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Prophylactic Antimalarial Intermittent Preventive Therapy in Pregnancy and Birth Weight in Togo

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Walden University
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Abstract

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Ingénieur Biologiste (Biological Engineer), Université de Lomé-Togo, 2009

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health—Epidemiology

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Abstract

In Togo, prophylactic antimalarial intermittent preventive therapy in pregnancy (IPTp) is provided to disrupt suboptimal pathways leading to the issue of low birth weight. However, there is a lack of nationally representative data on the determinants of this adverse birth outcome. The purpose of this quantitative cross-sectional study was to determine pregnancy-related determinants of low birth weight through a nationally representative dataset. Bronfenbrenner's ecological systems model guided this study to explore potential associations between the covariates IPTp, utilization of long-lasting insecticidal bed nets, age of pregnant women, socioeconomic status of pregnant women, and gravidity type of pregnant women and the outcome variable birth weight in infants (each covariate vs. the outcome variable at a time). Secondary data from the third Togo Demographic and Health Survey were used (N = 4,009). Statistical analyses included descriptive statistics and simple and multiple logistic regression. The results from multiple logistic regression showed that pregnant women of ageD1(15–19 years) were more likely to give birth to LBW infants as compared to older pregnant women (OR = 2.546, CI = 1.569 – 4.133, p = .000). Multigravida pregnant women (gravidityD3) were more likely to give birth to LBW infants as compared to primigravida and secundigravida pregnant women (OR = .720, CI = .605–.857, p = .000). Increasing coverage of IPTp chemoprevention among teenage pregnant women and multigravida pregnant women may alleviate the burden of low birth weight in Togo and create positive social change.

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Dedication

I dedicate this work to God for seeing me through. Here I raise my Ebenezer! For thus far the Lord has helped me.

Acknowledgments

I say a special thank you to Dr. Danawi Hadi, my chair; Dr. Cunningham Tina Duong, my committee member; and Dr. Agha M. Mehdi, the university research reviewer (URR), for your support and guidance through this incredible journey.

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Chapter 1: Introduction to the Study

Introduction

Malaria in pregnancy is by far the most important cause of adverse birth outcomes in sub-Saharan Africa (SSA). Among the five species responsible for malaria in humans, *P. vivax* and *P. falciparum* cause dire adverse maternal and fetal outcomes in pregnancy (Bauserman et al., 2019). In 2018, the World Health Organization (WHO) estimated that roughly 11 million pregnancies would have been exposed to malaria infection across sub-Saharan countries. Owing to that, about 872,000 children were born with low birthweight (LBW) in 2019, and West Africa had the highest prevalence of LBW children due to malaria in pregnancy (WHO, 2019). The WHO has a policy to control for malaria infection in pregnancy that includes the use of long-lasting insecticidal bed nets (LLINs), intermittent preventive therapy in pregnancy using sulfadoxine-pyrimethamine (IPTp-SP), and effective case management when appropriate (Cates et al., 2018). Through the Programme National de Lutte contre le Paludisme (PNLP), Togo has been implementing this policy with several strategies in place to alleviate the burden of malaria substantially by 2030. As part of the implementation of the malaria control interventions, the PNLP has been compiling digital information, either directly or in collaboration with partner development agencies. The Togo standard Demographic Health Survey is part of these initiatives (Bakai et al., 2020). In this regard, Viagbo (2018) investigated the effectiveness of intermittent preventive therapy in pregnancy (IPTp) in reducing the risks of LBW and reported an association between IPTp intervention and decreased risk of LBW in infants born to pregnant women participants in their study. He also recommended that other studies be conducted to investigate the specific effects of

different increments in IPTp doses regarding their hypothetical association with decreased risk of LBW in Togo. Other studies have been carried out at the health district level to identify the determinant factors of LBW in Togo. However, analyzing a nationally representative data set is needed to understand different types of associations between the identified determinants and birth weight within different target groups across the country. This will allow for tailoring interventions based on different contexts. To this end, the aim of the present study was to carry out a secondary data analysis using the Togo standard Demographic and Health Survey (DHS) 2013–2014, a nationally representative data set.

