (No holes)	267	39%	76	36%	191	40%	0.0459
Reasonable (A few holes)	254	37%	83	40%	171	36%	
Poor (Several small holes)	92	13%	27	13%	65	14%	
Extremely Poor (Big holes or tear)	52	8%	17	8%	35	7%	
Not Used (Still in package)	19	3%	3	1%	16	3%	
Unknown	4	1%	4	2%	0	0%	
Net Source							
Mass Campaign	239	35%	49	23%	190	40%	<0.0001
Government Assistance	158	23%	40	19%	118	25%	
Private help	24	3%	11	5%	13	3%	
Missionaries	26	4%	10	5%	16	3%	
Store/Retailer	91	13%	47	22%	44	9%	
Pharmacy	8	1%	5	2%	3	1%	
CHW	0	0%	0	0%	0	0%	
Job	2	0%	2	1%	0	0%	
Unknown	15	2%	6	3%	9	2%	
Other	125	18%	40	19%	85	18%	

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, CHW= Community Health Worker

*Due to low cell counts for the net source responses ‘Job’ and ‘Pharmacy,’ these responses were added to the ‘Other’ response category prior to the epidemiological modeling.

Table 2. Univariate logistic regression analysis of the association between household respondent and household characteristics and household ownership of a net

Explanatory Factors	*HH Surveyed (N=1,755)*						
	HH Owns a Net (n=688)		***HH Does Not Own a Net (n= 1,065)***				
	n	%	n	%	OR	95% CI	p-value
HH Respondent Characteristics							
Sex							
Male	201	41%	366	43%	1.00	-	-
Female	295	59%	479	57%	1.26	0.80- 1.97	0.3182
Age							
15-30 years	104	21%	163	19%	1.00	-	-
31-45 years	163	33%	269	32%	0.90	0.73- 1.12	0.3599
46-60 years	134	27%	235	28%	0.86	0.62- 1.19	
> 60 years	97	19%	176	21%	0.82	0.53- 1.26	
HH Characteristics							
HH Location							
Rural	210	31%	373	35%	1.00	-	-
Urban	478	69%	692	65%	1.51	1.00- 2.27	0.051
Pregnant woman in HH							
No	641	95%	997	96%	1.00	-	-
Yes	32	5%	45	4%	1.11	0.70- 1.76	0.6703
Child U5 in HH							
No	537	79%	888	84%	1.00	-	-
Yes	145	21%	169	16%	1.42	1.11- 1.82	0.0054
HH member with fever in the past 2 weeks							
No	571	85%	950	91%	1.00	-	-
Yes	101	15%	91	9%	1.85	1.37- 2.50	<0.0001
RDT positive result in HH							
No	655	99%	994	99%	1.00	-	-
Yes	7	1%	15	1%	0.71	0.29- 1.75	0.4537
Size of HH							
1-4 persons	438	64%	760	71%	1.00	-	-
5-9 persons	244	35%	292	27%	1.82	1.24- 2.68	0.0023
≥ 10 persons	6	1%	13	1%	2.46	1.38- 4.40	

*****HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval

Table 3. Final Multivariate Logistic Regression Model: Association between household respondent and household characteristics and household ownership of a net

Explanatory Factors	*HH Owns a Net*		
	OR	95% CI	p-value
HH Characteristics			
HH member with fever in the past 2 weeks			
No	1.00	-	-
Yes	1.82	1.34- 2.47	0.0001
Child U5 in HH			
No	1.00	-	-
Yes	1.29	1.00- 1.66	0.0528
Size of HH			
1-4 persons	1.00	-	-
5-9 persons	1.69	1.13- 2.54	0.0110
≥ 10 persons	2.20	1.20- 4.04	

*HH= Household, U5= child under five years of age, OR= Odds Ratio, CI= Confidence Interval

Table 4. Univariate logistic regression analysis of the association between net ownership and net slept under the previous night among households with a net

