PREDICTORS OF MALARIA PREVENTION AND CASE MANAGEMENT AMONG CHILDREN UNDER FIVE IN THREE AFRICAN COUNTRIES: ANALYSIS OF DEMOGRAPHIC HEALTH SURVEYS (DHS) MALARIA INDICATOR SURVEYS

by

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ABSTRACT

The focus of this dissertation is threefold: conduct a systematic review to identify literature regarding the use of malaria control methods, identify rates of control method use, and identify predictors associated with the combined use of control methods among African children under age five through Demographic and Health Surveys (DHS). A systematic review identified literature regarding malaria control methods utilizing DHS surveys. Sixty-five articles met the review criteria and were evaluated for insecticide treated nets (ITN) use, indoor residual spray (IRS), and prompt/appropriate treatment. While DHS datasets are a rich source to identify malaria practices in African children, additional research considering the combined use of malaria control methods is needed. DHS surveys from three countries at two separate time points were then analyzed to identify rates of children under five who reported fever and utilized one or more malaria control methods (ITNs, IRS, and/or prompt/appropriate treatment). Independent use of ITNs ranged from 30% to 75%, IRS from 1% to 18%, and prompt/appropriate treatment from 3% to 25%. Combined use of all control methods ranged between <1% to 3%. Within this descriptive analysis, while some improvements to using control methods were noted over time, independent and combined use of these methods are inadequate. Within the predictor analysis, using univariate, multivariate, and multinomial regression analysis, variables such as child age, maternal education, wealth index, and residence location were evaluated as possible predictors of the independent or combined use of these control methods. Higher maternal education and

wealth were found to be significant predictors of using one malaria control method among some of the populations. The sample sizes for using two and three methods were extremely small and significant associations among the variables were few and sporadic. In summary, there were no predictors that remained consistent across all surveys. This final analysis demonstrates the necessity for further evaluation of availability, access, and effective dissemination of these control methods both singularly and in combination to improve the transmission and impact of malaria in these endemic populations.

To Paul and Kathy Duncan for their continual encouragement and dedication to my education, and to Michael Adams for his unwavering support and love.

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CHAPTER 1

INTRODUCTION

Infectious diseases, such as malaria, cause some of the most complex global health issues faced today. Malaria is a continual threat that causes health, community, economic, and political problems to the developing world. Prevention and case management are important factors in reducing the severity of malaria in children and pregnant women. The focus of this dissertation project is to identify predictors associated with the combined use of both prevention and appropriate case management of malaria among children in three African countries who have participated in recent malaria-specific Demographic and Health Surveys.

Systematic Review

The first aim of this dissertation is to complete a systematic review of Demographic and Health Surveys (DHS) malaria literature in which the study population includes children under five or pregnant women. This review will establish the current state of literature available regarding the use of DHS surveys to identify practices and trends related to malaria control methods, specifically prevention and good case management of malaria in these populations. Preventive methods include the use of insecticide treated nets (ITNs), indoor residual spray (IRS), and the combination of prompt and appropriate treatment of malaria.

Descriptive Analysis

For the second aim of this dissertation, children under five that had a reported fever two weeks prior to the DHS survey were described and evaluated for the singular and combined use of malaria prevention methods (i.e., ITNs and IRS) and good case management methods (i.e. prompt and appropriate treatment) across three African countries across two separate time points for each country.

The second aim of this dissertation was originally proposed to include pregnant women and the singular and combined use of prevention control methods such as ITNs, IRS, and intermittent preventive therapy for pregnant women (IPTp), in addition to children under five, and identify predictors of the independent and combined use of control methods. However, upon commencement of this analysis, it became clear that there were important data to analyze and report related to the rates of use of these control methods among these populations. Upon further evaluation of the data, the data collected for pregnant women were for all women who had a pregnancy within the two years previous to the survey. Within this two-year span, it would be difficult to ascertain the use of ITNs during pregnancy as the data only provide whether the women used an ITN the evening prior to the survey. Use of an ITN the night prior to the survey would have to be used as an indication that an ITN had been used consistently during pregnancy. This extrapolation is difficult to make, especially over a potential two-year timeframe. Therefore, with the abundance of data available and the multiple analyses necessary to conduct the proposed research in children under five, the analyses for pregnant women was deferred. An important note for the DHS program would be the usefulness of collecting data on ITN use during pregnancy for the women who contribute to this rich dataset.

An analysis of prevalence rates of using all control methods within children under five is important for program and policy makers to help understand the baseline data of what is happening among these populations in regards to prevention and case management and identifying where improvements or lack of improvements are found across time in these populations. This paper also provides an important setup and continuity to the proposed aim of identifying the variables that predict the combine use of both malaria prevention and case management methods in children under five.

Predictor Analysis

The third aim of this dissertation is to identify the variables that may predict the combined use of both malaria prevention methods (i.e. ITNs and IRS) and the appropriate case management (i.e. prompt and appropriate treatment) of children under five in three African countries. Those predictor variables include maternal education, wealth index, urban vs. rural residential location, the age of the mother, the age of the child, the gender of the child, and the parity of the mother (both living and deceased children). This analysis consists of univariate, multivariate, and multinomial regression to provide, to program and policy makers, important information with additional context of where deficiencies exists and areas where improvements could be made to increase the use of both malaria prevention and good case management methods among children under five.

CHAPTER 2

MALARIA IN CHILDREN UNDER FIVE AND PREGNANT WOMEN: A SYSTEMATIC REVIEW OF DEMOGRAPHIC AND HEALTH SURVEYS

Abstract

Background

The World Health Organization recommends the utilization of both prevention and good case management methods in children under five and pregnant women to address the burden of malaria in endemic countries. Demographic and Health Surveys (DHS), specifically Malaria Indicator Surveys, report data on the use of prevention methods, including the use of insecticide treated nets (ITNs), intermittent preventive treatment for pregnant women (IPTp), and indoor residual spray (IRS). In addition, good case management methods, which include the use of prompt and appropriate treatment at the first symptoms of malaria (i.e. fever), are recorded for children under five.

Objectives

This systematic review will demonstrate the potential utility of using DHS data as a viable resource for secondary data analysis for malaria research and specifically will identify gaps in the current literature related to the individual and combined use of ITNs, IRS, and

prompt and appropriate treatment in children under five and the use of ITNs, IPTp, and IRS in pregnant women in Africa.

Methods

Relevant studies, published in English, reporting on ITN, IPTp, and IRS use and the prompt and appropriate treatment of malaria using DHS data in both children under five and pregnant women from Africa were identified through a systematic review of literature using the PubMed database. Studies were selected based upon inclusion and exclusion criteria that were determined *a priori*.

Results

The systematic review search produced 1,176 articles that were screened from PubMed. The selection was narrowed to 65 publications based on the outlined criteria. At least 46 African countries were represented through all of the surveys. These studies included a wide range of variables related to malaria, including treatment, prevention, and associated demographics. Many articles compared data outcomes from several different countries to look at overall practices as well as considered various surveys within a single country to identify trends over time. Of the 65 publications, 63 include children under five in the analysis and 17 publications included pregnant women in the analysis. Studies related to ITN use, IRS, IPTp, and prompt and appropriate treatment in children under five and pregnant women were identified and evaluated.

Conclusion

DHS datasets are a rich and justified source to identify trends and practices related to malaria in children and pregnant women in Africa. While many of these reviewed articles considered and analyzed prevention and case management methods in children under five and pregnant women, none of the articles using the DHS data considered the singular or combined use of all of these tools in one study. This review calls for additional research to fill this gap. Additionally, research to identify what factors or variables (e.g., maternal education, wealth) may contribute to the combined use of these proven, evidence-based methods to reduce transmission and improve malaria infection outcomes is justified and needed to inform programs and policy in efforts to reduce the overall burden of malaria.

Key Words

Malaria, Malaria Indicator Survey, Demographic and Health Survey, Measure DHS, children, pregnant.

Introduction

This systematic review serves two purposes. The first is to demonstrate the viability of using DHS data as a resource for secondary data analysis for malaria research. The second and more specific purpose is to identify gaps in the current literature related to the singular and the combined use of insecticide treated nets (ITNs), indoor residual spray (IRS), and prompt and appropriate treatment with an artemisinin-based combination therapy (ACT) in children under five and the use of ITNs, intermittent preventive therapy (IPTp), and IRS in pregnant women in Africa.

This review includes the use of a database with designated search terms to find relevant, published literature. Inclusion and exclusion criteria are outlined below and were applied *a priori* to determine which studies to include in the review. The review was then analyzed to provide findings on the utility of DHS data as a source for secondary analysis and to identify research gaps related to prevention and good case management of malaria in children under five and pregnant women. The review was undertaken and reported in a manner to allow for reproducibility [1-4].

Background

Malaria

Malaria is endemic in over one hundred countries, and approximately 50% of the world's population is exposed to the parasite that causes this disease. In 2010 and 2012, malaria caused approximately 655,000 and 627,000 deaths, respectively, and there is no vaccination and too little coverage with known control measures [5,6].

Children and Malaria

Infectious diseases, including malaria, are the most prominent causes of global mortality in children under age five [7]. Malaria contributes to approximately 7% of global deaths under five and up to 15% of deaths in African children [7]. As cited, "The primary tool for the control of malaria in many parts of Africa remains the early diagnosis and treatment of clinical cases of malaria" [8]. Roll Back Malaria, in connection with the World Health Organization (WHO), stated that to meet the Millennium Development Goals to reduce the infant and under five mortality and the burden of disease associated with malaria, 60% of children under five who live in malaria endemic regions and who have malaria symptoms should be treated within 24 hours of developing fever [9]. A Ugandan study indicated that children under age five were more likely to have malaria parasitemia, malaria disease, and fever versus children older than five [10].

In addition to prompt treatment of fever, the WHO and other health oriented organizations, such as the President's Malaria Initiative (PMI) and various ministries of health, recommend the use of ACTs for malaria treatment within 24 hours, the use of ITNS, and IRS. These methods are specifically geared towards children under five [11-14]. See **Table 2.1.**

Mothers are known to be the primary caregiver and responsible for most initial decisions in treating their children's illnesses [15]. Characteristics such as maternal education, occupation, social economic status, and available resources have been shown in various regions of Africa to be associated with treatment seeking behavior among caregivers [16].

Pregnancy and Malaria

Pregnant women who are infected with malaria have an increased risk of anemia, spontaneous abortion, stillbirth, prematurity, and low birth weight of the infant. To reduce the chances of malaria transmission, the WHO recommends that pregnant women sleep under ITNs, use IRS, and have at least two doses of IPTp during antenatal care. If infected with malaria, prompt and effective treatment is necessary to reduce potential complications [19].

Demographic and Health Surveys

Demographic and Health Surveys (DHS) began in 1984 and is funded primarily by the United States Agency for International Development (USAID). The purpose of DHS is

Table 2.1: A brief description of prevention and case management methods

Insecticide Treated Nets (ITNs)	A bed net that has been treated to repel and kill mosquitoes with a pyrethroid insecticide and provides a barrier against mosquitoes while sleeping under the net. The net will typically last 6-12 months dependent upon washing and sun exposure [17]. DHS defines this variable as sleeping under a treated bed net the night prior to the survey [18].
Indoor Residual Spray (IRS)	Interior walls of a household sprayed with an insecticide against mosquitoes. DHS defines this variable as the household dwelling has sprayed walls against mosquitoes in the last 12 months [18].
Prompt and Appropriate Treatment of Fever	The treatment of fever within 24 hours of onset with a course of antimalarial drug therapy as recommended by each individual country's Minister of Health. According to the WHO, artemisinin combination treatment (ACT) is the appropriate treatment of malaria [11].

to collect and analyze data in developing countries to provide information on the demographics, health, and nutrition of women and children [20]. The surveys are unique in that the sampling structure is large and covers all regions of each country in the survey. DHS conducts several types of surveys, including the Standard DHS, AIDS Indicator Surveys (AIS), Service Provisions Assessment (SPA) Surveys, Malaria Indicator Surveys (MIS), Key Indicator Surveys (KIS), and other quantitative surveys [21]. Beginning in 2000, some Standard DHS surveys began to collect information on malaria variables, including bed net use, prompt and effective treatment of fever, and prophylactic treatment for malaria in pregnant women. More recently, some of the Standard DHS surveys have included information on indoor residual spraying among other malaria related information [22]. **Table 2.2** outlines the specific purposes of each of these surveys.

Between 2000 and early 2014, there have been 85 Standard, Interim, or Special DHS surveys performed or are currently ongoing across 40 African countries. As of early 2014, MIS have been conducted 39 times in 24 countries in Africa since 2006, the year MIS surveys were initiated [23].

Upon completion of a survey, a Final Report is compiled and published by DHS and presents descriptive and analytical findings of the survey. The raw data from many of these surveys can be made available through a registration process to the academic community for additional analysis.

Methods

Systematic Review

To demonstrate DHS-related publications as a useful source of data for malaria research in children under five and pregnant women, relevant studies reporting on malaria

Table 2.2: Types and purposes of demographic and health surveys

Standard Demographic and Health Surveys (DHS)	Gathers data across a wide span of demographic and health indicators that can be used for monitoring and evaluation. Variations of this survey include Interim DHS and Special DHS.
AIDS Indicator Surveys (AIS)	A standardized tool to measure current status of HIV/AIDS status and programs within a country. Some AIS surveys include a malaria module to gather additional information in this area.
Service Provision Assessment Surveys (SPA)	A tool to collect data on health facilities and programs available within the country.
Malaria Indicator Surveys (MIS)	A survey specifically designed to gather information on bed net use, fever, prompt and type of treatment along with other malaria associated variables. Demographic data are included with these surveys.
Key Indicator Surveys (KIS)	A survey that gathers health and targeted information on activities within a specified region of the country.
Other Quantitative Research	Specialized surveys that can gather data over a short period of time or within a small targeted area.
Qualitative Research	DHS will support qualitative research to gather needed information that is outside the surveys listed above.

outcomes in these populations were identified through a review of literature using the PubMed database. PubMed was chosen as the only database searched as it includes over 24 million citations from MEDLINE, other health and life science journals, and online published books [24]. In addition, all articles published in the Malaria Journal, the premiere journal of malaria research, are included in PubMed [25]. A highly sensitive search strategy, to capture all possible relevant studies through a systematic review, reduces the potential bias of not including important and relevant studies to the search; however, this can be highly inefficient. Therefore, a precision methodology was incorporated to narrow the focus and allow for a reasonable management of references returned in the literature review. This search provided a balance of completeness and efficiency [26,27].

PubMed Selection

To identify all studies related to DHS and malaria in African children and pregnant women, the following inclusion and exclusion criteria were applied in selecting publications for review:

1) Articles must be original and include an abstract in PubMed. If an abstract was not included, the article was not reviewed.
2) All articles must be published in English. Articles published in other languages were excluded.
3) There must be a reference in the title or abstract of the article to Demographic and Health Surveys. See specific queries below. Articles that did not reference DHS in some manner were excluded from the review.
4) Children and or pregnant women must be referenced in the title or abstract; otherwise, the article was not reviewed.

5) Africa or an African country must be referenced in the title or abstract; otherwise, the article was excluded.
6) Malaria must be referenced in the title or abstract; otherwise, the article was excluded.

From the articles that met this criteria, prevention tools (ITN, IPTp, and IRS) and case management methods (prompt and appropriate treatment with ACT) for malaria were further evaluated. While several of the studies did not analyze prevention and or case management methods, additional information such as demographic variables that may affect the prevention or case management of malaria were captured to inform future analyses of potentially significant factors related to the use of prevention and case management methods in children under five and pregnant women.

Database Query

Within the PubMed database, the following key terms and phases were used in the search to narrow the results and specifically query malaria related DHS surveys such as Standard DHS, MIS, or AIS: "demographic and health survey" AND "malaria", Malaria Indicator Survey AND "under five", Malaria Indicator Survey AND child*, Malaria Indicator Survey AND "under five", Malaria Indicator Survey AND pregnan*, demographic health survey" AND "malaria", demographic and health survey AND "malaria" AND child*, and demographic and health survey AND "malaria" AND pregnan*. Double quotes were used to query specific key word expressions and asterisks were used to represent any letters in the search, for example: pregnan* would return results on the words pregnant, pregnancies, pregnancy, etc. The search terms represent the main themes of this study [28].

Results

PubMed

Between June 12, 2014 and July 9, 2014 the systematic review search produced 1,176 articles that were screened from PubMed. Eighty-four articles were selected based on the inclusion, exclusion criteria described above. After review of each of the articles, the selection was further narrowed to 65 publications [29-93]. Those removed from the selection included studies that used adapted DHS surveys rather than the actual surveys or did not include children under five or pregnant women in the analyses. All studies selected were secondary analyses of the DHS data. See **Figure 2.1**.

All 65 articles that were within the database search were published after 2000 with the exception of one study published in 1997 [93]; however, eight publications used survey data that were collected prior to 2000 [51,60,75,83,87,89,90,92]. From these findings, it is clear that variables related specifically to malaria were captured in DHS surveys prior to 2000.

The number of chosen publications peaked in 2011 with 13 publications and zero publications in 1998-2002 and 2008. As of July 2014, 9 publications in 2014 have been published. Within the 65 total publications, 382 surveys were analyzed with at least 58 of those surveys being MIS or AIS surveys. Only Tanzania and Uganda used an AIS to collect the same information on malaria as an MIS. The MIS and AIS surveys ranged between the years 2005-2012. 307 of the surveys were either standard DHS, Special DHS, Interim DHS, or other quantitative and qualitative surveys such as Multiple Indicator Cluster Surveys (MICS) and Anemia and Malaria Prevalence surveys (AMP) which fall under the Demographics and Health Survey's jurisdiction. Other privately funded surveys were used in conjunction with DHS or MIS surveys within 17 of the publications.