In this chapter, I discuss the problem statement for the study, the purpose statement, and an outline of the research questions and hypotheses in the study. This chapter also coversthe background for the study topic, the theoretical base, and the significance of the study, along with some operational definitions, assumptions, and limitations of the study.

Several research endeavors have been undertaken and research is still underway to address concerns around the detrimental effects of malaria in pregnancy. Searching the literature for the terms *antimalarial intermittent preventive therapy in pregnancy*, *antimalarial preventive therapy and pregnancy outcomes*, and other related key words generated a wealth of information upon which to build the present study.

Background of Study

Schmiegelow et al. (2017) examined the effects of early exposure to *P. falciparum* in pregnant women. Their results showed a 14% reduction in placental weight in exposed women as compared to nonexposed women and highlighted that early

exposure has negative effects on fetal growth and pregnancy duration, which consequently affect placental weight at delivery.

Agbozo et al. (2016) reported an increased risk of LBW in infants who are the first born to their mothers as compared to second- or third-born infants. The risk of LBW was also associated with age of pregnant women and number of IPTp doses received during antenatal care (ANC).

In a study that involved pregnant women treated with the IPTp-SP, Essiben et al. (2016) compared cases who had positive malaria diagnostic tests to controls with negative tests. Their findings showed that gravidity and history of possible malaria infection negatively affected outcomes of the IPTp-SP intervention. This was in line with the findings of Schmiegelow et al. (2017), which suggested more pronounced effects of exposure in primigravidae compared to secundigravidae, as immunity to malaria infection increases with gravidity.

In Togo, Djadou et al. (2018) reported that lack of preventive malaria treatment had detrimental effects in pregnant women and their newborns. They found that LBW occurred in 7.1% of the cases studied, which was attributed to lack of antimalarial preventive therapy for pregnant women. Along a similar vein, Viagbo (2018) reported that 80% of pregnant women received at least one dose of IPTp, which resulted in a reduction of the risk of LBW to 15% as compared to 23% in pregnant women who did not receive any dose.

Cates et al. (2018) and Anto et al. (2019) investigated possible effects of the IPTp on pregnancy outcomes using chi-square tests and logistic regression models. Both studies found that interventions that provided at least three doses of IPTp-SP were more

likely to decrease the risk of LBW in malaria-endemic countries. In furtherance, both studies concurred with Isha and colleagues, who found earlier that adding a third dose (to the current popular two doses of IPTp-SP) produced a better outcome in terms of reducing anemia in pregnancy and the risks of LBW (Isha et al., 2017).

Lastly, Lingani et al. (2020) found that using bed nets throughout pregnancy generated a reduction in the risk of LBW, while poor maternal nutritional status was reported as a key factor of poor fetal growth during pregnancy in rural areas. This finding implied that the socioeconomic status (SES) of pregnant women could be associated to the risk of LBW given the poor nutritional status reported for most women from rural areas.

In Togo, different studies have highlighted most of these risk factors and examined the effects of IPTp interventions with respect to decreasing the risk of LBW in children. However, no study has explored potential associations between the above-mentioned maternal and demographic determinants and risk of LBW using a nationwide data set. The present study aimed to explore these potential associations through a secondary data analysis. As I mentioned earlier, analyzing a nationally representative data set will be relevant for tailoring interventions based on different contexts.

Problem Statement

Malaria infection causes severe anemia during pregnancy, which results in nine deaths per 100,000 live births in endemic areas (Bauserman et al., 2019). Moreover, Bauserman and colleagues reported that 20% of LBW was associated to placental infection with malaria in endemic areas, and LBW was associated with up to 20-fold increase in infant mortality rates in SSA. The latest reports on worldwide trends and