Explanatory Factors	*HH Owning at Least 1 Net (N=688)*						
	Net Slept Under by a HH Member the Previous Night (n=477)		***Net Not Slept Under by a HH Member the Previous Night (n=209)***				
	n	%	n	%	OR	95% CI	p-value
HH Respondent Characteristics							
Sex							
Male	129	38%	72	47%	1.00	-	-
Female	213	62%	82	53%	2.10	0.97- 4.54	0.0585
Age							
15-30 years	83	24%	21	14%	1.00	-	-
31-45 years	119	35%	44	29%	0.54	0.37- 0.79	
46-60 years	80	23%	54	35%	0.40	0.23- 0.71	0.0016
> 60 years	62	18%	35	23%	0.30	0.14- 0.63	
HH Characteristics							
HH Location							
Rural	156	33%	52	25%	1.00	-	-
Urban	321	67%	157	75%	0.46	0.22- 0.97	0.0408
HH member with fever in the previous 2 weeks							
No	397	85%	173	85%	1.00	-	-
Yes	69	15%	31	15%	0.97	0.61- 1.54	0.8961
RDT positive result in HH							
No	451	98%	202	100%	1.00	-	-
Yes	7	2%	0	0%	-	-	-
Pregnant woman in HH							
No	444	95%	195	96%	1.00	-	-
Yes	23	5%	9	4%	1.12	0.51- 2.47	0.7742
Child U5 in HH							
No	364	77%	171	83%	1.00	-	-
Yes	110	23%	35	17%	1.48	0.97- 2.25	0.0701
Size of HH							
1-4 persons	305	64%	132	63%	1.00	-	-
5-9 persons	169	35%	74	35%	0.88	0.46- 1.68	0.7021
≥ 10 persons	3	1%	3	1%	0.83	0.31- 2.18	

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval

Table 4. Univariate logistic regression analysis of the association between net ownership and net slept under the previous night among households with a net (*continued*)

Explanatory Factors	*HH Owning at Least 1 Net (N=688)*						
	Net Slept Under by a HH Member the Previous Night (n=477)		***Net Not Slept Under by a HH Member the Previous Night (n=209)***				
	n	%	n	%	OR	95% CI	p-value
Net Characteristics							
Age of the net							
< 1 year	107	28%	44	27%	1.00	-	-
1-2 years	52	13%	22	13%	0.95	0.71- 1.27	
2-3 years	54	14%	19	12%	0.93	0.60- 1.42	0.7292
≥ 3 years	174	45%	78	48%	0.9	0.51- 1.60	
Net observed in HH							
No	237	50%	134	64%	1.00	-	-
Yes	240	50%	75	36%	1.81	1.29- 2.53	0.0005
Number of nets in HH							
1 net	231	49%	109	53%	1.00	-	-
More than 1 net	241	51%	98	47%	1.35	0.70- 2.59	0.3728
Net pretreated with insecticide prior to receipt							
No	74	48%	28	43%	1.00	-	-
Yes	80	52%	37	57%	0.82	0.46- 1.47	0.5004
Net treated with insecticide since receipt							
No	136	68%	22	28%	1.00	-	-
Yes	64	32%	57	72%	1.22	0.69- 2.17	0.4990
Net hung to sleep under							
No	4	1%	73	35%	1.00	-	-
Yes	473	99%	136	65%	63.47	22.79- 176.80	<0.0001
Net paid for by HH							
No	341	72%	175	85%	1.00	-	-
Yes	133	28%	31	15%	2.20	1.43- 3.39	0.0003
Net Condition							
Not used (Still in package)	1	0%	18	9%	1.00	-	-
Good (No holes)	178	37%	89	43%	1.17	0.98- 1.39	
Reasonable (A few holes)	202	42%	50	24%	1.37	0.96- 1.94	0.0812
Poor (Several small holes)	66	14%	26	13%	1.60	0.94- 2.70	
Extremely poor (Big holes or tear)	29	6%	23	11%	1.87	0.93- 3.76	
Net Source							
Other	93	20%	42	21%	1.00	-	-
Mass Campaign	171	37%	67	33%	1.42	0.46- 4.39	0.5444
Government Assistance	92	20%	66	32%	0.77	0.25- 2.42	0.6597
Private help	18	4%	6	3%	1.67	0.40- 6.97	0.4843
Missionaries	17	4%	9	4%	1.05	0.27- 4.09	0.9446
Store/Retailer	77	16%	14	7%	3.06	0.89- 10.48	0.0757

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval

Table 5. Final Multivariate Logistic Regression Model: Association between net ownership and net slept under the previous night