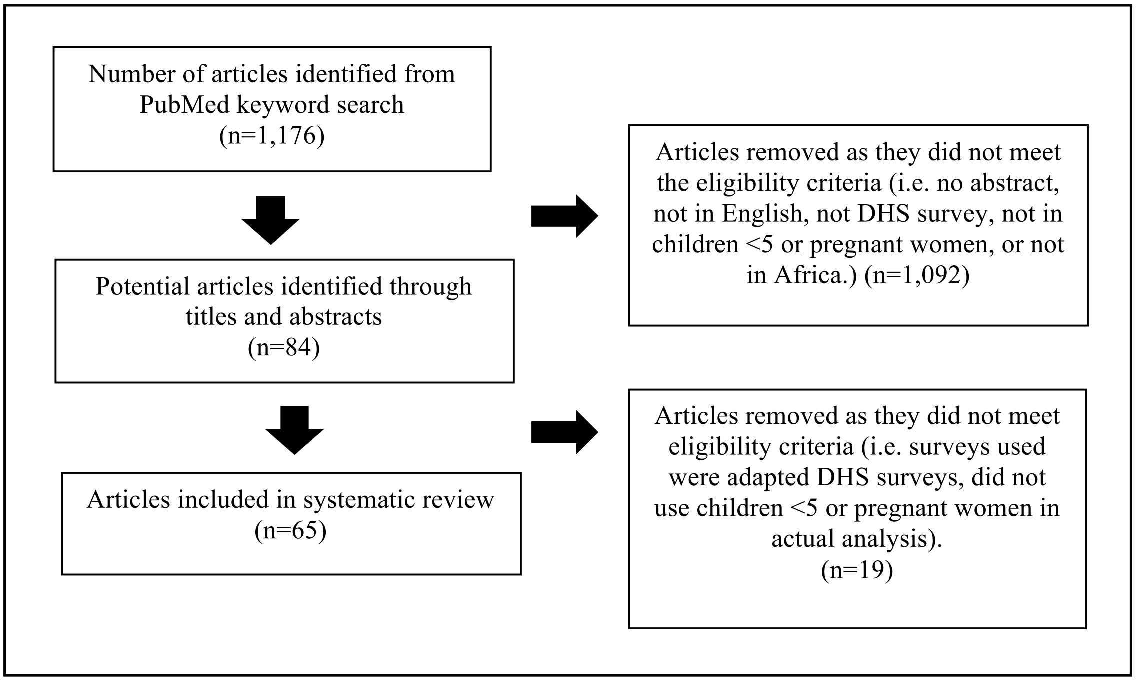

Figure 2.1: Systematic review inclusion/exclusion flow chart

At least 46 African countries were represented through all of the surveys. Of the countries listed, surveys from Ghana were used in 19 publications, Uganda surveys were used in 19 publications, surveys from Malawi were used in 18 publications, and Tanzania and Mali surveys were each used in 17 publications. Other countries with surveys such as South Africa, Sudan, and Botswana were only evaluated in one publication. Surveys in both the Congo (Brazzaville) and the Democratic Republic of the Congo were analyzed along with Sudan, North Sudan, and South Sudan in these publications. Many articles compared data outcomes from several different countries to look at overall practices as well as considered various surveys in one country to identify trends over time.

The 65 studies analyzed in this review were published in 26 different journals with the *Malaria Journal* claiming 21 of the publications and the *Public Library of Science (PLoS) One* with 10 publications. All other journals had a range of 1-4 publications.

Of the 65 publications, 63 included children under the age of five in the analysis and 17 publications included pregnant women in the analysis. Fifteen of the publications included both pregnant women and children under the age of five. Children over age five were also included in several of the articles that were analyzed but this was not broken down as the focus of this review is on children under five and pregnant women.

Research Focus

While the common theme of malaria and DHS surveys in children and pregnant women were used in the inclusion criteria, each study was unique in its hypothesis, primary outcomes, and the variables considered and controlled for in the data analyses. In this review, to examine utility of DHS surveys as a viable source of malaria research, demographic variables that may influence malaria outcomes such as age of the child, maternal age, family size, wealth index, urban/rural location, and maternal education were captured. In addition, variables related to the prevention and case management of malaria such as ITN use, IRS, IPTp, and prompt and appropriate treatment of malaria were included. The variables found throughout the reviewed literature were categorized into the following topical areas: Malaria Prevention, Malaria Treatment, Household Demographics, Household Properties, and General Health Care. The focus of this review are those variables related to Malaria Prevention and Malaria Treatment. See **Figure 2.2.** Other demographic variables included in the review articles that may be related to malaria prevalence, transmission, or prevention and case management are included in under Household Properties, Household Demographics, and General Health Care.

Prevention and Case Management

Forty of the articles reviewed consider at least one of the following: ITN use among children under five and or among pregnant women, IRS among households with children or pregnant women, prompt treatment among children under five, and/or ACT or appropriate treatment among children under five and IPTp use among pregnant women.

ITNs

Twenty-six of the 65 articles evaluated, to some extent, ITN use in children under five. Twelve of those articles considered different predictors of using an ITN including, household size, region of country, urban/rural residence, maternal knowledge of malaria, etc. Eleven articles evaluated ITN use among pregnant women. Other articles in the review (n=3) considered the use of bed nets but not specifically ITNs.

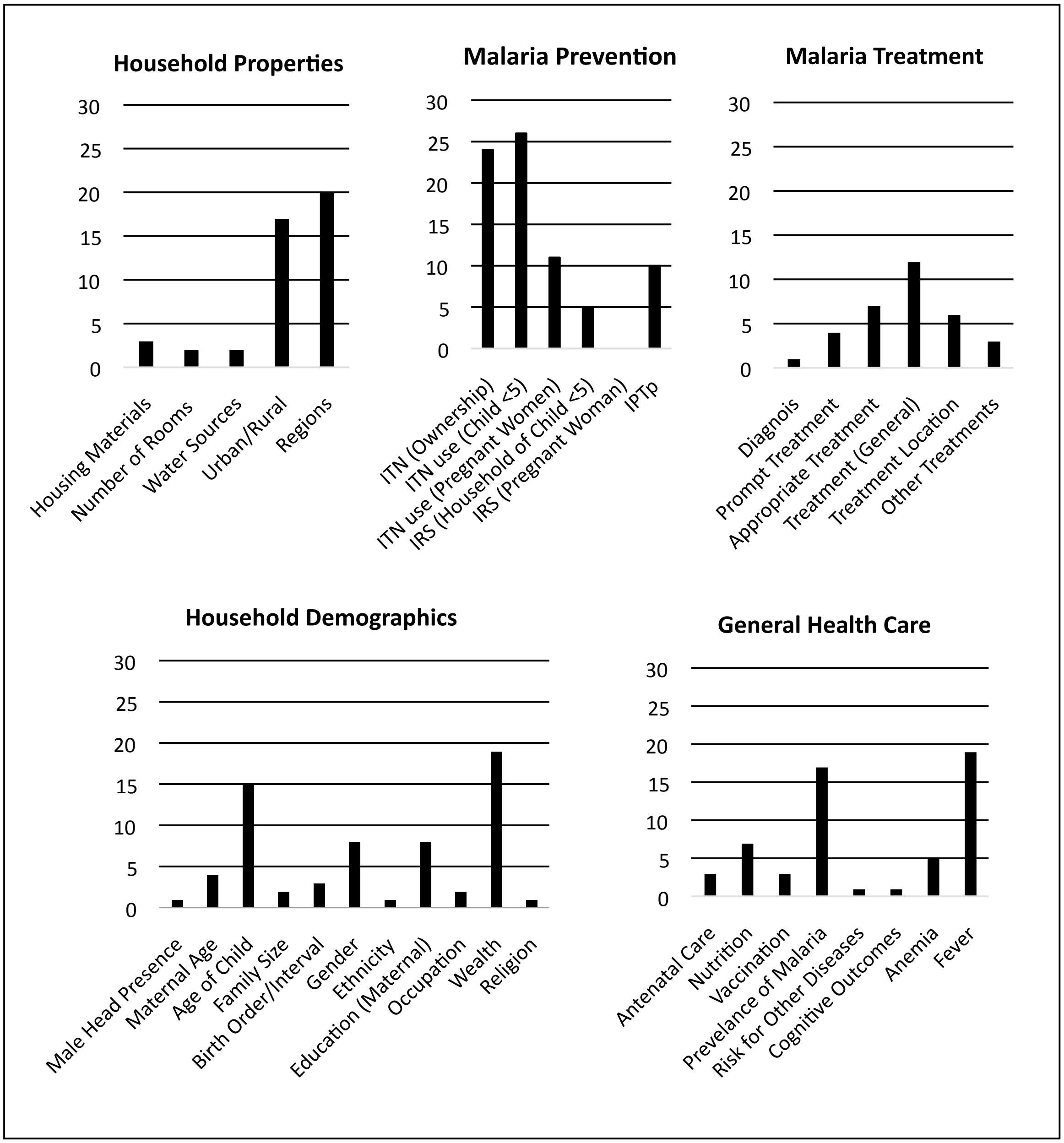

Figure 2.2: Number of times each variable was identified in the reviewed articles

IRS

Among the 65 articles reviewed, five included the prevalence of IRS in households with children under five. No additional analyses considering predictors of IRS use were included in these articles. There were no articles that looked at IRS use in households of pregnant women. Three other articles considered IRS use across all households but did not focus specifically on children under five or pregnant women.

Prompt Treatment among Children under Five

Four of the articles included prompt treatment in their analyses and three of the four considered a variation of region, urban/rural residence, wealth index, and where treatment was sought as potential predictors to prompt treatment. Of the four articles, two considered prompt treatment with an ACT.

Appropriate Treatment among Children under Five

Appropriate treatment for this systematic review is considered treatment with an ACT as treatment with other antimalarials such as chloroquine are no longer effective in most regions of malaria endemicity [61]. Seven articles specifically evaluated the use of ACT as a treatment in children under five. Two of those articles looked at wealth index and where treatment was sought as predictors of appropriate treatment. Twelve articles considered the use of antimalarials, but did not distinguish a difference between the use of ACT and other antimalarials. Other articles evaluated effective treatment but did not define effective treatment as non-ACT antimalarial or ACT, or the authors considered the use of quinine as an effective treatment. Six articles reported on receiving treatment but did not define what type of treatment.

IPTp

Within the review, ten articles reported the use of IPTp among pregnant women. Four of the articles considered region, urban/rural residence, wealth index, antenatal care visits, and owning a bed net as predictors of IPTp use.

Combination of Prevention and Case Management

Children under Five

Of the 65 articles reviewed, only six considered a combination of two prevention or case management methods in children under five. These included two articles that considered ITN use and prompt treatment of fever, three articles on ITN use and appropriate treatment with an ACT, and one article on the use of ITNs and IRS in the household. Only one article considered a combination of three prevention and case management methods: ITN use, prompt treatment, and appropriate treatment.

Pregnant Women

Only four articles considered a combination of two prevention methods for pregnant women; all were related to ITN and IPTp use. No articles considered a combination of all three prevention methods for pregnant women (ITN, IPTp, and IRS use).

Limitations

There are four main limitations to this review. First only the primary author of this study conducted the database literature review. Although thorough efforts were made to capture all relevant reviews and information, the lack of a second reviewer could allow for observer bias. Second, publication bias leads to positive outcomes being published. It is possible that there are other studies that have been conducted but are not published due to lack of "interesting findings" or "negative results." Third, efforts were taken to use the most relevant search terms; however, a search bias could be introduced if all possible terms were not included in this analysis. Finally, only articles that were published in English were evaluated. Publications in other languages may exist and provide additional information not captured in this review.

Discussion

The Demographic and Health Surveys, specifically those that collect information on malaria, are used as a tool to provide and monitor current practices and health trends to inform national malaria control programs and international programs such as the World Health Organization, the Roll Back Malaria program, the President's Malaria Initiative, the Global Fund, UNICEF, and other related organizations. The data gathered from these surveys is used by these organizations along with ministries of health and stakeholders of the individual countries. In addition, many of the dataset are available at no cost to the research community in general to conduct a larger range of analyses.

DHS Surveys

The outcomes of this systematic review clearly indicate that the DHS data whether used alone or in connection with other surveys can provide a wide breadth of information related to malaria. Hundreds of malaria-related DHS surveys across most African countries were included in the studies reviewed through this literature search. The number and variety of topics that could potentially affect malaria outcomes were found to be substantial and provide a wealth of knowledge. With only 65 studies found using the inclusion criteria, DHS surveys, specifically related to malaria in Africa and in children under five and pregnant women, may be an underutilized resource to study and publish important malaria findings across participating countries.

Through this review, the authors of this study found that the scope of information collected in these surveys, and the sample sizes that represent entire countries, lend this data to be a valuable resource for malaria research. Information regarding the current status of malaria, trends in malaria outcomes over time, and what factors may contribute to malaria within specific populations can be made available through publications to policy makers, governments, ministries of health, and nongovernment organizations. This knowledge can then be translated to assist in the tailoring of programs and policies for the various areas and regions affected by malaria.

Research Gaps

Prevention and Case Management

The following discusses the findings related to ITN use, IRS, prompt treatment of fever, appropriate treatment of fever, and IPTp use among children under five and pregnant women.

ITNs

Several of the articles reviewed contained data regarding ITN ownership in the household, but not all investigated the actual use of ITNs among children under five or pregnant women. When ITN use was evaluated, there were only a few articles that considered what variables such as wealth or education might influence the use of an ITN. Further studies using DHS data could provide additional information on the prevalence of

ITN use and what variables may predict the use of this evidence-based and recommended prevention tool across vulnerable populations.

IRS

There were few articles that reviewed IRS within the twelve months prior to data collection. As DHS surveys sample across a wide expanse of populations and regions, utilizing these surveys to identify the current status of IRS use is valuable to understand where spraying gaps may exist and where improvements could be made. Additional studies considering the prevalence and the predictors of IRS use among households with children and pregnant women are warranted.

Prompt Treatment of Fever

Although time to treatment of any antimalarial is captured in many of the DHS surveys, only four articles among the 65 reviewed reported information on prompt treatment. As prompt treatment is one of the cornerstones of malaria case management for the WHO and other health organizations such as the PMI and individual ministries of health, additional studies using DHS data would be useful to better examine where gaps in prompt treatment exist and what variables predict the use of prompt treatment of fever among children under five.

Appropriate Treatment

While several articles considered the treatment of fever with any antimalarial or other treatment options, the current recommendations of the WHO, along with other health organizations, is the use of ACTs. There were only a few articles that specifically evaluated the use of ACTs. It is important to note that a few articles considered the use of effective treatment, but never defined what constituted effective treatment. The DHS data collect information on specific antimalarials used for treatment of fever including ACTs and is a robust source for evaluating the use of ACTs among the populations. Further analyses regarding the use of ACT and what variables predict whether a child receives this appropriate treatment are suggested to further inform governments and policy makers how to improve the use of this recommendation.

Prompt/Appropriate Treatment

As with prompt treatment of fever, the information from the reviewed literature on the combination of prompt and appropriate treatment was scarce. As the joint use of both of these case management tools is recommended by the WHO and other health organizations, additional research in this area is encouraged through the use of DHS survey data along with identifying what variables may predict the use of combined prompt and appropriate treatment.

IPTp Use

As with the other forms of prevention considered in this review, only a few articles reviewed the use of IPTp among pregnant women. Additional research studying the variables that influence the use of recommended IPTp among this population would be valuable, especially when influencing what programs could be implemented to increase its use.

Combination of Prevention and Case Management

As previously outlined, the utilization of both malaria prevention and good case management methods is recommend by the WHO, several ministries of health, and other health organizations such as the PMI. While many of the articles reviewed included an evaluation of at least one preventive or one case management method, very few articles considered the combined use of more than one of these tools. None of the articles related to children under five considered the comprehensive use of ITNs, IRS, and prompt and appropriate treatment. Likewise, none of the articles related to pregnant women evaluated the comprehensive use of ITNs, IRS, and IPTp. This exposes a gap in the DHS literature regarding the study of recommended, evidence-based prevention and case management methods in an all-inclusive manner.

Conclusions

DHS datasets are a rich and useful source to identify trends and practices of malaria related to children and pregnant women in Africa. The findings from these datasets have the potential to improve intervention delivery, influence policy, and provide important information to individual countries concerning the current status of malaria.

It is important to note that although the recommendations of the WHO and other health organizations are to use control measures in combination, none of the articles reviewed analyzed the singular use of ITNs, IRS, prompt/appropriate treatment in children, or the use of ITNs, IRS, and IPTp in pregnant women within the context of one study and none of the articles considered the combined use of these control measures within the context of one study.

With the large amount of resources, including time and money, that is invested in malaria control, this review highlights the great need and calls for additional research to determine if children under age five and pregnant women are using none, some, or all of these prevention and case management methods in combination. Additionally, research to identify what factors or variables (e.g. maternal education, wealth, residence in urban/rural areas) might contribute to the comprehensive use of these individually proven methods to reduce transmission and improve malaria infection outcomes is justified and needed. This type of study would be valuable to both government and nongovernment policy makers as they determine, comprehensively, the gaps of using prevention and case management methods among malaria vulnerable populations such as children under five and pregnant women. The proposed studies could be conducted through the use of DHS data. Further use of this widely available data may provide important insight into areas that need improvement in efforts to advance the use of malaria control resources and reduce the overall burden of malaria in these endemic societies.