estimates of LBW prevalence showed that 20.5 million LBW babies were born globally in 2015. Of these, one quarter was attributed to Africa, with Eastern and Western Africa accounting for most of the cases. In line with this, Togo had a LBW prevalence of 16.1% in 2015 (UNICEF-WHO, 2019). Several maternal sociodemographic factors were reported to be associated with the risk of LBW in infants, including younger ages, malnourishment, primigravidae versus secundigravidae, lack of immunity to pregnancy-related malaria, a multigravida with history of stillbirth, and living with HIV (Bauserman et al., 2019; Lingani et al., 2020). The WHO (2019) reported that malaria control and elimination interventions cost up to US$ 2.7 billion in 2018. To this end, malaria has dire tolls on a human as well as a financial level in SSA. Like most countries, Togo has adopted the WHO's 1998 "Roll Back Malaria" initiative. The move was motivated by a report from the Ministry of Health in 2002 that showed that 49% of general-public visits to healthcare providers were triggered by malaria infection due to *P. falciparum*. In this regard, local strategies have been adopted to control for malaria in pregnancy. These strategies include encouraging pregnant women to sleep under LLINs and providing for intermittent preventive therapy in pregnancy (IPTp) with sulfadoxine-pyrimethamine (Viagbo, 2018). To this end, the new guidelines recommend providing pregnant women with at least three doses of IPTp-SP in combination with the utilization of LLINs, which constitutes the optimal prevention strategy (Nkoka et al., 2020). One dose of IPTp has proven effective in reducing the risk of LBW to 15% in infants born to pregnant women who received the therapy when compared to the 23% risk of LBW in infants born to pregnant women who received no dose of IPTp (Viagbo, 2018). However, no population-based study has been carried out yet in Togo to determine potential associations between

dose of IPTp, utilization of LLINs, age of pregnant women, SES of pregnant women, gravidity type of pregnant women, and birth weight, respectively. As suggested in Nkoka et al. (2020), carrying out such a study could help policymakers in tailoring interventions based on the findings. This could also help them design innovative prevention strategies targeting high-risk groups. In the present study, I aimed to explore the associations between dose of IPTp in pregnant women, utilization of LLINs by pregnant women, age of pregnant women, SES of pregnant women, gravidity type of pregnant women, and birth weight in infants through a secondary data analysis. The secondary data were collected through the DHS, a program funded by the U.S. Agency for International Development (USAID).

Purpose of the Study

This was a quantitative secondary data analysis with a purpose to explore potential associations between the two main independent variables, dose of IPTp and utilization of LLINs, and the dependent variable, birth weight. Based on their importance in the literature, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women were considered as covariates in the analysis and adjusted for while exploring the association between the main independent variables and the dependent variable.

Research Questions and Hypotheses

Research Question 1: Is there an association between dose of IPTp (IPTp0, IPTp1, IPTP2, IPTp3, etc.) in pregnant women and birth weight in infants?

H_{10}: There is no association between dose of IPTp in pregnant women and birth weight in infants.

H_{1A}: There is an association between dose of IPTp in pregnant women and birth weight in infants.

Research Question 2: Is there an association between utilization of LLINs by pregnant women and birth weight in infants?

H_{20}: There is no association between utilization of LLINs by pregnant women and birth weight in infants.

H_{2A}: There is an association between utilization of LLINs by pregnant women and birth weight in infants.

Research Question 3: Is there an association between age of pregnant women and birth weight in infants?

H_{30}: There is no association between age of pregnant women and birth weight in infants.

H_{3A}: There is an association between age of pregnant women and birth weight in infants.

Research Question 4: Is there an association between SES of pregnant women and birth weight in infants?

H_{40}: There is no association between SES of pregnant women and birth weight in infants.

H_{4A}: There is an association between SES of pregnant women and birth weight in infants.

Research Question 5: Is there an association between gravidity type of pregnant women and birth weight in infants?

H_{50}: There is no association between gravidity type of pregnant women and birth weight in infants.

H_{5A}: There is an association between gravidity type of pregnant women and birth weight in infants.

Research Question 6: Is there an association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women?