Explanatory Factors	*HH Owning at Least 1 Net*		
	Net Slept Under by a HH Member the Previous Night		
	OR	95% CI	p-value
HH Respondent Characteristics			
Age			
15-30 years	1.00	-	-
31-45 years	0.69	0.45- 1.06	
46-60 years	0.57	0.30- 1.09	0.0891
> 60 years	0.47	0.20- 1.12	
HH Characteristics			
HH Location			
Rural	1.00	-	-
Urban	0.41	0.14- 1.23	0.1118
Net Characteristics			
Net Observed			
No	1.00	-	-
Yes	2.14	1.34- 3.41	0.0014
Net hung to sleep under			
No	1.00	-	-
Yes	48.64	16.38- 144.40	<0.0001
Net paid for by HH			
No	1.00	-	-
Yes	2.46	1.35- 4.50	0.0035

*****HH= Household, OR= Odds Ratio, CI= Confidence Interval

CHAPTER III: FUTURE DIRECTIONS AND PUBLIC HEALTH IMPLICATIONS

Future Directions

Alongside Haiti's national malaria control program (PNCM), the vast number of and expertise of international partners operating in Haiti since the 2010 earthquake, and the high levels of funding for anti-malaria activities from The Global Fund, Haiti is well-positioned to continue its fight against malaria, leading to eventual elimination. Under the guidance of PNCM's strategic plan from 2016 to 2022 (Plan Stratégique National d'Elimination de la Malaria—PSNEM), concluding with the elimination of malaria by 2020, several interrelated goals have been addressed and will need to be achieved [29]. These include coordinating interventions, targeting coastal and low-altitude areas of Haiti, using microscopy or RDTs for all suspected cases, ensuring that all diagnosed cases of malaria in Haiti are due to imported cases, educating 80% of the population, and engaging in passive and active surveillance. Under this strategic plan, Haiti is currently moving from the pre-elimination phase to the elimination phase. As a result, and as depicted through the goals above, the national agenda is transitioning to case detection and management [29]. Even so, the importance of sustained and appropriate vector control measures cannot be understated.

The data from this study suggests that there are several statistically significant factors that are associated with mosquito net ownership and use in Haiti. Given the low percentage of net ownership observed in this study, these identified factors should be exploited to garner increased levels of household net ownership and use. Further, the factors non-significantly associated with net ownership and use should be further investigated, in addition to other associated factors highlighted in the literature, such as household income or education, to better understand the barriers to net ownership and use, ownership and use among pregnant women and children under five, potential urban versus rural differences, and why households owning a net would not have

appropriate use. As suggested previously, there is limited research on the effectiveness of and use of vector control strategies against malaria in Haiti, especially in regards to mosquito nets. Accordingly, the results from this study provide a strong foundation for future research into mosquito net usage in Haiti.

Public Health Implications

In applying the findings from this analysis to future public health practice in Haiti, several opportunities are noteworthy. One of the most striking findings implied from this analysis is the need for more comprehensive health education. For instance, household ownership of a net appeared to be higher in households with children under five years of age, but not in households with pregnant women, even though both groups are considered high-risk groups for malaria infection. This suggests that knowledge of these groups as high-risk is lacking, which will hinder efforts to reduce malaria morbidity and mortality among these groups. Similarly, most respondents in this study who owned a net did not know if their net was treated with insecticide. Since all of the nets distributed nationally in Haiti from 2011 to 2015 were treated nets, this suggests that nets were being distributed without corresponding information as to how the net, specifically the insecticide, helps to prevent malaria. Although providing health education at the same time as a mass distribution or through follow-up home or community visits involves more time, resources, and money, it is not enough to simply provide nets to people. Without simultaneous health education, it is nearly impossible to prevent people from trading or re-purposing their nets for something perceived to be of higher value or to maintain the long-term sustained use of the nets, including household re-treatment with insecticides as necessary, that is required for the nets to be an effective malaria prevention strategy. Maternal education has been shown to be an important predictor of net use [45]. As such, maternal education, potentially through prenatal and antenatal care, could be one way to provide education on malaria risk, the

importance of mosquito nets, proper net use, high-risk groups, and more, that would translate into improved household knowledge and ideally, improved household utilization of nets.