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CHAPTER 3

MALARIA PREVENTION AND CASE MANAGEMENT AMONG CHILDREN UNDER FIVE IN THREE AFRICAN COUNTRIES: ANALYSIS OF DHS MALARIA INDICATOR SURVEYS

Abstract

Background

The purpose of this study is to evaluate the independent and combined use of prevention and appropriate case management methods for malaria in children under age five in three different African countries (Angola, Liberia, and Tanzania). This assessment outlines practices, considers changes to practices over time, and identifies areas of opportunity to improve the prevention and management of malaria in these populations.

Methods

Demographic and Health Surveys from three countries at two separate time points (Angola 2006-07, Angola 2011, Liberia 2009, Liberia 2011, Tanzania 2007-08, and Tanzania 2011-12) were used for this study. A descriptive, evaluation analysis was undertaken to identify the percentages of children under age five who had a reported fever and utilized one or more malaria management method, i.e., insecticide treated nets (ITNs), indoor residual spray (IRS), and or prompt and/or appropriate treatment either independently or in combination.

Results

Among the six surveys, independent use of appropriate treatment ranged from 3% to 38%, prompt treatment ranged from 54% to 76%, and combined prompt/appropriate treatment ranged from 3% to 25%. ITN use ranged from 30% to 75% and IRS use ranged from 1% to 18%. When considering a combined use of both prevention and appropriate case management methods (ITN use, IRS use, and prompt/appropriate treatment), the range was between <1% to 3%.

Conclusion

While some improvements in the use of malaria prevention and appropriate case management methods were noted over time in the analysis, single and combined use of these management methods are inadequate. This analysis calls for additional studies that will evaluate what variables may predict the single and combined use of, and access to, prevention and appropriate case management methods. Such analyses would yield insight into why some and not others are utilizing proven methods to reduce the burden of malaria in children under age five.

Keywords

Malaria, Demographic Health Survey, children under age five, Malaria Indicator Survey.

Introduction

The World Health Organization (WHO), and other organizations such as the President's Malaria Initiative (PMI) and many ministries of health, encourage the combined use of both malaria prevention and prompt and appropriate case management methods in children under age five who have fever and who live in malaria endemic areas of Africa [1-3]. Yet, a review of the literature yielded no studies that determined the prevalence of the independent or combined use of malaria prevention methods such as insecticide treated nets (ITNs) or indoor residual spray (IRS), and prompt and appropriate treatment of malaria among children less than 5 years of age who were reported to have fever within one article. Demographic and Health Surveys (DHS) serves as an important source of health information and harbors information regarding malaria prevention and control coverage in many African countries. The purpose of this analysis is to examine DHS data to identify the rates of utilizing one or more malaria prevention and appropriate case management methods to reduce the overall impact of malaria on children under age five.

Background

Malaria

Infectious diseases, such as malaria, cause some of the most complex global health issues faced today. Malaria is a continual threat that adversely impacts health, development, and economic productivity in endemic regions [3]. A systematic analysis concluded that infectious diseases, including malaria, were the most prominent cause of global mortality in children under five [4]. Malaria contributes to approximately 7% of global mortality in children under five and up to 15% of deaths in African children [5]. Endemic in over one hundred countries approximately 50% of the world's population is at risk for malaria. In

2010 and 2012, malaria caused approximately 655,000 and 627,000 deaths, respectively, and there is no vaccination and too little coverage with known control measures [5,6].

Children and Malaria

As cited, "The primary tool for the control of malaria in many parts of Africa remains the early diagnosis and treatment of clinical cases of malaria" [7]. Roll Back Malaria, in connection with the World Health Organization (WHO), stated that to meet the Millennium Development Goals to reduce the infant and under age five mortality and the burden of disease associated with malaria, 60% of children under age five who live in malaria endemic regions and who have malaria symptoms should be treated within 24 hours of developing fever [8]. A Ugandan study indicated that children under five were more likely to have malaria parasitemia, malaria disease, and fever versus children older than five [9].

Mothers are known to be the primary caregiver and responsible for most initial decisions in treating their children's diseases [10]. Factors such as maternal education, occupation, social economic status, and available resources have been shown in various regions of Africa to affect seeking treatment for malaria [11].

In addition to *prompt treatment of fever* (within 24 hours of onset), the WHO and other health oriented organizations, such as PMI and ministries of health, also recommend the use of *appropriate treatment* with artemisinin-based combination therapies (ACTs), as well as the use of preventive methods such as ITNS and IRS, especially among children under age five [1-3]. The malaria control methods used by these organizations set the gold standard in this analysis for the most effective approach to comprehensive malaria control in children under five. While individual components of these recommendations (i.e., the use of ITNs, IRS, and prompt and appropriate treatment of fever) are essential to overcoming the burden of malaria, the use of these tools synergistically provide a comprehensive approach to control the transmission and health consequences of malaria [12]. See **Table 2.1.**

The Demographic and Health Surveys (DHS) Program data, specifically the Malaria Indicator Surveys, serve as a source to review patterns, identify correlations and relationships between variables, and provide additional information to the literature necessary to identify and implement effective interventions and public health policy to ultimately improve the health of people living in various populations among malaria endemic communities [13].

Malaria Indicator Surveys from three different countries across two separate time periods: Angola (2006-2007 and 2011), Liberia (2009 and 2011), and Tanzania (2007-2008 and 2011-2012), will constitute the datasets utilized for this analysis [14-19].

Demographic and Health Surveys (DHS)

The DHS Program began in 1984 and is funded primarily by the United States Agency for International Development (USAID). The purpose of the DHS Program is to collect and analyze data in developing countries to provide information on the demographics, health, and nutrition of women and children. As stated on the DHS Program website, "These surveys are designed to be nationally representative with a sample size often of more than 3,000 households…and are typically conducted every 3-5 years in collaboration with national ministries of health and statistics bureaus" [22]. The DHS Program conducts several topic-specific surveys, including a Malaria Indicator Survey.

These malaria-specific surveys provide a unique, comprehensive set of cross-sectional data with exceptionally large sample size structures that can offer an understanding of malaria-related health outcomes and practices across entire countries. While household information was gathered including demographic information about male residents, the

Malaria Indicator Surveys focused specifically on women within a reproductive age range. The DHS Program is distinctive in that the information collected not only informs decision making and policy within these countries, but provides each country with the ownership of the data to analyze and create appropriate policies that will improve the health and well-being of women and children.

Government Guidelines

As each malaria endemic region is different in respect to climate, geography, health systems, and resource availability, a custom approach to malaria control is necessary [3]. According to the WHO, "the package of interventions to be implemented in each district is first and foremost a country decision, informed by WHO malaria control recommendations" [3]. The government guidelines, by year and country, for case management and prevention measures are outlined in the *Approach* section.

Methods

The following analysis will describe the prevalence of using each of the control methods either independently or in combination among children under the age of five who reported a fever within the two weeks of the survey data collection.

Study Setting

These surveys were conducted across both urban and rural regions of the following countries during two different time periods: Angola (2006-2007 and 2011), Liberia (2009 and 2011), and Tanzania (2007-2008 and 2011-2012). The data were collected for DHS and were made available upon request through the DHS website: *MalariaSurveys.org*. These malaria-specific surveys are conducted during high malaria transmission seasons to capture these data.

Sampling Design

The Malaria Indicator Surveys (MIS) used a multistage randomized cluster sample of households in each country. A description of the sampling design may be found in the individual country Final Reports [14-19].

Study Subjects

Household surveys were conducted to identify women within a specified age range (15-49 years). A total of 40,208 women between the ages of 15-49 years of age were surveyed individually across these three countries (Angola, Liberia, and Tanzania) in two separate surveys conducted in each country. Within this sample, these women reported a total of 33,602 living children under the age of five. 9,006 of these children reported to have had a fever within the two weeks prior to the survey. As Zanzibar has a separate government and different policies regarding malaria than Tanzania, all data regarding children living in Zanzibar were removed from the analysis (n=229 from Tanzania 2007-08 and n=171 from Tanzania 2011-12) to avoid potential confounding. For this analysis, only those respondents who reported a fever in a child under five years of age during the two weeks prior to the survey were included.

Data Collection

Data were collected using the household and women's questionnaires, prepared by the Monitoring and Evaluation Reference Group (MERG) created for the Roll Back Malaria

Partnership. Each survey was adapted to the local context as necessary [23]. These surveys have collected data on general demographics in addition to the number of children under five who had a fever within two weeks prior to the survey, if and what type of antimalarials were used on the same or next day after the onset of fever, the use of ITNs among children, and IRS use in each household surveyed. After collection, data are recoded by DHS to improve accessibility and to facilitate efficient analysis. The recoded data are structured to have standardized data to allow for comparison across countries. Country-specific data is also collected. A recode data manual is provided on the DHS website (http://dhsprogram.com/publications/publication-dhsg4-dhs-questionnaires-and-manuals.cfm).

Human Subjects

DHS surveys, in connection with USAID and various ministries of health that represent each country that participated, obtained the necessary ethics reviews and consents to conduct each survey. Ethical review and approval for this study was provided by the Institutional Board Review from the University of Utah.

Measures

The following variables were considered in this analysis:

Use of Insecticide Treated Nets (ITN) in Children 0-59 Months **-** The DHS data provide the number of children under the age of five that slept under a mosquito net the night before the survey. The data include the use of "any net," an "ever-treated" net, or ITN. For this analysis, only the variable reporting the actual use of an ITN the night before the survey. The variables that report "any net" or "ever-treated net" were not included in this analysis.

Indoor Residual Spray (IRS) – This DHS variable includes all households that had the interior walls of the house sprayed with insecticide against mosquitoes within the 12 months prior to the survey.

Prompt Treatment of Fever - As defined by the DHS, prompt treatment of fever is treatment with an antimalarial drug, regardless of whether the antimalarial is appropriate or not, on the same or next day of fever onset. In order to limit recall bias, only information on fevers that had occurred in the two weeks previous to the survey was included.

Appropriate Treatment of Fever - Appropriate treatment of fever is defined as the treatment recommended by each individual country's ministry of health (**Table 3.1**). For the specific countries in this analysis, all government recommendations include treatment with an ACT. All other treatments were considered not-appropriate. This dataset provides the following options for treatment: SP/Fansidar, chloroquine, amodiaquine, quinine, combination with artemisinin (recommended), other, or nothing.

Government Guidelines

Table 3.1 summarizes the guidelines outlined by the ministry of health for each country and year of the surveys analyzed.

Data Analysis

Statistical analysis was conducted by using StataCorp. 2003. Stata Statistical Software: Release 8.2. College Station, TX: StataCorp LP. Descriptive and general statistics for each country were used to identify characteristics of the sample including the prevalence of each variable and outcome. Only those children under age five that had a fever in the past two weeks were included in the data analysis. A comparison within each country across years was

Table 3.1: Government guidelines for each country and year [2,24-28]

	Appropriate Treatment	**ITN**	**IRS**
Angola 2006-07	Artemether-lumefantrine (an ACT) OR amodiaquine-artesunate (an ACT) if not available	Government supports use of ITN and provides free distribution to all CU5	Government supports the use of IRS - some provinces in the country received IRS via government
Angola 2011	Artemether-lumefantrine (an ACT) OR amodiaquine-artesunate (an ACT) if not available	Universal coverage with one ITN for every two residents - free net distribution	IRS coverage across many provinces of Angola -all provinces to receive IRS – coverage not 100% as of 2011
Liberia 2009	Artesunate-amodiaquine (an ACT)	One ITN per sleeping space (approx. 3 nets per household)	No specific national plan for IRS - PMI supports IRS in some areas
Liberia 2011	Artesunate-amodiaquine (an ACT)	ITN use among whole population - free distribution to children - supplies limited.	No specific national plan for IRS - PMI supports IRS in some areas
Tanzania 2007-08	Artemether-lumefantrine (an ACT)	Goal was 40% coverage of CU5 - discount vouchers available, however limited distribution	No formal IRS efforts, but IRS provided in some areas
Tanzania 2011-12	Artemether-lumefantrine (an ACT)	Universal coverage strategy	IRS coverage of 2 million in 2010 - continued IRS is planned for 2011-12

also conducted.

Results

The following results are outlined by fever and according to prevention and case management methods of malaria in children under age five. Information for each country and survey year is found within each section.

Fever

Within the Angola 2006-07 survey, there were 1,698 children under the age of five. 380 (22.7%) of the children were either marked on the surveys as "do not know" or had missing data related to fever, and 265 (15.6%) of the children were reported to have had a fever within two weeks prior to the survey. For the Angola 2011 survey, there were 8,242 children under age five, 536 (6.5%) of the children were either marked on the surveys as "do not know" or had missing data related to fever, and 2,645 (32%) children were reported to have had a fever within two weeks prior to the survey.

In the Liberia 2009 survey, there were 4,193 children under age five, 555 (13.2%) of the children were either marked on the surveys as "do not know" or had missing data related to fever, and 1,600 (38.1%) children under five were reported to have had a fever within two weeks prior to the survey. The Liberia 2011 survey included 3,319 children under age five, 309 (9.3%) children were either marked on the surveys as "do not know" or had missing data related to fever, and 1,617 (48.7%) children were reported to have had a fever within two weeks prior to the survey.

Within the Tanzania 2007-2008 survey, there were 5,526 children under age five, 519 (9.3%) of the children were either marked on the surveys as "do not know" or had missing data related to fever, and 1,200 (21.7%) children were reported to have had a fever within two weeks prior to the survey. Lastly, during the Tanzania 2011-12 survey, there were 7,529 children under age five, 491(6.5%) children were either marked on the surveys as "do not know" or had missing data related to fever, and 1,679 (22.3%) children were reported to have had a fever within two weeks prior to the survey.

As previously noted, only those children with a reported fever within the two weeks of survey administration were included in this analysis. Those children who were missing data regarding appropriate treatment, prompt treatment (if treated), ITN use, and IRS were removed from the analysis. **Table 3.2** outlines the initial baseline number of children under five with a fever for each country and survey and includes the number of children removed from the analysis of each survey due to missing variables related to malaria prevention and case management.

ITNs

For the Angola 2006-07 survey, approximately 35% of the data regarding the use of ITNs among children was missing from this specific dataset. To determine whether the populations that provided data and those missing data were different on key factors such as urban/rural residential location, maternal education, or wealth index, a chi-squared attrition analysis was conducted. The analysis determined that the populations were indeed significantly different (p-value <.05) based on urban/rural residential location, maternal education, and wealth index. Based on this information, and the high number of missing values, ITN use for this survey was not further considered in the analysis. See **Table 3.3**. In the Angola 2011 survey (n=2,603), 29% (frequency [*f*] =769) of children slept under an ITN the night prior to the survey. In the Liberia 2009 survey (n=1,549), 34% (*f*=531) of the children under five slept under an ITN the night prior to the survey. Within the Liberia 2011

Table 3.2: Number and percentage of values removed when data for ITN use, IRS use, appropriate, and prompt treatment was missing

Survey	Total number of children under five with fever (within 2 weeks of survey)	Final number of children included in analysis after key missing variables were removed	Percentage of missing values (ITN use, IRS, and prompt/ appropriate treatment)
Angola 2006-2007	265	255	3.77%
Angola 2011	2,645	2,603	1.59%
Liberia 2009	1,600	1,549	3.19%
Liberia 2011	1,617	1,529	5.44%
Tanzania 2007-2008	971	936	3.60%
Tanzania 2011-2012	1,508	1,453	3.65%

Table 3.3: Children reported to have a fever within two weeks of the survey that utilized a form of malaria prevention or case management

	Angola 2006-07 n=255 *f* (%)	Angola 2011 n=2,603 *f* (%)	Liberia 2009 n=1,549 *f* (%)	Liberia 2011 n=1,529 *f* (%)	Tanzania 2007-08 n=936 *f* (%)	Tanzania 2011-12 n=1,453 *f* (%)
ITN Use	-	769 (29.5)	531 (34.3)	620 (40.6)	280 (30)	1,090 (75)
IRS Use	9 (3.5)	147 (5.7)	-	149 (9.7)	10 (1)	262 (18)
Appropriate Treatment	8 (3.1)	543 (20.9)	447 (28.9)	587 (38.4)	213 (22.8)	512 (35.2)
Prompt Treatment (any treatment)	53 (75.7)	387 (54.4)	512 (54)	518 (62.9)	314 (59.8)	525 (64.9)
Prompt & Appropriate Treatment	7 (2.7)	277 (10.6)	241 (15.6)	383 (25)	140 (15)	334 (23)
"-" indicates too many missing values for analysis						

survey (n=1,529), 40% (*f*=620) of the children slept under an ITN the night prior to the survey. In the Tanzania 2007-08 survey (n=936), 30% (*f*=280) of the children slept under an ITN the night prior to the survey. Lastly, in the Tanzania 2011-12 survey (n=1,453), 75% (*f*=1,090) of the children slept under an ITN the night prior to the survey.

IRS

The following percentages and frequency of households with children under five that used IRS within 12 months of the survey are as follows: Angola 2006-2007 (3%, *f*=9), Angola 2011 (5%, *f*=147), Liberia 2009 (data on IRS use within households over the 12 months prior to the survey were not captured within this survey), Liberia 2011 (10%, *f*=149), Tanzania 2007-08 (1%, *f*=10), and Tanzania 2011-12 (18%, *f*=262). See **Table 3.3**.