H_{60}: There is no association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

H_{6A}: There is an association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

Theoretical Framework

Bronfenbrenner's ecological systems model was used as the theoretical framework for this study. Ecological systems theory allows for the researcher to investigate several systems concomitantly and highlight the interdependent relations between these systems at the same time (Eriksson et al., 2018). As suggested in Eriksson et al. (2018), bioecological systems theory offers conceptual and methodological tools relevant for organizing and/or evaluating public health interventions. Bronfenbrenner's

ecological systems model evolved in three phases between 1973 and 2006 (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018).

Per Eriksson et al. (2018), the initial phase was developed during the 1970s and named the "ecological model of human development." At this phase, the theory focused on the constructs of microsystem, mesosystem, exosystem, and macrosystem. Eriksson and colleagues described the microsystem to encompass the relations between a person and their immediate surrounding environment. The mesosystem represents the interrelations between the different settings containing the person. The exosystem relates to social structures, and the macrosystem represents the laws, regulations, and implicit rules and norms of a particular society.

Bronfenbrenner developed the second phase of the theory between 1980 and the mid-1990s while extending the ecological framework to biology and chronosystems. At this phase, Bronfenbrenner emphasized what he called the "proximal processes," which refer to the close and reciprocal interactions between persons and their immediate environment. By adding the chronosystem to the theory, Bronfenbrenner allowed for the framework to be used to investigate changes occurring over time and how these changes affect a person's developmental outcome (Bronfenbrenner, 1986, as cited in Eriksson et al., 2018).

During the final phase of the ecological framework, Bronfenbrenner further specified the nature, operation, and developmental effects of the proximal processes (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018). He suggested that proximal processes operate within the microsystems involving interaction with persons, objects, and symbols, which are three features of the immediate environment (Bronfenbrenner,

1995, as cited in Eriksson et al., 2018). Thus, Bronfenbrenner and colleagues coined the model of process-person-context-time (PPCT) as a guideline that bioecological researchers could use to understand why developmental outcomes vary between different persons (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018). The construct of process involves assessing frequent activities and their interactions with persons, objects, and symbols in persons' lives. The construct of person involves analyzing how person characteristics (e.g., age, gender, intelligence, etc.) influence the proximal processes. The construct of context involves assessing the influences of different exosystems and/or different macrosystems on the proximal processes. Lastly, the construct of time involves considering at least two measurement points, including the current point of historical time (Tudge et al., 2009, as cited in Eriksson et al., 2018).

Finally, it is worth mentioning that Bronfenbrenner emphasized the need for using at least two different ecological systems in ecological research to help understand a specific developmental outcome (Bronfenbrenner, 1975, as cited in Eriksson et al., 2018).

The present study was therefore limited to using the constructs of context and person characteristics. Prophylactic antimalarial IPTp and utilization of LLINs were used as context factors. Age, SES, gravidity type of pregnant women, and birth weight were used as person characteristics. Therefore, I examined potential associations between these different factors and the outcome of interest, which was the birth weight of children born to pregnant women participants in the study. Table 1 indicates how I matched the theoretical framework with the study variables.

Table 1

Theoretical Framework and Study Variables

Theoretical framework title:Bronfenbrenner's ecological systems model	Proposed study title: Prophylactic antimalarial intermittent preventive therapy in pregnancy and birth weight in Togo	
List of constructs	List of variables	Variable nature
Context factor	Dose of IPTp	Categorical
	Utilization of LLIN	Binomial (Yes/No)
Person characteristic	Age of pregnant women	Categorical
	SES of pregnant women	Categorical
	Gravidity type of pregnant women	Categorical
	Birth weight	Interval-ratio