Another notable opportunity for public health practice resulting from this study is the opportunity to reevaluate how nets are distributed in Haiti. Only 39% of households in this study reported owning a net, a strikingly low percentage compared to other studies of a similar nature, and ownership appeared to be higher in urban settings compared to rural settings. This points to a need to improve net distribution mechanisms to ensure not only more equitable geographic provision of nets, but similarly, continuous availability of nets, whether in a market or through a health facility. As implied previously, in the rural areas, this will likely require simultaneous improvement of community infrastructure, such as roads and transportation, so that health workers and others distributing nets are able to reach the most remote areas, no matter the season [46]. Furthermore, this study highlighted that households that paid for their nets had a greater odds of net usage. Since cost is often cited as a hindrance to net ownership, perhaps an alternative could be to complement mass distribution of nets with market availability of high-quality nets at a reasonable price as has been seen in other settings [41]. This would provide a foundation for the sustained availability of nets, especially considering the trend that malaria funding has plateaued or declined in most regions of the world [2].

In considering improvements to net distribution campaigns, this study showed that having a net hung above a sleeping area was associated with a greater odds of net use. While at first a seemingly straightforward result, this result does have notable public health implications. To combat the widely recognized phenomenon of households owning a net but not reporting using the net, net distributions campaigns could be more effective if instead of mass distribution at only a few distribution points, there were more home-based distributions that allow for the installation of the nets. In fact, a related practice has been emerging, called “Hang-Up Visits.” These are

home visits completed by community agents, such as health workers, following mass campaigns or prior to peak malaria transmission periods to ensure that nets are hanging above a sleeping area and being used properly [28]. During visits like these, there is the opportunity for more individualized health education and behavior-change communication, a potential way to ensure that if a household does not have enough nets for each household member or sleeping space, at least the most high-risk individuals in a household are advised to use the nets. While the success of "Hang-Up Visits" has been shown to depend on the baseline rates of net utilization in an area, a study conducted in Togo found that households that received these visits had levels of net use that were typically 5% to 10% higher than control households, suggesting that this could be a positive public health strategy moving forward [28].

Conclusion

In conclusion, compared to other malaria-endemic countries, particularly in Sub-Saharan Africa, Haiti has a fairly low rate of malaria transmission. Not only is this promising in regards to Haiti's strategic plan to eliminate malaria by 2020, but it also provides the opportunity for more creative public health practice. Considering the public health implications discussed above, with the country's high level of national and international support to eliminate malaria in the near future, Haiti has the opportunity to reimagine the way health education is disseminated and net distribution and provision occurs. That being said, it is important that as Haiti's focus transitions to malaria case detection and management, effective vector control is not forgotten or abandoned. Mosquito nets are still needed, and this study provides a starting point to better understand how rates of net ownership and use can be improved in Haiti.

APPENDIX A: Stratified Tables Exploring Household Location as a Potential Effect Measure Modifier

Table 1A. Univariate logistic regression analysis of the association between household respondent and household characteristics and household ownership of a net