Prompt and Appropriate Treatment

In the Angola 2006-2007 survey, 3% (*f*=8) received appropriate treatment (ACT), and 24% (*f*=63) received a different antimalarial. Of the 71 children that were treated with any antimalarial, 74% (*f*=53) received the treatment on the same or next day of fever onset. Seven children (3%) received both prompt and appropriate treatment. Within the Angola 2011 survey, 20% (*f*=543) received appropriate treatment (ACT), and 6% (*f*=169) received a different antimalarial. Of the 712 children that were treated with any antimalarial, 54% (*f*=387) received treatment on the same or next day of fever onset. 277 children (11%) received both prompt and appropriate treatment.

In the Liberia 2009 survey, 29% (*f*=447) received appropriate treatment (ACT) and 32% (*f*=501) received a different antimalarial. Of the 948 children that were treated with any antimalarial, 512 (54%) received treatment on the same or next day. 241 children (15%) received both prompt and appropriate treatment. For the Liberia 2011 survey, 38% (*f*=587) received appropriate treatment (ACT) and 15% (*f*=237) received a different antimalarial. Of the 824 children that were treated with any antimalarial, 518 (63%) received treatment on the same or next day. 383 children (25%) received both prompt and appropriate treatment.

Within the Tanzania 2007-08 survey, 23% (*f*=213) received appropriate treatment (ACT) and 33% (*f*=312) received a different antimalarial. Of the 525 children that were treated with any antimalarial, 60% (*f*=314) received treatment on the same or next day. 140 children (15%) received both prompt and appropriate treatment. Lastly, in the Tanzania 2011-12 survey, 35% (*f*=512) received appropriate treatment (ACT) and 20% (*f*=297) used a different antimalarial. Of the 809 children that were treated with any antimalarial, 525 (65%) received treatment on the same or next day. 334 children (23%) received both prompt and appropriate treatment. See **Table 3.3**.

Combination of Prevention and Case Management

In the Angola 2006-07 survey, when considering the combined use of prompt and appropriate treatment and IRS, 0% of the children reported to have had with fever used these two options (ITN use was not described due to the high number of missing values). For the Angola 2011 survey, nine children or <1% used a combination of prompt/appropriate treatment, ITNs, and IRS. There were 158 children (6%) that utilized some combination of two of these three tools: ITN and IRS (*f*=49), prompt/appropriate treatment and IRS (*f*=17), and prompt/appropriate treatment and ITN (*f*=92).

Within the Liberia 2009 survey, when considering the combined use of prompt/appropriate treatment and ITN use, 90 children with fever (6%) used these two options (IRS was not described as these data were not captured during the survey). For the Liberia 2011 survey, ten (<1%) children used a combination of prompt/appropriate treatment, ITNs, and IRS. 230 children (15%) utilized some combination of two of these three tools: ITN and IRS (*f*=48), prompt/appropriate treatment and IRS (*f*=31), and prompt/appropriate treatment and ITN (*f*=151).

For the Tanzania 2007-08 survey, less than 1% of all children (*f*=2) used a combination of appropriate treatment, ITNs, and IRS. 65 children (7%) utilized some combination of two of these three tools: ITN and IRS (*f*=2), prompt/appropriate treatment and IRS (*f*=1), and prompt/appropriate treatment and ITN (*f*=62). In the Tanzania 2011-12 survey, there was an increase in the number of children that used a combination of appropriate treatment, ITNs, and IRS, as recommended by the WHO and PMI (3% or *f*=46). 393 children (27%) utilized some combination of two of these three tools: ITN and IRS (*f*=159), prompt/appropriate treatment and IRS (n=9), and prompt/appropriate treatment and ITN (*f*=225). See **Table 3.4**.

Comparisons of Countries over Time

A chi-squared analysis was conducted for each country to determine whether there was a significant difference found between, ITN use, IRS, appropriate treatment, prompt treatment with any antimalarial, and a combined prompt/appropriate treatment over the time (from one survey to the next). See **Table 3.5**. A similar analysis was conducted for each country to determine whether there was a significant difference found between the combined use of ITNs, IRS, and prompt/appropriate treatment over the years of the surveys for each country. See **Table 3.6**.

Table 3.4: Outcomes of combined prevention and case management for each country and survey

Prompt/ Appropriate Treatment	ITN Use	IRS Use	Angola 2006-07 n= 255 *f* (%)	Angola 2011 n=2,603 *f* (%)	Liberia 2009 n=1,549 *f* (%)	Liberia 2011 n=1,529 *f* (%)	Tanzania 2007-08 n=936 *f* (%)	Tanzania 2011-12 n=1,453 *f* (%)
No	No	No	239 (94)	1,586 (61)	867 (56)	627 (41)	575 (61.4)	252 (17.3)
Yes	No	No	7 (2.7)	159 (6)	151 (9.8)	191 (12.5)	75 (8)	54 (3.7)
Yes	Yes	No	-	92 (3.5)	90 (5.8)	151 (9.9)	62 (6.6)	225 (15.5)
Yes	No	Yes	0 (0)	17 (<1)	-	31 (2)	1 (<1)	9 (<1)
No	Yes	No	-	619 (23.8)	441 (28.5)	411 (26.9)	214 (22.9)	660 (45.4)
No	Yes	Yes	-	49 (1.9)	-	48 (3.1)	2 (<1)	159 (10.9)
No	No	Yes	9 (3.5)	72 (2.8)	-	60 (3.9)	5 (<1)	48 (3.3)
Yes	Yes	Yes	-	9 (<1)	-	10 (<1)	2 (<1)	46 (3.2)

Table 3.5: Chi-Squared analysis to detect differences between survey years for ITN use, IRS, appropriate treatment, prompt treatment, and the combination of prompt and appropriate treatment

	Angola 2006-07 n=255 *f* (%)	Angola 2011 n=2,603 *f* (%)	Angola Combined P-value	Liberia 2009 n=1,549 *f* (%)	Liberia 2011 n=1,529 *f* (%)	Liberia Combined P-value	Tanzania 2007-08 n=936 *f* (%)	Tanzania 2011-12 n=1,453 *f* (%)	Tanzania Combined P-value
ITN Use	-	769 (29.5)	-	531 (34.3)	620 (40.6)	0.000*	280 (30)	1,090 (75)	0.000*
IRS Use	9 (3.5)	147 (5.7)	0.155	-	149 (9.7)	-	10 (1)	262 (18)	0.000*
Appropriate Treatment	8 (3.1)	543 (20.9)	0.000*	447 (28.9)	587 (38.4)	0.000*	213 (22.8)	512 (35.2)	0.000*
Prompt Treatment (any treatment)	53 (75.7)	387 (54.4)	0.001*	512 (54)	518 (62.9)	0.000*	314 (59.8)	525 (64.9)	0.060
Prompt & Appropriate Treatment	7 (2.7)	277 (10.6)	0.000*	241 (15.6)	383 (25)	0.000*	140 (15)	334 (23)	0.000*

P-values <.05 are denoted with an *.

Table 3.6: Chi-Squared analysis to detect differences between survey years for combined prevention and case management

Prompt & Appro-priate Treatment	ITN Use	IRS Use	Angola 2006-07 n= 255 *f* (%)	Angola 2011 n=2,603 *f* (%)	Angola Combined p-value	Liberia 2009 n=1,549 *f* (%)	Liberia 2011 n=1,529 *f* (%)	Liberia Combined p-value	Tanzania 2007-08 n=936 *f* (%)	Tanzania 2011-12 n=1,453 *f* (%)	Tanzania Combined p-value
No	No	No	239 (94)	1,586 (61)	0.000*	867 (56)	627 (41)	0.000*	575 (61.4)	252 (17.3)	0.000*
Yes	No	No	7 (2.7)	159 (6)	0.028*	151 (9.8)	191 (12.5)	0.015*	75 (8)	54 (3.7)	0.000*
Yes	Yes	No	-	92 (3.5)	-	90 (5.8)	151 (9.9)	0.000*	62 (6.6)	225 (15.5)	0.000*
Yes	No	Yes	0 (0)	17 (<1)	0.196	-	31 (2)	-	1 (<1)	9 (<1)	0.058
No	Yes	No	-	619 (23.8)	-	441 (28.5)	411 (26.9)	0.324	214 (22.9)	660 (45.4)	0.000*
No	Yes	Yes	-	49 (1.9)	-	-	48 (3.1)	-	2 (<1)	159 (10.9)	0.000*
No	No	Yes	9 (3.5)	72 (2.8)	0.483	-	60 (3.9)	-	5 (<1)	48 (3.3)	0.000*
Yes	Yes	Yes	-	9 (<1)	-	-	10 (<1)	-	2 (<1)	46 (3.2)	0.000*

P-values <.05 are denoted with an *

Angola 2006-07 and 2011

As a significant amount of ITN data was missing from the Angola 2006-07 survey, a comparison between years on this preventive tool is not possible. Although IRS use appeared to slightly increase over the four-year period, it was not significantly different (p-value=0.15) and the rate of use remained extremely low. Using an ACT for presumptive treatment of malaria greatly increased and showed a significant difference (p-value=0.000) from the first survey to the second (3.1% to 20.9%). The reason for this increase is unknown; however, it is possible that the sample size increase in the second survey provided a better estimate of those receiving ACTs or perhaps there was increased availability of ACTs. Prompt treatment of fever decreased across years demonstrating a significant difference (p-value=0.001). The reason for this decrease is unknown. Finally, the combination of prompt/appropriate treatment did significantly increase (p-value=0.000) from 2.7% to 10.6%. This is most likely due to the increase in the number of children receiving an ACT in 2011. When considering the combined use of preventive and case management methods, the number of children that did not use any control methods significantly decreased by 33% from 2006-07 to 2011.

Liberia 2009 and 2011

The use of ITNs significantly increased by approximately 6% over a two-year period in Liberia (p-value=0.000). Changes to IRS use are unavailable, as these data were not captured in the 2009 survey. Use of an ACT for treatment of fever significantly increased by approximately 10% (p-value=0.000) across the two surveys and prompt treatment with any antimalarial also significantly increased by 8% (p-value=0.000). With these increases, the combination of both prompt and appropriate treatment significantly increased by approximately 10% over the two-year period (p-value=0.000). Although relatively small, significant differences were found from 2009-2011 in the number of children using at least one or more combined control methods. Specifically, in the second Liberian survey (2011), there was an increase of 15% of children utilizing at least one of the malaria control methods compared to 2009 (p-value=0.000).

<u>Tanzania 2007-08 and 2011-12</u>

The data within the Tanzanian surveys allow for a comparison of all malaria control methods over time. When considering the use of an ITN, there was a significant increase of use (30% to 75%, p-value=0.000) over the four-year period of the surveys. There was also a 17% increase (p-value = 0.000) in the use of IRS across the two surveys. Appropriate treatment with an ACT increased by about 12% (p-value=0.000). Although prompt treatment with any antimalarial improved by approximately 5%, the difference between survey years was not found to be significant (p-value=0.060). When considering the combined used of prompt and appropriate treatment, there was an overall significant increase of 8% (p-value=0.000). While there are many significant but modest increases across the use of combined malaria control methods, the biggest change was found among those that used at least one method of prevention and/or appropriate case management. Specifically, the number of children that did not use any control methods decreased by 44% from 2007-08 to 2011-12 (p-value=0.000). This is likely due to the significant increase of ITN use among the population.

Discussion

With the WHO recommendations, along with other health organizations, to utilize a descriptive analysis reviews the rates of implementation of these guidelines in Angola, Liberia and Tanzania during the DHS surveyed years among children under age five with reported fever.

Limitations

As this is a retrospective, secondary data analysis, this study is limited to the data provided. The data are provided as was reported by the women interviewed. Each survey was conducted over several months; therefore, the surveys may not have captured every interview during the high malaria transmission season.

While malaria was not confirmed by diagnostic testing in these children, fever was used as a marker for malaria given the endemicity and prevalence of malaria in this region. Other causes of fever were not considered in the analysis. There were also several children in the general population that had missing data related to a fever in the two weeks prior to the survey. While this may introduce some bias, due to the nature of secondary data analysis, only those with a reported fever were included in this study.

With the evaluation of only children under five with a fever, this group of children could potentially be part of a more noncompliant population. Further evaluation of those that did not have a fever and used prevention methods (ITNs and IRS) may demonstrate potential differences between these two populations.

For this study, only the use of ITNs was included. There are data pertaining to the use of untreated bed nets, ever treated bed nets, etc., but as ITNs are the most effective and standard for most countries, it was the variable evaluated. In addition, with the nature of cross-sectional studies, the use of the ITN the night previous to the study must be used as a reliable indicator of consistent use. Data about correct usage of ITNs were not provided.

Fever

Although the numbers of reported fever for each country may not accurately reflect the actual number of fevers that occurred in the two weeks prior to the survey due to missing values, it is interesting to note that the percentage of fevers increased within each country across surveys. With the exception of Tanzania surveys, the increase in fevers is substantial. This may be an indicator that the programs and information regarding prevention and case management methods in Angola and Liberia are not making the intended impact to reduce malaria prevalence. While fever has not greatly increased across the four year span in Tanzania, it did not decrease, also suggesting that the intended consequences of national programs may not be making as large of an impact as intended.

ITNs

For Angola, a comparison of ITN use from year to year to year is not possible due to a significant amount of missing values in the first survey (2006-07). Although the guidelines in 2011 call for universal coverage with one ITN for every two residents, only 30% of this vulnerable population utilized an ITN. There is a great need to understand what populations are and are not using the ITNs, what populations possess or do not possess an ITN, and how to better incorporate the use of ITNs among the population to meet Angola's goal of universal coverage of all residents. In Liberia, from 2009 to 2011, there is a small but significant increase in ITN use. As with Angola, there is still a great need to understand why some of the population is utilizing ITNs as the reported coverage is still not sufficient and does not meet the government recommendations of ITN use among the whole population. Of significant note, the use of ITNs from one year to the next in Tanzania increased substantially. This surge in use is to be commended and could be due to the shift in policy in 2007-08 of 40% coverage among children under five to the universal coverage strategy in 2011-12.

IRS

The use of IRS did not increase dramatically in Angola from the years 2006-07 to 2011) despite the government's IRS activities in various regions of the country over the years of both surveys. The IRS program was still underway in 2011 after the survey was completed.

IRS data were not recorded in the Liberia 2009 survey and only a small number of households in the 2011 study reported the use of IRS within 12 months of the survey. This low use of IRS corroborates with the lack of a specific national plan for IRS in Liberia.

In Tanzania, the use of IRS in households increased from 2006-07 to 2011-12. While a large gap in the use of IRS exists, this increase may be attributed to a planned intensification of coverage starting in 2010.[2] Continued IRS was planned for 2011-12, possibly during or after the survey data were collected.

Prompt and Appropriate Treatment

In Angola, the percentage of children that utilize an appropriate treatment increased over the course of four years. This may demonstrate possible improvement in either knowledge, wealth, or access to ACTs within Angola. Further analysis to determine what variables such as education, rural/urban location, wealth index, etc. predict this increase are warranted. From 2009 to 2011 in Liberia, there are small but important increases in the use of appropriate treatment, prompt treatment with any antimalarial or other treatment, and combined prompt and appropriate treatment. As with Angola, there is still a great need to understand why some of the population is utilizing prompt and appropriate treatment and others are not. Across the survey years in Tanzania, appropriate treatment, prompt treatment with any treatment, and a combination of prompt and appropriate treatment increased. However, the percentage of those treated with an ACT that also received prompt treatment remained similar between surveys.

Combination of Prevention and Case Management

Angola

While some of the children may have used an ITN in the 2006-07 survey (unknown due to the high number of missing values), no children under five that had a fever were reported to use of either the WHO recommended prevention (IRS) or case management tools (prompt/appropriate treatment). For 2011, very few children used a combination of all three tools (ITN, prompt/appropriate treatment and IRS) or a combination of two tools.

Liberia

In Liberia, the percentage of the populations using a combined approach of prevention and appropriate case management was also quite low for both years. While some of the children may have had IRS applied in their household in 2009 (unknown), the combine use of ITNs and prompt/appropriate treatment was found only among approximately 5% of the population. In 2011, while the number of children using two or more prevention or case a management tools increased to approximately 15%, the number of those that used a combination of prompt/appropriate treatment and ITNs and IRS was less than 1% of the population.

Tanzania

Considering the combined use of prevention and case management tools in the 2007-08 survey, only two children who had a fever met these criteria. While small, there was a significant increase in the number of children using a combination of prompt/appropriate treatment, ITNs, and IRS in 2011. There was a modest increase across years in the use of two prevention or case management tools such as ITN and prompt/appropriate treatment. This increase is likely due to the improved use of ITNs and IRS among the sampled populations in 2011-12. In the 2006-07 survey, over half of the children did not received any of the WHO or PMI recommended prevention or case management tools, however, this number significantly decreased in 2011-12. This is also most likely due to the large increase in ITN use and the increase in IRS across households.

Comparisons of Countries over Time

The surveys conducted within these three countries were spaced approximately across four years for Angola, two years for Liberia, and four years for Tanzania. Although many of the changes over time were small, they were oftentimes found to be significant. Analyzing survey data from year to year provide a quick snapshot of how practices might be trending or changing over time; however, additional follow-up with subsequent surveys would add greatly to the data and findings, especially in the countries that were missing data on ITN and IRS use.