Nature of the Study

This study was quantitative cross-sectional research that used descriptive, simple, and multiple logistic regression analyses. Secondary data from the third Togo standard DHS2013–2014 were analyzed to examine potential associations between dose of IPTp (IPTp0, IPTp1, IPTp2, IPTp3), utilization of LLINs, age of pregnant women, SES of pregnant women, gravidity type of pregnant women, and pregnancy outcomes in terms of birth weight (low or normal birth weight) in children born to women participants of the survey at their last live birth. The third standard DHS was carried out in Togo between November 2013 and April 2014. Using a stratified two-stage cluster design, data were

collected from women aged 15–49 years through face-to-face interviews whereby information was gathered on measures of population health and birth histories. The Togo Direction Générale de la Statistique et de la Comptabilité Nationale (DGSCN) and the International Classification Function under the DHS program approved the surveys. In the present secondary data analysis, dose of IPTp, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women were used as independent variables. Birth weight (low or normal birth weight) represented the dependent variable. The dose of IPTp is presented as IPTpN (*N* = number of therapies received). Wealth index was used as a proxy for the variable SES of pregnant women. Data on wealth index were measured in quintiles and presented in the data set as "lowest," "second," "middle," "fourth," and "highest" wealth quintiles (Ministère de la planification, du development et de la aménagement du territoire [MPDAT], Ministère de la santé [MS], & ICF International, 2015). Birth weight was either low (2.5 kg or less) or normal (greater than 2.5 kg).

Operational Definitions

The independent variables included the prophylactic antimalarial IPTp-SP, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women. The birth weight of children born to pregnant women respondents to the survey represented the dependent variable, which was categorized as LBW or normal birth weight. The following represent the operational definition terms for the variables.

Antimalarial intermittent preventive therapy in pregnancy (IPTp): Chemoprevention strategy to control for malaria infection in pregnancy. Every pregnant woman is provided with monthly doses of antimalarial medication starting in the second

trimester. Sulfadoxine-pyrimethamine (SP) is the drug commonly used in women who are HIV-negative (Bauserman et al., 2019).

Dose of IPTp:The number of intermittent preventive therapies received. This is presented as IPTpN (*N* = number of therapies received).

Normal birth weight: Per the WHO, a baby who reaches full term and weighs between 2.7 and 4.1 kg is said to have normal weight. The average value of a normal weight is 3.5 kg (Axame et al., 2020).

Low birth weight (LBW): A baby who reaches full term and weighs 2.5 kg or less is said to have LBW (Axame et al., 2020).

Placental malaria: Placental malaria refers to malaria-infested placenta that is due to the tendency of parasite-infested red blood cells to be sequestrated in the placenta.

Gravidity type of pregnant woman: The number of times that a woman has been pregnant.

Primigravidae: First-time pregnant woman.

Multigravidae: Pregnant woman who has had at least two pregnancies.

Long-lasting insecticidal bed nets (LLINs): Survey respondents were asked if they slept under a long-lasting insecticidal bed net the night before the survey. Answers were recorded as “yes” or “no.”

Age of pregnant woman: Maternal age at the birth of the most recent child.

Socioeconomic status of pregnant woman: Determined based on household’s ownership of items including consumer goods, dwelling characteristics, type of drinking water source, toilet facilities, et cetera, and proxied in terms of wealth index.

Assumptions

It was assumed that the secondary data collected by the Togo standard DHS 2013–2014 were reliable. Sample size was sufficient, the statistical tests were appropriate, and the researchers who gathered the primary data used appropriate methods to reduce bias and confounding. Equally important were four other assumptions that needed to be met to avoid Type I or Type II error (i.e., over- or underestimation of significance or effect size) and warrant trustworthiness of the results for studies involving logistic regression analysis (Daniel & Cross, 2013; Frankfort-Nachmias& Leon-Guerrero,2016; Osborne & Waters, 2002). These were the assumption of linearity, the assumption of sampling independence, the assumption of normality, and the assumption of homoscedasticity (Frankfort-Nachmias& Leon-Guerrero,2016).

Assumption of Linearity

As suggested in Frankfort-Nachmias and Leon-Guerrero (2016), it was assumed that the association between the dependent variable and the independent variables was linear in nature. Nonlinear associations could cause the results to underestimate the true association. With linear associations, each unit change in the independent variable relates to a constant change in the dependent variable (Osborne & Waters, 2002). This assumption was tested for through examination of a scatter diagram, which consisted of the plots of the standardized residuals as a function of the standardized predicted values (Daniel & Cross, 2013; Osborne & Waters, 2002).