Explanatory Factors	*Rural (N=583)*							*Urban (N=1,170)*						
	HH Owns a Net (n=210)		*HH Does Not Own a Net (n= 373)*					*HH Owns a Net (n=478)*		*HH Does Not Own a Net (n=692)*				
	n	%	n	%	OR	95% CI	p-value	n	%	n	%	OR	95% CI	p-value
Characteristics														
Sex														
Male	41	31%	96	35%	1.00	-	-	160	44%	270	47%	1.00	-	-
Female	91	69%	178	65%	1.81	1.05- 3.10	**0.0326	204	56%	301	53%	2.43	1.20- 4.94	**0.0141
Age														
15-30 years	30	23%	62	23%	1.00	-	-	74	20%	101	18%	1.00	-	-
31-45 years	50	38%	106	39%	1.18	0.87- 1.61	0.2975	113	31%	163	29%	1.59	0.95- 2.66	0.0798
46-60 years	31	23%	74	27%	1.10	0.75- 1.62	0.6175	103	28%	161	28%	1.48	0.85- 2.60	0.1662
> 60 years	22	17%	32	12%	1.03	0.64- 1.66	0.8947	75	21%	144	25%	1.39	0.75- 2.58	0.2975
HH Characteristics														
Pregnant woman in HH														
No	195	95%	350	96%	1.00	-	-	446	96%	647	95%	1.00	-	-
Yes	11	5%	14	4%	1.34	0.81- 2.23	0.2540	21	4%	31	5%	1.64	0.88- 3.05	0.1211
Child U5 in HH														
No	169	81%	314	84%	1.00	-	-	368	78%	574	84%	1.00	-	-
Yes	39	19%	58	16%	1.74	1.26- 2.39	**0.0007	106	22%	111	16%	2.13	1.32- 3.44	**0.0018
HH member with fever in the past 2 weeks														
No	169	82%	326	90%	1.00	-	-	402	86%	624	92%	1.00	-	-
Yes	37	18%	38	10%	2.33	1.60- 3.40	*<0.0001	64	14%	53	8%	2.9	1.71- 4.92	**<0.0001
RDT positive result in HH														
No	197	99%	343	99%	1.00	-	-	458	99%	651	98%	1.00	-	-
Yes	1	1%	5	1%	0.86	0.34- 2.18	0.7572	6	1%	10	2%	1.07	0.40- 2.88	0.8973
Size of HH														
1-4 persons	129	61%	266	71%	1.00	-	-	309	65%	494	71%	1.00	-	-
5-9 persons	79	38%	99	27%	2.27	1.46- 3.54	**0.0003	165	35%	193	28%	2.81	1.58- 4.98	**0.0004
≥ 10 persons	2	1%	8	2%	3.08	1.66- 5.74	**0.0004	4	1%	5	1%	3.81	1.85- 7.83	**0.0003

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval; **= significant at an alpha-level of 0.05

Table 2A. Final Multivariate Logistic Regression Model: Association between household respondent and household characteristics and household ownership of a net

Explanatory Factors	*Rural*			*Urban*		
	HH Owns a Net			*HH Owns a Net*		
	OR	95% CI	p-value	OR	95% CI	p-value
HH Respondent Characteristics						
Sex						
Male	1.00	-	-	1.00	-	-
Female	1.73	0.99- 3.01	**0.0536	2.41	1.17- 4.98	**0.0175
HH Characteristics						
HH member with fever in the past 2 weeks						
No	1.00	-	-	1.00	-	-
Yes	2.80	1.80- 4.35	**<0.0001	3.91	2.07- 7.35	**<0.0001
Child U5 in HH						
No	1.00	-	-	1.00	-	-
Yes	1.77	1.19- 2.64	**0.005	2.47	1.37- 4.47	**0.0027
Size of HH						
1-4 persons	1.00	-	-	1.00	-	-
5-9 persons	2.51	1.45- 4.33	**0.001	3.51	1.73- 7.08	**0.0005
≥ 10 persons	3.37	1.56- 7.25	**0.0019	4.70	1.94- 11.41	**0.0006

*HH= Household, U5= child under five years of age, OR= Odds Ratio, CI= Confidence Interval;
**= significant at an alpha-level of 0.05

Table 3A. Univariate logistic regression analysis of the association between net ownership and net slept under the previous night among households with a net