Conclusion

The low combined use of prompt and appropriate malaria treatment as well as prevention methods is concerning in the highly endemic regions of Angola, Liberia, and Tanzania during the surveyed years. There remains a malaria epidemic across these countries and although many programs and policies are in place to address this disease, based on this data analysis there is a surprising lack, with few exceptions, of using evidence-based preventive and appropriate case management methods independently and/or in a combined manner to control malaria.

Despite the recommendation of using an ACT for the treatment of malaria, ACT use is very low across all three countries. While ACT use did increase overtime across the studied countries and demonstrates a positive trend, coverage is still inadequate. When the data for ACT and other antimalarial use (e.g., quinine, chloroquine) is combined, both Liberia and Tanzania reached a coverage that averaged 56%. Angola had a considerably lower percentage. Overall this indicates, that at best, only half of the children with a reported fever received any antimalarial medication and even fewer were appropriately treated with an ACT.

There are many potential reasons for this low utilization including: a lack of ACT availability, the associated cost of purchasing an ACT, and other demographic variables that could predict its use (e.g., education level, wealth index, rural vs. urban location, etc.). Further analysis of all of these factors is warranted to assist in the understanding of how programs (both government and private) might improve the overall use of ACT in children with fevers.

Prompt treatment of fever was found among approximately 60% of those that used some type of antimalarial. While this figure is encouraging, additional investigation of demographic variables among the populations may elucidate why 40% of children under five are not receiving some form of prompt treatment and how programs might address this gap to improve the number of children receiving treatment on the same or next day of a fever.

When considering prompt and appropriate treatment across the populations, there is great room for improvement as no country or survey year exceeded 25%. As with the single use of ACTs and prompt treatment, further analysis of what populations are using the combination of prompt and appropriate treatment may provide essential information to how to improve the use of these important case management methods to reduce the health impact and ultimately the transmission of malaria.

Although ITN use was found to be an important component of government programs to reduce the transmission of malaria, ITN use was generally reported by only a third of caregivers for child under five in the studied populations. Programs of ITN coverage among children under five, along with free distribution of ITNs were found among all of the populations; however the percentage of ITNs use greatly improved only in Tanzania from one survey to the next. Understanding what variables predict ITN use, access to ITNs, and a robust evaluation of how Tanzania improved ITN coverage would be of great value as other malaria endemic nations adopt guidelines, develop programs, and campaign to improve ITN coverage.

While IRS is recommended by both the WHO and the PMI, the rate of use was very low among all the populations. Although increases in IRS use were noted in Angola and Tanzania, based on the published government guidelines, IRS spraying is sporadic across many regions throughout the countries studied. The outcomes demonstrated in this analysis further establish the need for governments and other invested groups to provide systematic IRS across all regions at prescribed intervals. The authors of this study note that some IRS campaigns were ongoing during a few of the surveys and continued past the time of data collection.

In summary, this analysis identifies where gaps in the prevention and case management of malaria exist to both government ministries and policy makers. While some improvements in the reported use of these evidence-based prevention and appropriate case management methods of malaria were noted in the analysis, the single use (perhaps with the exception of ITN use in Tanzania 2011-12) and especially the combined use of these recommendations are inadequate. Furthermore, this analysis demonstrates the need for additional studies that evaluate what variables such as education, wealth, or urban/rural residence might be associated and predict the use of prevention and appropriate case management tools to further understand why some and not others within these populations are utilizing these proven methods to reduce the burden of malaria in children under age five. Additional studies regarding access to these tools would also be important. The outcomes of these additional analyses may help guide governments and private groups in the development and implementation of appropriate and effective intervention packages that address ITN use, regular IRS application, and prompt/appropriate treatment of fever in a compressive manner to reduce and eliminate malaria in these endemic areas.

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CHAPTER 4

PREDICTORS OF MALARIA PREVENTION AND CASE MANAGEMENT AMONG CHILDREN UNDER FIVE IN THREE AFRICAN COUNTRIES: ANALYSIS OF DHS MALARIA INDICATOR SURVEYS

Abstract

Background

The World Health Organization, in conjunction with other health organizations and ministries of health, recommend the use of prevention methods such as insecticide treated nets (ITNs) and indoor residual spray (IRS) and good case management methods such as prompt and appropriate treatment of fever in efforts to reduce the transmission and impact of malaria on vulnerable populations such as children under age five. This analysis focused on identifying potential predictors of utilizing, independently and in combination, the recommended prevention and good case management methods among children under five in three African countries across six surveys using Demographic and Health Surveys.

Methods

Utilizing univariate, multivariate, and multinomial regression analysis, variables such as child age, gender, maternal education, wealth index, maternal age, parity, and residence

location were evaluated with the single and combined use of ITNs, IRS, and prompt/appropriate treatment.

Results

Within the multivariate modeling, lower child age was found to be a significant predictor of ITN use across four of the six surveys: Angola 2011 (OR=0.74, CI=0.69-0.80), Liberia 2009 (OR=0.88, CI=0.81-0.96), Liberia 2011 (OR=0.87, CI=0.79-0.96), and Tanzania 2007-08 (OR=0.78, CI=0.68-0.89). Higher wealth index was also found to be associated with ITN use in both Angola 2011 (OR=1.33, CI=1.18-1.50) and Tanzania 2007-08 (OR=1.64, CI=1.40-1.92). For IRS use, the sample sizes were extremely small leading to the conclusion that any significant associations, which were sporadic across variables, may be weak or due to sampling bias. The percentages that utilized prompt/appropriate treatment were also low; however, higher child age demonstrated a consistent significant association or at least a trend across five of the six surveys: Angola 2006-07 (OR=2.18, CI=1.13-4.21), Angola 2011 (OR=1.09, CI=0.99-1.21), Liberia 2009 (OR=1.15, 1.04-1.28), Liberia 2011 (OR=1.20, CI=1.08-1.34), and Tanzania 2011-12 (OR=1.17, OR=1.06-1.29). When considering the use of ITNs, IRS, and prompt/appropriate treatment in combinations, the sample sizes were extremely small and significant associations varied greatly across years and different combinations. Within the multinomial regression models, higher maternal education was found to be a significant predictor of using one of the malaria prevention or case management methods (compared to using none) among two of the surveys: Angola 2011 (OR=1.69, CI=1.40-2.04) and Tanzania 2007-08 (OR=1.83, CI=1.27-2.65). Higher wealth index was significantly associated with using one method among two surveys: Angola 2011 (OR=1.45, CI=1.30-1.61) and Tanzania 2007-08 (OR=1.71, CI=1.49-1.96). The sample sizes for using two and three methods, compared to none, were extremely small and significant associations among the variables were few and sporadic.

Conclusion

The utilization of ITNs, IRS, and prompt appropriate treatment either independently or combined among children under five in these populations is inadequate. While some indications demonstrate that lower child age, higher maternal education, or wealth index may influence the use of these control methods, there were no single predictors that remained consistent across all countries and surveys. This evaluation establishes the pressing need for further evaluation of access to ITNs, IRS, and prompt/appropriate treatment and the need for effective dissemination of these prevention and case management tools both independently and in combination packages to improve the transmission and impact of malaria in these endemic populations.

Keywords

Malaria, Demographic Health Survey, Children under age five, Malaria Indicator Survey.

Introduction

The World Health Organization (WHO) encourages the combined use of malaria prevention and appropriate case management methods among children under age five living in malaria endemic areas [1,2]. Using Demographic and Health Surveys (DHS), a study considering the rates associated with mothers of children less than five years of age implementing the use of insecticide treated nets (ITNs), indoor residual spray (IRS), and seeking prompt and appropriate treatment for fever either independently or in combination, in children reported to have had a fever, was recently completed [3]. Using DHS data, this analysis seeks to identify the predictors of utilizing both prevention tools and appropriate case management methods in an independent and combined effort to reduce the overall impact of malaria in children under age five.

Background

Infectious diseases, such as malaria, cause some of the most complex global health issues faced today. Malaria is a continual threat that adversely impacts health, development, and economic productivity in endemic regions [4]. While individual components of the WHO and other health organization recommendations (i.e., the prompt treatment of fever, the appropriate drug treatment for malaria, the use of ITNs, and IRS in children under five) are essential to overcoming the burden of malaria, the use of these tools synergistically provide a comprehensive approach to control the transmission and health consequences of malaria [5]. See **Table 2.1**.

The DHS data, specifically the Malaria Indicator Survey, serve as a source to review patterns, identify correlations and relationships between variables, and provide additional information to the literature necessary to identify and implement effective interventions and public health policy to ultimately improve the health of people living in various populations among malaria endemic communities [6].

Malaria Indicator Surveys from three different countries across two separate time periods (Angola [2006-2007 and 2011], Liberia [2009 and 2011], and Tanzania [2007-2008 and 2011-2012]) constitute the dataset for this analysis, which has explored the hypothesis that demographic variables such as maternal education, parity, and social economic status predict the combined use of both prevention methods (specifically, ITNs and IRS) and the appropriate case management (i.e., prompt and appropriate treatment of fever) of malaria in children under the age of five [9-14].

Demographic and Health Surveys (DHS)

The DHS program began in 1984 and is funded primarily by the United States Agency for International Development (USAID). The purpose of DHS is to collect and analyze data in developing countries to provide information on the demographics, health, and nutrition of women and children. As stated on the DHS website, "These surveys are designed to be nationally representative with a sample size often of more than 3,000 households…and are typically conducted every 3-5 years in collaboration with national ministries of health and statistics bureaus" [15]. DHS conducts several topic-specific surveys, including a Malaria Indicator Survey.

These malaria specific surveys provide a unique, comprehensive set of cross-sectional data with exceptionally large sample size structures that can offer an understanding of malaria-related health outcomes and practices across entire countries. While household information was gathered including demographic information about male residents, the Malaria Indicator Surveys focus specifically on women within a reproductive age range. DHS is distinctive in that the information collected not only informs decision making and policy within these countries, but provides each country with the ownership of the data to analyze and create appropriate policies that will improve the health and well-being of women and children.

Malaria

A systematic analysis concluded that infectious diseases, including malaria, were the most prominent cause of global mortality in children under five [16]. Malaria contributes to approximately 7% of global mortality in children under five and up to 15% of deaths in African children [17]. Endemic in over one hundred countries approximately 50% of the world's population is at risk for malaria. In 2010 and 2012, malaria caused approximately 655,000 and 627,000 deaths, respectively, and there is no vaccination and too little coverage with known control measures [17,18].

Children and Malaria

As cited, "The primary tool for the control of malaria in many parts of Africa remains the early diagnosis and treatment of clinical cases of malaria" [19]. Roll Back Malaria, in connection with the WHO, stated that to meet the Millennium Development Goals to reduce the infant and under-five mortality and the burden of disease associated with malaria, 60% of children under age five who live in malaria endemic regions and who have malaria symptoms should be treated within 24 hours of developing fever [20]. A Ugandan study indicated that children under five were more likely to have malaria parasitemia, malaria disease, and fever versus children older than five [21].

Mothers are known to be the primary caregiver and responsible for most initial decisions in treating their children's diseases [22]. Factors such as maternal education, occupation, social economic status, and available resources have been shown in various regions of Africa to affect seeking treatment for malaria [23].

In addition to *prompt treatment of fever* (within 24 hours of onset), the WHO and other health oriented organizations, such as the President's Malaria Initiative (PMI) and ministries of health, also recommend the use of *appropriate treatment* with artemisinin-based combination therapies (ACTs), as well as the use of prevention methods such as ITNS and IRS, especially among children under age five [1,2,4,5]. The malaria control methods used by these organizations have set the gold standard in this analysis for the most effective approach to comprehensive malaria control in children under five.

Government Guidelines

As each malaria endemic region is different in respect to climate, geography, health systems, and resource availability, a custom approach to malaria control is necessary [4]. According to the WHO, "the package of interventions to be implemented in each district is first and foremost a country decision, informed by WHO malaria control recommendations" [4]. The government guidelines, by year and country, for case management and prevention measures are outlined in the *Approach* section.

Methods

The following analysis will describe what variables predicted the use of control methods either independently or in combination among children under age five who reported a fever within the two weeks of the survey data collection.

Study Setting

These surveys were conducted across both urban and rural regions of the following countries during two different time periods: Angola (2006-2007 and 2011), Liberia (2009 and 2011), and Tanzania (2007-2008 and 2011-2012). The data were collected for DHS and was made available upon request through the DHS website: *MalariaSurveys.org*. These malaria-specific surveys are conducted during high malaria transmission seasons to capture these data.

Sampling Design

The Malaria Indicator Surveys used a multistage randomized cluster sample of households in each country. A description of the sampling design may be found in the individual countries Final Reports [9-14].

Study Subjects

Household surveys were conducted to identify women within a specified age range (15-49 years). A total of 40,208 women between the ages of 15-49 years of age were surveyed individually across these three countries (Angola, Liberia, and Tanzania) in two separate surveys conducted in each country. Within this sample, these women reported a total of 33,602 living children under the age of five. 9,006 of these children reported to have had a fever within the two weeks prior to the survey. As Zanzibar has a separate government and different policies regarding malaria than Tanzania, all data regarding children living in Zanzibar were removed from the analysis (n=229 from Tanzania 2007-08 and n=171 from Tanzania 2011-12) to avoid potential confounding. For this analysis, only respondents who reported a fever in a child under 5 years during the two weeks prior to the survey were included.

Data Collection

Data were collected using the household and women's questionnaires, prepared by the Monitoring and Evaluation Reference Group (MERG) created for the Roll Back Malaria

Partnership. Each survey was adapted to the local context as necessary [24]. These surveys have collected data on general demographics including age, levels of education, wealth among both urban and rural populations, and parity. In addition, these surveys have reported on the number of children under five who had a fever within two weeks prior to the survey, if and what type of antimalarials were used on the same or next day after the onset of fever, the use ITNs among children, and IRS use in each household surveyed. After collection, data are recoded by DHS to improve accessibility and to facilitate efficient analysis. The recoded data are structured to have standardized data to allow for comparison across countries. Country specific data are also collected. A recode data manual is provided on the DHS website (http://dhsprogram.com/publications/publication-dhsg4-dhs-questionnaires-and-manuals.cfm).

Human Subjects

DHS surveys in connection with USAID and various ministries of health that represent each participating country obtained the necessary ethics reviews and consents to conduct each survey. Ethical review and approval for this study was provided by the Institutional Board Review from the University of Utah.

Measures

The following variables were considered in this analysis:

Use of Insecticide Treated Nets (ITNs) in Children 0-59 Months - The DHS data provide the number of children under the age of five that slept under a mosquito net the night before the survey. The data include the use of “any net,” an “ever-treated” net, or ITN. For this analysis, only the variable reporting the actual use of an ITN the night before the survey was used. The variables that report "any net" or "ever-treated net" were not included in this analysis.

Indoor Residual Spray (IRS) – This DHS variable includes all households that had the interior walls of the house sprayed with insecticide against mosquitoes within the 12 months prior to the survey.

Prompt Treatment of Fever - As defined by DHS, prompt treatment of fever is treatment with an antimalarial drug, regardless of whether the antimalarial is appropriate or not, on the same or next day of fever onset. In order to limit recall bias, only information on fevers that had occurred in the two weeks previous to the survey was included.

Appropriate Treatment of Fever - Appropriate treatment of fever is defined as the treatment recommended by each individual country's ministry of health. For the specific countries in this analysis, all government recommendations included treatment with an ACT. All other treatments were considered not-appropriate. This dataset provided the following options for treatment: SP/Fansidar, chloroquine, amodiaquine, quinine, combination with artemisinin (recommended), other, or nothing.

Prompt and Appropriate Treatment – For the purposes of this analysis, prompt/appropriate treatment is using an ACT on the same or next day of fever onset.

Sex of Child – This is a dichotomous variable and is defined as either male or female.

Child Age – Child age is represented by completed life years at the time of the survey. Children 0-59 months at the time of the survey were included in the analysis.

Maternal Education Level - The education level of each women age 15-49 was gathered as part of DHS. Women were asked to identify their highest level of schooling attended or completed. These levels were divided into the following categories: no education, primary, secondary, or higher. Each education program was based on individual country schemes and may not be standardized across different countries.

Wealth Index - Socio-economic status is defined by the DHS wealth index variable. This variable was created by assigning specific assets of a household (e.g., drinking water source, possession of a television, etc.) a weight or factor score that was generated using principal component analysis [25]. These asset scores were then standardized and an overall score was given to each household. This sample was then divided into quintiles (lowest, second, middle, fourth, highest).

Maternal Age – The age of the mother is represented by completed life years at the time of the survey. Eligible women included those age 15-49 at the time of the survey.

Parity of Mother - The number of total children born to each woman interviewed at the time of the survey. This variable includes both living and deceased children.

Residence Location - This variable is dichotomous and is defined as whether the household identified by the survey, where the interview took place, was located in a rural or urban region.

Government Guidelines

Table 3.1 summarizes the guidelines outlined by the ministry of health for each country and year of the surveys analyzed.

Data Analysis

Statistical analysis was conducted by using StataCorp. 2003. Stata Statistical Software: Release 8.2. College Station, TX: StataCorp LP. As the sampling design for each country is a multistage randomized cluster sample of households and the samples were selected with disproportionate probability to increase the number of cases in the survey, sampling weights were utilized to provide appropriate representation across the country. The sampling weight for a specific household is “the inverse of the household selection probability multiplied by the inverse of the household response rate of its household response rate group” [2]. DHS has included sample weights within the datasets to allow for adjustments to reflect the sampling design.

Univariate analysis were conducted for each possible outcome factor using the previously described predictor variables. The outcomes of this analysis influenced the creation of multiple logistic regression models through a step-wise strategy following an inclusion/exclusion criterion of variables set at a 5% significance level or those values approximating the 5% significance level using the log-likelihood ratio test. Variables with the lowest p-values in the univariate tests were first used in building the multivariable models. Variables such as child age and sex were used as controls in this analysis to avoid potential confounding. A multinomial model was then used to run a logistic analysis on multiple outcome possibilities. These outcomes included: the use of none of the methods of malaria prevention or appropriate case management; use of one of the methods; use of two of the methods; and use of all three methods (ITNs, IRS, and prompt and appropriate treatment). Each country and year were analyzed separately.

Results

The following results and tables provide descriptive outcomes for missing variables and the independent and combined use of malaria prevention and case management methods. Univariate and multivariate logistic regression results of predictor variables are then outlined according to prevention and case management methods of malaria in children under age five. A multinomial regression analysis is then outlined according to predictor variables. Information for each country and survey year is found within each section.

Descriptive Data

Within the Angola 2006-07 survey, there were 1,698 children under the age of five. 380 (22.7%) of the children were either marked on the surveys as “do not know” or had missing data related to fever, and 265 (15.6%) of the children were reported to have had a fever within two weeks prior to the survey. For the Angola 2011 survey, there were 8,242 children under age five, 536 (6.5%) of the children were either marked on the surveys as “do not know” or had missing data related to fever, and 2,645 (32%) children were reported to have had a fever within two weeks prior to the survey.

In the Liberia 2009 survey, there were 4,193 children under age five, 555 (13.2%) of the children were either marked on the surveys as “do not know” or had missing data related to fever, and 1,600 (38.1%) children under five were reported to have had a fever within two weeks prior to the survey. The Liberia 2011 survey included 3,319 children under age five, 309 (9.3%) children were either marked on the surveys as “do not know” or had missing data related to fever, and 1,617 (48.7%) children were reported to have had a fever within two weeks prior to the survey.

Within the Tanzania 2007-2008 survey, there were 5,526 children under age five, 519 (9.3%) of the children were either marked on the surveys as “do not know” or had missing data related to fever, and 1,200 (21.7%) children were reported to have had a fever within two weeks prior to the survey. Lastly, during the Tanzania 2011-12 survey, there were 7,529 children under age five, 491(6.5%) children were either marked on the surveys as “do not know" or had missing data related to fever, and 1,679 (22.3%) children were reported to have had a fever within two weeks prior to the survey.

As previously noted, only those children with a reported fever within the two weeks of survey administration were included in this analysis. Those children who were missing data regarding appropriate treatment, prompt treatment (if treated), ITN use, and IRS were removed from the analysis. **Table 3.2** outlines the initial baseline number of children under five with a fever for each country and survey and includes the number of children removed from the analysis of each survey due to missing variables related to malaria prevention and case management.

Table 3.3 outlines the number and percentage of children under age five that used a malaria prevention and case management method. **Table 3.4** outlines the outcomes of combined malaria prevention and case management methods for each country and survey.

Univariate and Multiple Logistic Regression Analysis

The following is an outline of the characteristics of the predictor variables used in the univariate and multiple logistic regression analysis: sex of child (male [ref.]/female), child age (completed life years 0-4 [0 is ref.]), maternal education (no education [ref.], primary, secondary, higher), wealth index (quintiles; lowest [ref.], second, middle, fourth, highest), maternal age (completed life years 15-49 [15 is ref.]), parity (total children born [1 is ref.]), and residence (urban [ref.]/rural).

Independent Methods of Prevention and Case Management

ITNs

For the Angola 2006-07 survey, approximately 35% of the data regarding the use of ITNs among children was missing from this specific dataset. To determine whether the populations that provided data and those missing data were different on key factors such as urban/rural residential location, maternal education, or wealth index, a chi-squared attrition analysis was conducted. The analysis determined that the populations were indeed significantly different (p-value <.05) based on urban/rural residential location, maternal education, and wealth index. Based on this information, and the high number of missing values, ITN use for this survey was not further considered in the analysis.

The Angola 2011 ITN data included 769 children and demonstrated in the univariate analysis that lower child age (OR=0.73, CI=0.68-0.79), higher maternal education (OR=1.45, CI=1.21-1.72), higher wealth index (OR = 1.34, CI=1.19-1.51), and lower parity (OR=0.91, CI=0.87-0.95) were significant predictors of using an ITN (see **Table 4.1**). However, in the multivariate model, maternal education was no longer found a significant predictor of ITN use.

For the Liberia 2009 survey univariate analysis, a lower child age (OR=0.88, CI=0.81-0.96) demonstrated significant use of an ITN. In Liberia 2011, lower child age (OR=0.87, CI=0.79-0.96) also significantly predicted the use of an ITN.

In the Tanzania 2007-08 survey univariate analysis, lower child age (OR=0.83, CI=0.74-0.95), higher maternal education (OR=2.00, CI=1.38-2.91), higher wealth index (OR=1.85, CI=1.62-2.12), lower parity (OR=0.89, CI=0.82-0.97), and living in an urban location (OR=0.21, CI=0.14-0.33) all predicted use of an ITN. Being a female (OR=1.38, CI=1.00-1.90) as a predictor of ITN use met the p<.05 level, but the confidence intervals

Table 4.1: Logistic regression of predictors of ITN use in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 0 (0)							
	Too many missing values						
Angola 2011 (n=2,603), *f* (%) = 769 (29.5)							
	Child Age	0.73*	0.68-0.79	0.74*	0.69-0.80	0.74*	0.69-0.80
	Sex of Child	1.12	0.92-1.36	1.12	0.92-1.37	1.12	0.92-1.37
	Maternal Education	1.45*	1.21-1.72	1.07	0.89-1.30	***	***
	Wealth Index	1.34*	1.19-1.51	1.31*	1.15-1.49	1.33*	1.18-1.50
	Parity	0.91*	0.87-0.95	0.92*	0.88-0.97	0.92*	0.88-0.96
Liberia 2009 (n=1,549), *f* (%) = 531 (34.3)							
	Child Age	0.88*	0.81-0.96	0.88*	0.81-0.96	0.88*	0.81-0.96
	Sex of Child	1.10	0.81-1.49	1.10	0.81-1.49	1.10	0.81-1.49
Liberia 2011 (n=1,529), *f* (%) = 620 (40.6)							
	Child Age	0.87*	0.79-0.96	0.87*	0.79-0.96	0.87*	0.79-0.96
	Sex of Child	0.89	0.68-1.17	0.89	0.68-1.17	0.89	0.68-1.17
Tanzania 2007-08 (n=936), *f* (%) = 280 (30)							
	Child Age	0.83*	0.74-0.95	0.79*	0.69-0.90	0.78*	0.68-0.89
	Sex of Child	1.38**	1.00-1.89	1.33	0.95-1.87	1.33	0.94-1.87
	Maternal Education	2.00*	1.38-2.91	1.19	0.80-1.76	***	***
	Wealth Index	1.85*	1.62-2.12	1.60*	1.37-1.87	1.64*	1.40-1.92
	Parity	0.89*	0.82-0.97	0.97	0.89-1.05	***	***
	Residence	0.21*	0.14-0.33	0.49*	0.30-0.79	0.47*	0.30-0.75
Tanzania 2011-12 (n=1,453), *f* (%) = 1,090 (75)							
	No variable showed significance						
***Significant P-values (<.05). Child age and sex are controlled for in each model. ** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance. ***Variable was removed from the regression to improve overall model fit.**							

suggested that it may only be trending towards significance. In the multivariate model, female gender, maternal education, and parity lost significance when included in the modeling. The other predictors remained relatively constant. There were no significant predictors of ITN use in the Tanzania 2011-12 survey.

IRS

Table 4.2 outlines the variables that predicted the use of IRS across the countries and years. Angola 2006-07 did not have any variables that predicted use of IRS; however, the sample size was considerably low (n=9). Higher maternal education (OR=1.71, CI=1.18-2.49) and higher wealth index (OR=1.97, CI=1.48-2.62) significantly predicted use of IRS in Angola during the 2011 survey.

Both higher child age and urban residence trended towards significance. In the multivariate model, while child age met a p-value <.05, the confidence interval suggests that the association may be quite weak. In addition, maternal education and residence no longer predicted IRS use among this population.

Wealth index remained relatively constant. IRS use was not captured in the Liberia 2009 survey, and only higher parity (OR=1.06, CI=1.00-1.14) may have trended towards significance in the Liberia 2011 survey. For Tanzania 2007-08, higher wealth index (OR=2.06, CI=1.29-3.28) demonstrated a significance p-value (<.05) and being female trended towards significance; however, with only a sample of n=10 children, any association may be due to sampling bias. In Tanzania 2011-12, only living in a rural location predicted IRS use (OR=2.40, CI=1.12-5.10).

Table 4.2: Logistic regression of predictors of IRS use in children under five for each country and year

		Univariate Logistic Regression		Multivariate Logistic Regression		Final Multivariate Logistic Regression	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 9 (3.5)							
	No variable showed significance						
Angola 2011 (n=2,603), *f* (%) = 147(5.7)							
	Child Age	1.14**	0.96-1.36	1.17**	1.00-1.36	1.17**	1.00-1.36
	Sex of Child	1.23	0.83-1.81	1.19	0.80-1.75	1.19	0.80-1.75
	Maternal Education	1.71*	1.18-2.49	0.97	0.69-1.37	0.97	0.69-1.37
	Wealth Index	1.97*	1.48-2.62	1.94*	1.36-2.78	1.94*	1.36-2.78
	Residence	0.48**	0.21-1.08	0.82	0.36-1.87	0.82	0.36-1.87
Liberia 2009 (n=1,549), *f* (%) = 0 (0)							
	IRS was not captured in this survey						
Liberia 2011 (n=1,529), *f* (%) = 149 (9.7)							
	Child Age	1.06	0.94-1.20	1.03	0.90-1.17	1.03	0.90-1.17
	Sex of Child	0.89	0.53-1.48	0.88	0.53-1.47	0.88	0.53-1.47
	Parity	1.06**	1.0-1.13	1.06**	1.0-1.13	1.06**	1.0-1.13
Tanzania 2007-08 (n=936), *f* (%) = 10 (1)							
	Child Age	0.99	0.60-1.64	0.97	0.59-1.58	0.97	0.59-1.58
	Sex of Child	4.56**	0.97-21.35	4.41**	0.92-21.03	4.41**	0.92-21.03
	Wealth Index	2.06*	1.29-3.28	2.06*	1.29-3.28	2.06*	1.29-3.28
Tanzania 2011-12 (n=1,453), *f* (%) = 262 (18)							
	Child Age	0.99	0.88-1.10	0.98	0.88-1.10	0.98	0.88-1.10
	Sex of Child	0.95	0.68-1.33	0.92	0.65-1.28	0.92	0.65-1.28
	Residence	2.40*	1.12-5.10	2.40*	1.12-5.10	2.40*	1.12-5.10

***Significant P-values (<.05). Child age and sex are controlled for in each model.**
**** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance.**

Prompt and Appropriate Treatment

Although higher child age trended towards significance, with a sample size of n=7 in Angola 2006-07, no predictors of prompt/appropriate treatment were identified in the univariate analysis. In the multivariate analysis, higher child age was found significant; however, with the low sample size, there may be possible sampling bias (see **Table 4.3**). In Angola 2011, higher maternal education (OR=2.53, CI=1.90-3.38), higher wealth index (OR=1.76, CI=1.53-2.04), and urban location (OR=0.29, CI= 0.19-0.44) predicted use of prompt/appropriate treatment. In the multivariate model, higher child age began to trend towards significance and higher maternal education, higher wealth index, and urban residence continued to predict prompt/appropriate treatment.

In Liberia 2009, higher child age (OR=1.15, CI=1.04-1.28) and in Liberia 2011, higher child age (OR=1.21, CI=1.09-1.35), lower wealth index (OR=0.82, CI=0.69-0.97), and rural residence (OR=1.70, CI=1.09-2.66) predicted prompt/appropriate treatment. Higher child age remained constant in the Liberia 2009 multivariate models and only higher child age remained a significant predictor of prompt/appropriate treatment in Liberia 2011 when modeled with wealth index and residence.

In Tanzania 2007-08, lower child age (OR=0.86, CI=0.74-0.99), higher wealth index (OR=1.24, CI=1.05-1.47), lower parity (OR=0.90, CI=0.82-0.99), and urban residence (OR=0.57, CI=0.33-0.98) significantly predicted prompt/appropriate treatment. While higher maternal education met a p-value of <.05, the confidence intervals suggest only a trend towards significance. In the multivariate model, parity and residence were removed due to lack of significance and only lower child age (OR=0.85, CI=0.73-0.98) and higher wealth index (OR=1.22, CI 1.02-1.45) remained as significant predictors of prompt/appropriate

Table 4.3: Logistic regression of predictors of prompt/appropriate treatment use in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 7 (2.7)							
	Child Age	2.06**	0.95-4.45	2.18*	1.13-4.21	2.18*	1.13-4.21
	Child Gender	1.18	0.19-7.13	1.14	0.18-7.04	1.14	0.18-7.04
	Maternal Age	0.96	0.87-1.06	0.96	0.88-1.06	0.96	0.88-1.06
	Parity	0.93	0.72-1.20	0.99	0.78-1.26	0.99	0.78-1.26
Angola 2011 (n=2,603), *f* (%) = 277(10.6)							
	Child Age	1.05	0.96-1.16	1.09**	0.99-1.21	1.09**	0.99-1.21
	Sex of Child	1.07	0.84-1.35	1.05	0.82-1.34	1.05	0.82-1.34
	Maternal Education	2.53*	1.90-3.38	1.50*	1.06-2.11	1.50*	1.06-2.11
	Wealth Index	1.76*	1.53-2.04	1.46*	1.22-1.74	1.46*	1.22-1.74
	Residence	0.29*	0.19-0.44	0.55*	0.36-0.83	0.55*	0.36-0.83
Liberia 2009 (n=1,549), *f* (%) = 241 (15.6)							
	Child Age	1.15*	1.04-1.28	1.15*	1.04-1.28	1.15*	1.04-1.28
	Sex of Child	0.79	0.55-1.14	0.79	0.55-1.14	0.79	0.55-1.14
Liberia 2011 (n=1,529), *f* (%) = 383 (25)							
	Child Age	1.21*	1.09-1.35	1.20*	1.08-1.34	1.20*	1.08-1.34
	Sex of Child	0.93	0.66-1.32	0.95	0.67-1.35	0.95	0.67-1.35
	Wealth Index	0.82*	0.69-0.97	0.90	0.74-1.08	0.90	0.74-1.08
	Residence	1.70*	1.09-2.66	1.39	0.86-2.27	1.39	0.86-2.27
Tanzania 2007-08 (n=936), *f* (%) = 140 (15)							
	Child Age	0.86*	0.74-0.99	0.85*	0.74-0.99	0.85*	0.73-0.98
	Sex of Child	1.10	0.71-1.72	1.07	0.68-1.68	1.09	0.70-1.69
	Maternal Education	1.42**	0.99-2.02	1.15	0.81-1.65	1.19	0.83-1.71
	Wealth Index	1.24*	1.05-1.47	1.16	0.96-1.40	1.22*	1.02-1.45
	Parity	0.90*	0.82-0.99	0.93	0.84-1.02	***	***
	Residence	0.57*	0.33-0.98	0.83	0.46-1.51	***	***
Tanzania 2011-12 (n=1,453), *f* (%) = 334 (23)							
	Child Age	1.17*	1.06-1.29	1.17*	1.06-1.29	1.17*	1.06-1.29
	Sex of Child	0.87	0.65-1.18	0.87	0.65-1.18	0.87	0.65-1.18

*Significant P-values (<.05). Child age and sex are controlled for in each model.
** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance.
***Variable was removed from the regression to improve overall model fit.

treatment. Only higher child age (OR=1.17, CI=1.06-1.29) predicted prompt/appropriate treatment in Tanzania 2011-12.

Combination of Prevention and Case Management

When combining the use of prevention and case management methods, the sample sizes for each country and survey, to a large extent, decreased; therefore, sampling bias must be considered. The following are findings from the univariate and multivariate regression analysis.

ITN and IRS

The Angola 2006-07 survey had too many missing ITN variables for consideration in this analysis. In Angola 2011 (n=49), lower maternal age (OR=0.94, CI=0.89-0.99), higher wealth index (OR=2.24, CI=1.53-3.30), and lower parity (OR=0.85, CI=0.73-0.98) significantly predicted the combined use of ITN and IRS. When considered in a multivariate model, parity was removed, as it no longer demonstrated significance and maternal age and wealth index remained relatively constant. Liberia 2009 did not capture IRS data and in Liberia 2011, no variables showed significance. In Tanzania, the sample size was only n=2; therefore, the significant value of higher maternal education may or may not be truly significant due to potential sampling bias. In Tanzania 2011-12 (n=159), only higher parity (OR=1.09, CI=1.02-1.16) demonstrated significance as a predictor of combined ITN and IRS use (see **Table 4.4**).