Explanatory Factors	*Rural (N=208)*							*Urban (N=478)*						
	Net Slept Under by a HH Member the Previous Night (n=156)		*Net Not Slept Under by a HH Member the Previous Night (n=52)*					*Net Slept Under by a HH Member the Previous Night (n=321)*		*Net Not Slept Under by a HH Member the Previous Night (n=157)*				
	n	%	n	%	OR	95% CI	p-value	n	%	n	%	OR	95% CI	p-value
Characteristics														
Sex														
Male	29	30%	12	35%	1.00	-	-	100	41%	60	50%	1.00	-	-
Female	69	70%	22	65%	1.46	0.57- 3.72	0.4298	144	59%	60	50%	1.07	0.31- 3.75	0.9108
Age														
15-30 years	24	24%	6	18%	1.00	-	-	59	24%	15	13%	1.00	-	-
31-45 years	39	39%	11	32%	0.40	0.23- 0.72	**0.0020	80	33%	33	28%	0.29	0.11- 0.77	**0.0127
46-60 years	24	24%	7	21%	0.30	0.15- 0.61	**0.0009	56	23%	47	39%	0.22	0.08- 0.62	**0.0043
> 60 years	12	12%	10	29%	0.22	0.09- 0.53	**0.0006	50	20%	25	21%	0.16	0.05- 0.51	**0.0020
HH Characteristics														
HH member with fever in the previous 2 weeks														
No	129	84%	39	76%	1.00	-	-	268	86%	134	88%	1.00	-	-
Yes	24	16%	12	24%	0.64	0.35- 1.18	0.1555	45	14%	19	12%	0.44	0.18- 1.07	0.0707
RDT positive result in HH														
No	147	99%	48	100%	1.00	-	-	304	98%	154	100%	1.00	-	-
Yes	1	1%	0	0%	-	-	-	6	2%	0	0%	-	-	-
Pregnant woman in HH														
No	146	95%	47	92%	1.00	-	-	298	95%	148	97%	1.00	-	-
Yes	7	5%	4	8%	0.76	0.31- 1.83	0.5357	16	5%	5	3%	0.52	0.17- 1.55	0.2394
Child U5 in HH														
No	124	80%	43	84%	1.00	-	-	240	75%	128	83%	1.00	-	-
Yes	31	20%	8	16%	1.00	0.58- 1.74	0.9893	79	25%	27	17%	0.67	0.29- 1.55	0.35
Size of HH														
1-4 persons	96	51%	32	62%	1.00	-	-	209	50%	100	64%	1.00	-	-
5-9 persons	59	32%	19	37%	0.59	0.28- 1.25	0.1666	110	26%	55	35%	0.40	0.15- 1.08	0.0704
≥ 10 persons	32	17%	1	2%	0.55	0.19- 1.56	0.2577	100	24%	2	1%	0.37	0.11- 1.28	0.1159

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval; **= significant at an alpha-level of 0.05

Table 3A. Univariate logistic regression analysis of the association between net ownership and net slept under the previous night among households with a net (*continued*)

Explanatory Factors	*Rural (N=208)*							*Urban (N=478)*						
	Net Slept Under by a HH Member the Previous Night (n=156)		*Net Not Slept Under by a HH Member the Previous Night (n=52)*					*Net Slept Under by a HH Member the Previous Night (n=321)*		*Net Not Slept Under by a HH Member the Previous Night (n=157)*				
	n	%	n	%	OR	95% CI	p-value	n	%	n	%	OR	95% CI	p-value
Net Characteristics														
Age of the net														
< 1 year	38	31%	12	31%	1.00	-	-	69	26%	32	26%	1.00	-	-
1-2 years	20	16%	8	21%	0.65	0.40-1.06	0.0849	32	12%	14	11%	0.43	0.18- 1.03	0.0596
2-3 years	15	12%	1	3%	0.64	0.36- 1.14	0.1304	39	15%	18	15%	0.43	0.18- 1.07	0.0692
≥ 3 years	51	41%	18	46%	0.63	0.31- 1.25	0.1865	123	47%	60	48%	0.42	0.16- 1.13	0.0849
Net observed in HH														
No	86	55%	37	71%	1.00	-	-	151	47%	97	62%	1.00	-	-
Yes	70	45%	15	29%	1.21	0.75- 1.95	0.4430	170	53%	60	38%	0.78	0.35- 1.72	0.5392
Number of nets in HH														
1 net	75	49%	27	53%	1.00	-	-	156	49%	82	53%	1.00	-	-
2-3 nets	71	46%	23	45%	1.17	0.59- 2.31	0.6611	141	44%	74	47%	0.76	0.30- 1.95	0.5723
4-6 nets	8	5%	1	2%	1.55	0.61- 3.97	0.3578	21	7%	0	0%	1.02	0.33- 3.17	0.9753
Net treated with insecticide upon receipt														
No	30	57%	7	47%	1.00	-	-	44	44%	21	42%	1.00	-	-
Yes	23	43%	8	53%	0.50	0.21- 1.17	0.1092	57	56%	29	58%	0.29	0.07- 1.19	0.0858
Net treated with insecticide since receipt														
No	38	61%	11	69%	1.00	-	-	98	71%	46	73%	1.00	-	-
Yes	24	39%	5	31%	0.67	0.28- 1.62	0.3742	40	29%	17	27%	0.38	0.09- 1.59	0.1858