Table 4.4: Logistic regression of predictors of combined ITN and IRS use in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 0 (0)							
	Too many missing ITN variables						
Angola 2011 (n=2,603), *f* (%) = 49 (1.9)							
	Child Age	0.96	0.75-1.23	1.04	0.80-1.35	1.04	0.80-1.34
	Sex of Child	1.22	0.62-2.40	1.20	0.61-2.35	1.21	0.61-2.39
	Maternal Age	0.94*	0.89-0.99	0.91	0.82-1.02	0.93*	0.88-0.99
	Wealth Index	2.24*	1.52-3.30	2.32*	1.52-3.53	2.28*	1.54-3.36
	Parity	0.85*	0.73-0.98	1.08	0.81-1.43	***	***
Liberia 2009 (n=1,549), *f* (%) = 0 (0)							
	IRS was not captured in this survey						
Liberia 2011 (n=1,529), *f* (%) = 48 (3.1)							
	No variable showed significance						
Tanzania 2007-08 (n=936), *f* (%) = 2 (<1)							
	Child Age	1.46	0.69-3.08	1.15	0.76-1.71	1.15	0.76-1.71
	Sex of Child	1.94	0.11-34.00	1.24	0.09-16.04	1.24	0.09-16.04
	Maternal Education	15.71*	3.60-68.40	15.71*	3.60-68.40	15.71*	3.60-68.40
Tanzania 2011-12 (n=1,453), *f* (%) = 159 (10.9)							
	Child Age	0.93	0.80-1.07	0.90	0.78-1.04	0.90	0.78-1.04
	Sex of Child	0.94	0.64-1.37	0.94	0.64-1.38	0.94	0.64-1.38
	Parity	1.09*	1.02-1.16	1.09*	1.02-1.16	1.09*	1.02-1.16
*Significant P-values (<.05). Child age and sex are controlled for in each model. ***Variable was removed from the regression to improve overall model fit.							

ITN and Prompt and Appropriate Treatment

The Angola 2006-07 survey had too many missing ITN variables for consideration in this analysis. In Angola 2011 (n=92), lower child age (OR=0.86, CI=0.75-0.99), higher maternal education (OR=2.47, CI=1.72-3.55), higher wealth index (OR=1.84, CI= 1.39-2.42), and urban residence (OR=0.47, CI=0.28-0.80) significantly predicted the combined use of ITNs and prompt/appropriate treatment. When combined in a multivariate model, lower child age (OR=0.87, CI=0.76-0.99), higher maternal education (OR 1.81, CI=1.10-2.98), and higher wealth index (OR=1.59, CI=1.17-2.16) remain significant.

In Liberia for both 2009 and 2011(n= 90, n=151), lower wealth index was associated with a combination of ITN and prompt/appropriate treatment (OR=0.81, CI=0.66-0.99 and OR=0.78, CI=0.64-0.95, respectively).

In the univariate models for Tanzania 2007-08 (n=62), lower child age (OR=0.79, CI 0.64-0.97), female children (OR=1.91, CI=1.06-3.44), higher maternal education (OR=1.73, CI=1.19-2.50), higher wealth index (OR=1.55, CI=1.22-1.97), and urban residence (OR=0.28, CI=0.15-0.52) were found to predict the use of combined ITN and prompt/appropriate treatment. When the significant predictors were combined in a multivariate model, maternal education was removed from the model as it no longer demonstrated significance. In addition, female gender appears to now only trend towards significance. All other variables remained significant in the model. Higher child age (OR=1.14, CI=1.01-1.28) was the only predictor of combined use of ITN and prompt/appropriate treatment in Tanzania 2011-12 (see **Table 4.5**).

Table 4.5: Logistic regression of predictors of combined ITN and prompt/appropriate treatment use in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 0 (0)							
	Too many missing ITN variables						
Angola 2011 (n=2,603), *f* (%) = 92 (3.5)							
	Child Age	0.86*	0.75-0.99	0.87*	0.76-0.99	0.87*	0.76-0.99
	Sex of Child	0.93	0.58-1.48	0.91	0.56-1.46	0.91	0.56-1.46
	Maternal Education	2.47*	1.72-3.55	1.81*	1.10-2.98	1.81*	1.10-2.98
	Wealth Index	1.84*	1.39-2.42	1.59*	1.17-2.16	1.59*	1.17-2.16
	Residence	0.47*	0.28-0.80	1.11	0.66-1.87	1.11	0.66-1.87
Liberia 2009 (n=1,549), *f* (%) = 90 (5.8)							
	Child Age	0.95	0.84-1.08	0.94	0.83-1.07	0.94	0.83-1.07
	Sex of Child	1.27	0.74-2.17	1.26	0.74-2.14	1.26	0.74-2.14
	Wealth Index	0.81*	0.66-0.99	0.81*	0.66-0.99	0.81*	0.66-0.99
Liberia 2011 (n=1,529), *f* (%) = 151 (9.9)							
	Child Age	1.05	0.92-1.19	1.04	0.92-1.18	1.04	0.92-1.18
	Sex of Child	1.06	0.68-1.67	1.09	0.69-1.72	1.09	0.69-1.72
	Wealth Index	0.78*	0.64-0.95	0.78*	0.64-0.95	0.78*	0.64-0.95
Tanzania 2007-08 (n=936), *f* (%) = 62 (6.6)							
	Child Age	0.79*	0.64-0.97	0.76*	0.62-0.94	0.76*	0.62-0.95
	Sex of Child	1.91*	1.06-3.44	1.79**	0.99-3.24	1.78**	0.98-3.22
	Maternal Education	1.73*	1.19-2.50	1.15	0.73-1.81	***	***
	Wealth Index	1.55*	1.22-1.97	1.29**	0.98-1.71	1.31*	1.02-1.70
	Residence	0.28*	0.15-0.52	0.46*	0.22-0.96	0.45*	0.22-0.94
Tanzania 2011-12 (n=1,453), *f* (%) = 255 (15.5)							
	Child Age	1.14*	1.01-1.28	1.14*	1.01-1.28	1.14*	1.01-1.28
	Sex of Child	0.98	0.70-1.38	0.98	0.70-1.38	0.98	0.70-1.38

*Significant P-values (<.05). Child age and sex are controlled for in each model.
** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance.
***Variable was removed from the regression to improve overall model fit.

IRS and Prompt and Appropriate Treatment

Angola 2006-07 did not have any children under five with a fever that used both IRS and prompt/appropriate treatment (see **Table 4.6**). The Angola 2011 survey (n=17), demonstrated that higher child age (OR=1.70, CI=1.16-2.48), higher maternal education (OR=2.96, CI=1.53-5.74), and higher wealth index (OR=2.57, 1.35-4.90) were significant predictors of the combined use of IRS and prompt/appropriate treatment; however, it is possible that the outcomes are biased due to the low sample size. When included in a multivariate model, only higher child age and higher wealth index remained significant and relatively constant. Maternal education dropped out of the model due to lack of significance.

IRS data were not captured in the Liberia 2009 survey and only living in a rural residence predicted significance (OR=3.99, CI=1.10-14.46) in Liberia 2011 (n=31). However, with the wide confidence interval range and smaller sample size, it is unclear how strong rural residence can predict the combined use of IRS and prompt/appropriate treatment in this population.

For Tanzania 2006-07, only one child utilized both IRS and prompt/appropriate treatment. While there were some indications that lower maternal age and parity may be associated with the use of this combination, it is impossible to determine with the available sample size. In Tanzania 2011-12, only n=9 children met the criteria of using both IRS and prompt/appropriate treatment. Higher maternal education (OR=1.44, CI=0.97-2.14) was the only variable that trended towards significance when using this combination.

ITN, IRS and Prompt and Appropriate Treatment

The sample sizes for each country and year were very low for the number of children under age five with a fever that used a combination of all three prevention and case

Table 4.6: Logistic regression of predictors of the combined use of IRS and prompt/appropriate treatment in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 0 (0)							
	Cannot evaluate with *f* =0						
Angola 2011 (n=2,603), *f* (%) = 17 (<1)							
	Child Age	1.70*	1.16-2.48	1.68*	1.17-2.41	1.69*	1.17-2.42
	Sex of Child	0.44	0.18-1.06	0.44	0.18-1.07	0.42	0.17-1.02
	Maternal Education	2.96*	1.53-5.74	1.86	0.78-4.44	***	***
	Wealth Index	2.57*	1.35-4.90	2.10**	0.99-4.43	2.57*	1.35-4.90
Liberia 2009 (n=1,549), *f* (%) = 0 (0)							
	IRS was not captured in this survey						
Liberia 2011 (n=1,529), *f* (%) = 31 (2)							
	Child Age	0.97	0.74-1.27	0.95	0.73-1.24	0.95	0.73-1.24
	Sex of Child	0.57	0.25-1.28	0.59	0.26-1.32	0.59	0.26-1.32
	Residence	3.99*	1.10-14.46	3.99*	1.10-14.46	3.99*	1.10-14.46
Tanzania 2007-08 (n=936), *f* (%) = 1 (<1): Child Age, Sex of Child, Maternal Education and Residence predicted failure perfectly, therefore all were removed from modeling.							
	Maternal Age	0.72*	0.69-0.75	0.68*	0.64-0.72	0.68*	0.64-0.72
	Wealth Index	1.09**	1.00-1.18	1.09	0.97-1.22	1.09	0.97-1.22
	Parity	0.53*	0.50-0.56	1.25*	1.09-1.44	1.25*	1.09-1.44
Tanzania 2011-12 (n=1,453), *f* (%) = 9 (<1)							
	Child Age	0.96	0.53-1.75	0.97	0.54-1.75	0.97	0.54-1.75
	Sex of Child	0.31	0.05-1.67	0.31	0.05-1.68	0.31	0.05-1.68
	Maternal Education	1.44**	0.97-2.14	1.44**	0.97-2.14	1.44**	0.97-2.14

*Significant P-values (<.05). Child age and sex are controlled for in each model.
** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance.
***Variable was removed from the regression to improve overall model fit.

management methods (see **Table 4.7**); therefore, care must be taken in the interpretation of these results. Angola 2006-07 is not evaluable as no children met all three criteria. In Angola 2011, n=9 met the criteria with higher child age (OR=1.21, CI=1.06-1.37), higher maternal education (OR=3.14, CI=1.69-5.83), and higher wealth index, (OR=2.81, CI=1.50-5.26) significantly predicting the use of all three methods. When combined in a multivariate model, maternal education no longer showed significance.

IRS was not captured in Liberia 2009; therefore, this survey year is not evaluable. In Liberia 2011, n=10 children met the criteria of using all three methods. Higher child age (OR=1.75, CI=1.34-2.29) and lower wealth index (OR 0.38, CI=0.17-0.85) demonstrated to be significant predictors of using ITNs, IRS, and prompt/appropriate treatment. Lower parity may have trended towards significance with the confidence interval containing 1.00. In the multivariate model, higher child age, and lower wealth index remained significant and lower parity also moved to be significant (OR=.68, CI=0.48-0.97).

In Tanzania 2007-08 (n=2), lower maternal age (OR=0.88, CI=0.84-0.92), higher maternal education (OR=2.15, CI=1.61-2.85), and higher wealth index (OR=3.90, CI=1.18-12.88) indicated to be significant predictors. The wider confidence intervals for wealth index also lend to some variation in interpretation. This may all be due to the low sample size. In the multivariate model, maternal education dropped out of the model and lower maternal age and higher wealth index remained relatively the same. Lastly, Tanzania 2011-12, n=46, showed higher child age (OR=1.25, CI=1.04-1.51) and living in a rural residence (OR 8.94, CI=1.17-68.40) were significant associated with using all three recommended methods, ITN, IRS, and prompt/appropriate treatment. The multivariate model remained similar to the univariate model for this country and year. The wide confidence intervals for rural location may indicate a weaker association.

Table 4.7: Logistic regression of predictors of the combined use of ITNs, IRS, and prompt/appropriate treatment in children under five for each country and year

		Univariate Logistic Regression		**Multivariate Logistic Regression**		**Multivariate Logistic Regression**	
Country /Year	**Predictor Variables**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**	**Odds Ratio**	**95 % CI**
Angola 2006-07 (n=255), *f* (%) = 0 (0)							
	Cannot evaluate with *f* =0						
Angola 2011 (n=2,603), *f* (%) = 9 (<1): Sex of Child predicts failure perfectly, therefore was removed from model.							
	Child Age	1.21*	1.06-1.37	1.20*	1.05-1.37	1.20*	1.05-1.37
	Maternal Education	3.14*	1.69-5.83	1.93	0.96-3.88	1.93	0.96-3.88
	Wealth Index	2.81*	1.50-5.26	2.27*	1.25-4.12	2.27*	1.25-4.12
Liberia 2009 (n=1,549), *f* (%) = 0 (0)							
	IRS was not captured in this survey						
Liberia 2011 (n=1,529), *f* (%) = 10 (<1)							
	Child Age	1.75*	1.34-2.29	2.04*	1.65-2.55	2.04*	1.65-2.55
	Sex of Child	0.52	0.10-2.56	0.57	0.10-3.00	0.57	0.10-3.00
	Wealth Index	0.38*	0.17-0.85	0.30*	0.11-0.82	0.30*	0.11-0.82
	Parity	0.78**	0.61-1.00	0.68*	0.48-0.97	0.68*	0.48-0.97
Tanzania 2007-08 (n=936), *f* (%) = 2 (<1):							
	Child Age	0.97	0.62-1.50	1.07	0.65-1.75	1.07	0.65-1.76
	Sex of Child	1.40	0.08-23.6	1.45	0.07-27.04	1.45	0.08-26.31
	Maternal Age	0.88*	0.84-0.92	0.87*	0.84-0.90	0.87*	0.84-0.89
	Maternal Education	2.15*	1.61-2.85	1.01	0.49-2.08	***	***
	Wealth Index	3.90*	1.18-12.88	4.01**	0.97-16.46	4.02*	1.07-15.00
Tanzania 2011-12 (n=1,453), *f* (%) = 46 (3.2)							
	Child Age	1.25*	1.04-1.51	1.25*	1.03-1.52	1.25*	1.03-1.52
	Sex of Child	1.00	0.51-1.99	0.94	0.47-1.86	0.94	0.47-1.86
	Residence	8.94*	1.17-68.40	8.94*	1.17-68.40	8.94*	1.17-68.40

*Significant P-values (<.05). Child age and sex are controlled for in each model.
** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating a possible trend towards significance.
***Variable was removed from the regression to improve overall model fit.

Multinomial Logistic Regression

For this analysis, using one, two, or all three methods was compared to using none of the methods of malaria prevention and case management. Child age and sex were controlled for in each analysis (see **Table 4.8**).

One Method of Malaria Prevention or Case Management

Two of the surveys, Angola 2011 (OR=0.80, CI=0.74-0.87) and Tanzania 2007-08 (OR=0.86, CI=0.75-0.98) demonstrated that lower child age may be a contributing predictor to the use of either an ITN, IRS, or prompt/appropriate treatment. Higher maternal education was found to be a significant predictor of using one of these methods among three of the surveys (Angola 2011 [OR=1.69, CI=1.40-2.04], Liberia 2011 [OR=1.22, CI=1.00-1.48], and Tanzania 2007-08 [OR=1.83, CI=1.26-2.64]) although the confidence intervals for the Liberia survey may only indicate a trend towards significance. Higher wealth index was significantly associated with using one method among two surveys, Angola 2011 (OR=1.45, CI=1.30-1.61) and Tanzania 2007-08 (OR=1.71, CI=1.49-1.96).

While maternal age had a p-value of 0.05 in two surveys, Liberia 2009 (OR=1.02, CI=1.00-1.04) and Tanzania 2007-08 (OR=0.96, CI=0.94-0.99), the confidence intervals for Liberia do not indicate a significant association. Lower parity was found to be significant across three surveys for using one method (Angola 2011 [OR=0.94, CI=0.89-0.98], Liberia 2011 [OR=0.94, CI=0.89-0.99], and Tanzania 2007-08 [OR=0.87, CI=0.80-0.95]).

Urban residence was found to predict the use of one method in both Angola 2011 (OR=0.56, CI=0.42-0.74) and Tanzania 2007-08 (OR=0.30, CI=0.19-0.48). In summary, lower child age, higher maternal education, higher wealth index, lower parity, and urban

Table 4.8**:** Multinomial regression models of predictors of prevention and case management

	Outcomes					
Predictor Variables	**One Method vs. None**		**Two Methods vs. None**		**Three Methods vs. None**	
	Relative Risk Ratio	95% CI	Relative Risk Ratio	95% CI	Relative Risk Ratio	95% CI
Angola 2006-07, n=255	***ƒ*=16**		***ƒ*=0**		***ƒ*=0**	
Child Sex (male-ref.)	1.28	0.34-4.81	-	-	-	-
Child Age (0-ref.)	1.58	0.97-2.58	-	-		
Maternal Education (No Education- ref)	1.10	0.82-1.48	-	-	-	-
Wealth (Lowest -ref)	1.18	0.82-1.69	-	-		
Maternal Age (15-ref)	0.98	0.90-1.08	-	-	-	-
Parity (1-ref)	0.99	0.78-1.25	-	-		-
Residence (urban-ref)	1.05	0.28-3.98	-	-	-	-
Angola 2011, n=2,603	***ƒ*=16**		***ƒ*=158**		***ƒ*=9**	
Child Sex (male-ref.)	1.15	0.95-1.39	0.99	0.68-1.44	2.69*	1.08-6.65
Child Age (0-ref.)	0.80*	0.74-0.87	0.89	0.77-1.03	1.09	0.96-1.25
Maternal Education (No Education- ref)	1.69*	1.40-2.04	2.91*	2.05-4.12	4.64*	2.35-9.16
Wealth (Lowest -ref)	1.45*	1.30-1.61	2.38*	1.84-3.08	3.43*	1.77-6.61
Maternal Age (15-ref)	0.99	0.98-1.00	0.98	0.96-1.02	1.08	0.96-1.21
Parity (1-ref)	0.94*	0.89-0.98	0.86*	0.78-0.96	0.90	0.69-1.18
Residence (urban-ref)	0.56*	0.42-0.74	0.39*	0.22-0.66	0.14*	0.02-0.86
Liberia 2009, n=1,549	***ƒ*=592**		***ƒ*=90**		***ƒ*=0**	
Child Sex (male-ref.)	0.86	0.66-1.13	1.20	0.68-2.12	-	-
Child Age (0-ref.)	0.99	0.91-1.08	0.95	0.83-1.09		
Maternal Education (No Education- ref)	1.01	0.83-1.23	0.75	0.52-1.07	-	-
Wealth (Lowest -ref)	1.01	0.89-1.14	0.81	0.65-1.02		
Maternal Age (15-ref)	1.02**	1.00-1.04	1.00	0.96-1.04	-	-
Parity (1-ref)	1.04	0.99-1.09	1.03	0.90-1.17		-
Residence (urban-ref)	1.06	0.74-1.51	1.29	0.61-2.70	-	-
Liberia 2011, n=1,529	***ƒ*=662**		***ƒ*=230**		***ƒ*=10**	
Child Sex (male-ref.)	0.93	0.68-1.26	0.84	0.53-1.33	0.49	0.10-2.45
Child Age (0-ref.)	0.99	0.88-1.10	1.00	0.89-1.12	1.74*	1.33-2.29
Maternal Education (No Education- ref)	1.22**	1.00-1.48	0.94	0.71-1.26	0.46	0.14-1.47
Wealth (Lowest -ref)	1.02	0.89-1.17	0.80*	0.66-0.97	0.37*	0.16-0.85
Maternal Age (15-ref)	0.99	0.97-1.01	1.00	0.98-1.03	0.95	0.83-1.08
Parity (1-ref)	0.94*	0.89-0.99	1.02	0.95-1.09	0.76*	0.60-0.97

Table 4.8: Continued

	Outcomes					
Predictor Variables	**One Method vs. None**		**Two Methods vs. None**		**Three Methods vs. None**	
	Relative Risk Ratio	95% CI	Relative Risk Ratio	95% CI	Relative Risk Ratio	95% CI
Tanzania 2007-08, n=936	***f*=294**		***f*=65**		***f*=2**	
Child Sex (male-ref.)	1.12	0.81-1.53	2.05*	1.13-3.73	1.52	0.09-25.53
Child Age (0-ref.)	0.86*	0.75-0.98	0.75*	0.61-0.93	0.91	0.59-1.40
Maternal Education (No Education- ref)	1.83*	1.26-2.64	2.46*	1.49-4.04	2.93*	2.09-4.11
Wealth (Lowest -ref)	1.71*	1.49-1.96	1.96*	1.52-2.52	5.25*	1.50-18.33
Maternal Age (15-ref)	0.96*	0.94-0.99	1.00	0.95-1.05	0.87*	0.82-0.91
Parity (1-ref)	0.87*	0.80-0.95	0.90	0.78-1.03	0.22	0.04-1.20
Residence (urban-ref)	0.30*	0.19-0.48	0.17*	0.08-0.32	0.08	0.00-1.17
Tanzania 2011-12, n=1,453	***f*=732**		***f*=393**		***f*=46**	
Child Sex (male-ref.)	0.88	0.60-1.28	0.84	0.57-1.24	0.90	0.43-1.88
Child Age (0-ref.)	0.99	0.84-1.16	1.05	0.89-1.25	1.26**	1.00-1.60
Maternal Education (No Education- ref)	1.16	0.78-1.73	1.12	0.73-1.71	1.05	0.53-2.04
Wealth (Lowest -ref)	0.95	0.83-1.08	0.93	0.80-1.07	0.85	0.68-1.07
Maternal Age (15-ref)	1.00	0.98-1.03	1.00	0.97-1.02	0.97	0.92-1.02
Parity (1-ref)	1.02	0.95-1.09	1.04	0.97-1.13	1.01	0.89-1.13
Residence (urban-ref)	1.17	0.74-1.85	1.74	0.96-3.15	11.19*	1.41-88.50

***Significant P-value (<.05). Child age and sex were controlled for in the modeling.**
**** P-values that either trended towards significant or met a p-value of <.05 that had a confidence interval containing 1.00 indicating only a trend towards significance.**

residence all may have some influence on whether one method of malaria prevention or case management was used.

Two Methods of Malaria Prevention and/or Case Management

Within the Tanzania 2007-08 survey, being a male child was significant (OR=2.05, CI=1.13-3.73) in the use of two methods of malaria prevention and/or case management. This is the only case were gender may have played any role in the associated use of any number of methods. There are no indications from the data why this was the only and only case of significance among child gender. Only in the Tanzania 2007-08 survey was a lower child age found to be significant (OR=0.75, CI=0.61-0.93) in the use of two methods. Higher maternal education was found to be significant among the Angola 2011 (OR=2.91, CI=2.05-4.12) and Tanzania 2007-08 (OR=2.46, CI=1.49-4.04) populations when considering the use of two methods. Higher wealth index was found to be significant for using two methods among two different surveys (Angola 2011 [OR=2.38, CI=1.84-3.08] and Tanzania 2007-08 [OR=1.96, CI=1.52-2.52]); however, lower wealth index was found to be significant in using only two methods in the Liberia 2011 (OR=0.80, CI=0.66-0.97) population. Reasons for this aberration are unknown and may be due to random chance. Maternal age did not predict the use of two methods among any of the populations. Lower parity did predict the use of two methods in only the Angola 2011 (OR=0.86, CI=0.78-0.96) survey. Urban residence predicted the use of two methods in two surveys, Angola 2011 (OR=0.39, CI=0.22-0.66) and Tanzania 2007-08 (OR=0.17, CI=0.08-0.32). In summary, higher maternal education, higher wealth index, and urban residence may all have had some influence on whether two methods of prevention and or case management methods were used.

Three Methods of Malaria Prevention and Case Management

The sample sizes for each of the countries, with the exception of the Tanzania 2011-12 survey (n=46) were less than ten. With these sample sizes and the wide confidence intervals (or those that contained 1.00 within the interval), it is difficult to determine any significant or strong associations among the variables and whether they could predict the use of all three methods of malaria prevention and case management were used.

Discussion

With the WHO recommendations and other programs' focus, such as PMI, to utilize a combined approach with both malaria prevention and good case management methods, this analysis highlights variables that predicted the use of these approaches in Angola, Liberia, and Tanzania during the DHS surveyed years among children under age five that had a reported fever within two weeks of the data collection.

Limitations

While malaria was not confirmed by diagnostic testing in these children, fever was used as a marker for malaria given the endemicity of malaria in this region. Other causes of fever were not considered in the analysis. There were also several children in the general population that had missing data related to a fever in the two weeks prior to the survey. While this may introduce some bias, due to the nature of secondary data analysis, only those with a reported fever were included in this study.

With the evaluation of only children under five with a fever, this group of children could potentially be part of a more noncompliant population. Further evaluation of those that did not have a fever and used prevention methods (ITNs and IRS) may demonstrate potential differences between these two populations.

For this study, the use of ITNs only was included. While data pertaining to the use of untreated bed nets, ever treated bed nets, etc. is available, as ITNs are the most effective and standard for most countries, it was the variable evaluated. In addition, with the nature of cross-sectional studies, the use of the ITN the night previous to the study must be used as a reliable indicator of consistent use. Data about correct usage of ITNs were not provided.

As this is a retrospective, secondary data analysis, this study is limited to the data provided. The data are provided as was reported by the women interviewed. Each survey was conducted over several months; therefore, the surveys may not have captured every interview during the high malaria transmission season. In addition, when considering the children under age five with a fever that utilized one, two or three of the previously outlined methods, sample sizes, at times, were very small. While potential trends to significance may be noted, conclusive associations are not able to be made due to potential bias. Finally, generalizability of these results and conclusions are limited to the countries and years studied.

Univariate and Multivariate Regression

Independent Methods of Prevention and Case Management

ITNs - Lower child age, higher maternal education, higher wealth index, lower parity, and urban residence appear to be the main variables that may influence the use of an ITN in child under age five although they may not remain consistent over different areas of malaria endemicity. Interestingly, in Tanzania 2011-12, the survey with the highest ITN use (74%), child age, sex, maternal education, wealth index, maternal age, parity, and residence were not found to be significantly associated with ITN use.

IRS - Few variables were found to be predictive of IRS use across the six surveys. Tanzania 2011-12 had the highest percentage of IRS use across all the surveys at 18% and living in a rural area was a predictor of using IRS according to the results of this analysis. As IRS is often completed through government campaigns and has been found to be sporadic in nature, it is possible that many households, including those with children under the age of five, have not had access to IRS and only those regions targeted by the government IRS campaigns were able to use this preventive measure.

Prompt and Appropriate Treatment - With respect to prompt/appropriate treatment, only child age, higher maternal education, higher wealth index, and urban residence demonstrated any significant associations across the surveys. Only higher child age appeared to remain somewhat consistent across all the surveys with the exception of Tanzania 2007-08 where lower child age was associated with prompt/appropriate treatment. This analysis does not offer an explanation of why there is a difference in the Tanzania 2007-08 survey related to child age.

<u>Combination of Prevention and Case Management</u>

ITN and IRS - Higher wealth index, lower maternal age, and higher parity demonstrated significant associations with ITN and IRS use; however, these predictors were sporadic and not found to be associated with combined ITN and IRS use across all surveys.

ITN and Prompt/Appropriate Treatment - Both higher and lower child age, higher maternal education, higher and lower wealth index levels, and urban residence were found significantly associated with a combined use of ITN and prompt/appropriate treatment. It is unclear why some areas have discordance among higher and lower child age and wealth index levels. Further analyses in these areas are warranted to determine why differences exist among the various populations.

IRS and Prompt/Appropriate Treatment - The sample sizes across the surveys of those that used a combination of IRS and prompt/appropriate treatment were small and any significant associations are difficult to determine. Only potential trends of associations may be identified through this analysis.

ITN, IRS and Prompt/Appropriate Treatment - The sample sizes across the surveys of those that used a combination of ITN, IRS, and prompt/appropriate treatment were small and significant associations are difficult to prove. Only potential trends may be identified through this analysis.

Multinomial Regression

One Method of Malaria Prevention or Case Management

*L*ower child age, higher maternal education, higher wealth index, lower parity, and urban residence all may have some influence on whether one method of malaria prevention or case management was used compared to none.

Two Methods of Malaria Prevention and/or Case Management

Higher maternal education, higher wealth index, and urban residence may all have had some influence on whether two methods of prevention and or case management were used compared to none.

Three Methods of Malaria Prevention and Case Management

The sample sizes for each of the countries, with the exception of the Tanzania 2011-12 survey, were less than ten. With these small sample sizes and the wide confidence intervals (or those confidence intervals that contained 1.00), it is difficult to determine any significant or strong associations among the variables and whether they can predict the use of all three methods of malaria prevention and case management compared to none.

Conclusions

While the independent use of either ITNs, IRS, or prompt/appropriate treatment varied across different countries, the combined use of these malaria prevention and case management methods was very low across all countries and time periods. Despite the call for using all of these evidence-based tools by the WHO, ministries of health, and other health-related organizations, the interventions and programs being utilized to implement these interventions are either insufficient or have not worked in a synergistic manner to improve coverage with all of these proven recommendations. While some of the variables evaluated in this analysis may predict the use of one or two of these malaria control methods (e.g., lower child age, higher maternal education, and higher wealth index), it is impossible to evaluate their influence on the combined use of both two and all three recommended interventions.

From this analysis, it is possible to glean some information that may be useful to programs and policy makers to improve the use of these tools in the future. It is clear that with a mandate for universal coverage of ITNs in Tanzania in 2011, coverage among children under five rose from 30% to 75%. Better understanding of how this campaign was rolled out may assist other countries in determining how to raise their number of ITN coverage and use. Furthermore, additional focus of ITN campaigns may be warranted in the following women: women who have children one to five years of age as many of the ITN distribution campaigns focus on those women who are attending antenatal visits or have recently given birth, women who fall within a lower wealth index quintile as they may not have sufficient resources to access ITNs even with discount vouchers, those that have a higher number of children (parity), and those that live in rural regions as access may be more limited in these areas.

The use of IRS is low across all of the studied populations. Although government campaigns may issue IRS coverage across specific regions, a more systematic and regular approach should be undertaken by ministries of health to meet the recommendation of applying indoor residual insecticide spray every 12 months in every household dwelling. If IRS is applied regularly, it is likely that transmission of malaria will decrease over time lending to more opportunities of eliminating malaria and its host across endemic areas.

There was low use of prompt and appropriate treatment and no strong predictors with the exception of child age in some of the surveys. When further broken down, many women are seeking prompt care when their child presents with a fever, but the children are not necessarily receiving the appropriate treatment. This leads to a call for additional studies to determine accessibility to ACTs to both rural and urban populations and the need for widespread recalls of all other antimalarials found to be resistant to malaria. Furthermore, subsidizing the cost of ACTs may be an option for ministries of health to provide financial access of ACTS to those in lower quintiles of wealth index.

In summary, the findings from these surveys demonstrate that while there may be trends for some variables such as child age, maternal education, or wealth index to influence the independent and combined use of ITNs, IRS, and prompt/appropriate treatment, there is not a "one size fit's all" predictor model for each country. The results of this study also suggest that availability and access to prevention and appropriate case management may be the primary problem rather than demographic variables. While malaria campaigns, interventions, or programs may benefit and improve outcomes by including a specific focus on populations that have older children within the range of under age five, lower education, lower wealth quintiles, higher maternal age, higher parity, and that live in rural areas, additional studies that evaluate availability and access to ITNs, IRS, and appropriate treatment should be undertaken to more fully understand the broader picture and to assist in identifying what package of interventions, programs, or campaigns might be most successful in improving the use of proven malaria prevention and case management methods in a combined manner.

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SUMMARY AND PERSPECTIVES

Demographic and Health Surveys (DHS) datasets are a rich source to identify trends and practices of malaria related to children and pregnant women in Africa. These findings resulting from these datasets have the potential to improve intervention delivery, influence policy, and provide important information to individual countries concerning the current status of malaria.

The systematic review of this dissertation demonstrated that although the recommendations of the WHO and other health organizations are to use control measures in combination, none of the articles reviewed analyzed the singular use of ITNs, IRS, prompt/appropriate treatment in children, or the use of ITNs, IRS, and IPTp in pregnant women within the context of one study and none of the articles considered the combined use of these control measures within the context of one study.

With the large amount of resources, including time and money, that is invested in malaria control, this review highlights the great need and calls for additional research to determine if children under age five and pregnant women are using none, some, or all of these prevention and case management methods in combination. These types of studies would be valuable to both government and nongovernment policy makers as they determine, comprehensively, the gaps of using prevention and case management methods among malaria vulnerable populations such as children under five and pregnant women. These studies could also be conducted through the use of DHS data.

For the highly endemic regions of Angola, Liberia, and Tanzania that this analysis reviews, the low combined use of malaria treatment and prevention methods is concerning. There remains a malaria epidemic across these countries and although many programs and policies are in place to address this disease, based on these data analyses, there is a surprising lack, with few exceptions, of using evidence-based preventive and appropriate case management methods singularly and/or in a combined manner to control malaria.

Despite the recommendation of using an ACT for the treatment of malaria, ACT use is considerably low across all three countries. There are many potential reasons for this low utilization, including a lack of ACT availability and the associated cost of purchasing an ACT to name a couple. While prompt treatment of fever was found among approximately 60% of those that used some type of antimalarial, there is still room for improvement, especially when it combining appropriate treatment with prompt treatment.

Although ITN use was found to be an important component of government programs to reduce the transmission of malaria, ITN use was generally used by only a third of the child under five in the studied populations. Programs of ITN coverage among children under five, along with free distribution of ITNs were found among all of the populations; however, the percentage of ITNs use greatly improved only in Tanzania from one survey to the next. Understanding what variables predict ITN use, access to ITNs, and a robust evaluation of how Tanzania improved ITN coverage would be of great value as other malaria endemic nations adopt guidelines, develop programs, and campaign to improve ITN coverage.

While IRS is recommended by both the WHO and the PMI, the rate of use was considerably low and sporadic among all the populations. The outcomes demonstrated in this analysis further establish the need for governments and other invested groups to provide systematic IRS across all regions at prescribed intervals.

The final analysis, to identify variables that may predict the use of malaria prevention and case management methods, demonstrated that while there may be trends for some variables such as child age, maternal education, or wealth index to influence the individual and combined use of ITNs, IRS, and prompt/appropriate treatment, there is not a "one size fit's all" predictor model for each country. Malaria campaigns, interventions, or programs may benefit and improve outcomes by including a specific focus on populations that have older children within the range of under age five, lower education, lower wealth quintiles, higher maternal age, higher parity, and that live in rural areas.

In summary, the findings from this study indicate the need to re-evaluate, at least in these three specific countries, how these evidence-based, recommended malaria prevention and case management methods could be better integrated into the individual practices of these households of children to overcome and eliminate malaria among these endemic populations.