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval; **= significant at an alpha-level of 0.05

Table 3A. Univariate logistic regression analysis of the association between net ownership and net slept under the previous night among households with a net (*continued*)

Explanatory Factors	*Rural (N=208)*							*Urban (N=478)*						
	Net Slept Under by a HH Member the Previous Night (n=156)		*Net Not Slept Under by a HH Member the Previous Night (n=52)*					*Net Slept Under by a HH Member the Previous Night (n=321)*		*Net Not Slept Under by a HH Member the Previous Night (n=157)*				
	n	%	n	%	OR	95% CI	p-value	n	%	n	%	OR	95% CI	p-value
Net Characteristics														
Net hung to sleep under														
No	2	1%	24	46%	1.00	-	-	2	1%	49	31%	1.00	-	-
Yes	154	99%	28	54%	37.05	2.57- 109.2	<0.0001	319	99%	108	69%	19.81	5.44- 72.15	<0.0001
Net paid for by HH														
No	94	61%	37	74%	1.00	-	-	247	77%	138	88%	1.00	-	-
Yes	60	39%	13	26%	1.55	0.83- 2.87	0.1667	73	23%	18	12%	1.15	0.45- 2.90	0.7734
Net Condition														
Not used (Still in package)	1	1%	2	4%	1.00	-	-	0	0%	16	10%	1.00	-	-
Good (No holes)	52	34%	24	49%	0.76	0.50- 1.15	0.1944	126	39%	65	41%	0.50	0.23- 1.07	0.0753
Reasonable (A few holes)	68	44%	13	27%	0.88	0.52- 1.48	0.6299	134	42%	37	24%	0.57	0.25- 1.33	0.1944
Poor (Several small holes)	21	14%	6	12%	1.02	0.53- 1.97	0.9504	45	14%	20	13%	0.67	0.26- 1.69	0.3925
or tear)	13	8%	4	8%	1.18	0.53- 2.65	0.6797	16	5%	19	12%	0.77	0.27- 2.19	0.6299
Net Source														
Other	36	24%	11	22%	1.00	-	-	57	18%	31	20%	1.00	-	-
Mass Campaign	41	27%	7	14%	1.10	0.34- 3.58	0.8695	130	41%	60	39%	0.82	0.22- 3.11	0.7704
Government Assistance	23	15%	17	34%	0.59	0.18- 1.95	0.3895	69	22%	49	32%	0.44	0.11- 1.70	0.2344
Private help	9	6%	2	4%	1.20	0.27- 5.36	0.8067	9	3%	4	3%	0.90	0.17- 4.61	0.8948
Missionaries	6	4%	4	8%	0.77	0.19- 3.19	0.7227	11	3%	5	3%	0.57	0.12- 2.75	0.4884
Store/Retailer	38	25%	9	18%	2.18	0.59- 8.05	0.2440	39	12%	5	3%	1.62	0.37- 7.08	0.5239

*HH= Household, U5= child under five years of age, RDT= Rapid Diagnostic Test, OR= Odds Ratio, CI= Confidence Interval; **= significant at an alpha-level of 0.05

Table 4A. Final Multivariate Model: Association between net ownership and net slept under the previous night

Explanatory Factors	*Rural*			Urban		
	Net Slept Under by a HH Member the Previous Night			*Net Slept Under by a HH Member the Previous Night*		
	OR	95% CI	p-value	OR	95% CI	p-value
HH Respondent Characteristics						
Age						
15-30 years	1.00	-	-	1.00	-	-
31-45 years	0.41	0.21- 0.79	**0.0076	0.25	0.08- 0.75	**0.0141
46-60 years	0.34	0.15- 0.75	**0.0076	0.20	0.06- 0.67	**0.0093
> 60 years	0.28	0.10- 0.73	**0.0093	0.17	0.04- 0.62	**0.0076
Net Characteristics						
Net hung to sleep under						
No	1.00	-	-	1.00	-	-
Yes	25.14	8.10- 78.03	**<0.0001	15.20	3.66- 63.06	**0.0002

*HH= Household, OR= Odds Ratio, CI= Confidence Interval; **= significant at an alpha-level of 0.05