Assumption of Sampling Independence

Per Frankfort-Nachmias and Leon-Guerrero (2016), this assumption indicated that independent samples were used in the model. Thus, it was assumed that the choice of

sample members from one enumeration area did not affect the choice of sample members from the second, third, or fourth enumeration area.

Assumption of Normality

It was assumed that the outcome variable had a normal distribution. Normally distributed variables are neither skewed nor kurtotic, and they do not come with substantial outliers. This assumption was tested for through visual inspection of data plots, skew, kurtosis, and P-P plots (Daniel & Cross, 2013; Frankfort-Nachmias& Leon-Guerrero,2016).

Assumption of Homoscedasticity

It was assumed that the variance of errors was the same across all levels of the independent variables. The possibility of Type I error increases when homoscedasticity is remarkably not assumed. This assumption was tested for through visual examination of a plot of the standardized residuals by the regression of standardized predicted value (Osborne &Waters, 2002).

Scope and Delimitations

In this study, I analyzed secondary data from the Togo standard DHS 2013–2014 to determine the effect of the prophylactic antimalarial IPTp-SP, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women on the risk of LBW, respectively, while adjusting for the others. The data collected through the DHS pertain to pregnant women who used ANC services in Togo. Thus, the delimitation of the study was restricted to participants living in Togo, and the results may not be generalizable to countries beyond Togo.

Limitations

I anticipated that there would be limited control over selection and measurements of the variables because of the secondary nature of the samples. Some of the participants of the survey might have provided erroneous responses due to their inability to recall past events such as the use of ANC services during their past pregnancies. Erroneous responses could also have resulted from the participants providing false responses on utilization of LLINs on the grounds of social desirability. These situations may affect reliability of the data and the possibility of inference from study results.

Significance of the Study

Malaria in pregnancy constitutes a real public health problem in SSA. The consequences include preterm birth, LBW, and related increase of 1-year mortality in infants. Several other detrimental effects have been highlighted, including odds of neonatal death, which are 7 times higher in LBW infants as compared to their non-LBW counterparts (Bater et al., 2020), and under-5 mortality of over 1 million deaths each year (Ngai et al., 2020). Based on the hypothesis of fetal origins of adult diseases, birth weight has long been reported as hypothetically associated with people's predisposition to certain diseases in adulthood (Zeng & Zhou, 2019). The authors reported that lower birth weight was associated with coronary artery disease, myocardial infarction, Type 2 diabetes, and body mass index (BMI)-adjusted Type 2 diabetes. A study in Togo reported heart failure as a leading cause of hospitalization at the cardiology department of the Sylvanus Olympio University Hospital Center (Pio et al., 2014, as cited in Sabi et al., 2019). Moreover, Sabi et al. (2019) determined that SES, diabetes, hypertension, and chronic alcoholism constitute important risk factors for the onset of renal failure and/or

heart failure in patients hospitalized at the cardiology department of that same hospital center. While providing policymakers with information critical for improvement of the delivery of antimalarial preventive therapy in pregnancy and strengthening its efficacy in preventing LBW, the present study may also help policymakers design innovative prevention strategies targeting high-risk groups. Moreover, the results of the study could help indirectly to control for the burden of coronary artery disease, myocardial infarction, Type 2 diabetes, and BMI-adjusted Type 2 diabetes health conditions in adults. A contribution to positive social change may be possible as the reduction of the risk of LBW is sustained.

Summary and Transition

Malaria in pregnancy constitutes a real public health issue in SSA with dire consequences for maternal, neonatal, and infant health. To control for the detrimental effects of malaria in pregnancy, Togo has adopted the strategies set forth by the WHO, which include encouraging pregnant women to sleep under LLINs and providing for IPTp-SP (Viagbo, 2018). A study by Viagbo (2018) highlighted the efficacy of the IPTp-SP in reducing the risk of LBW from 23% in infants born to pregnant women with no dose of IPTp to 15% in infants born to pregnant women who received one dose of the preventive therapy. However, how different increments in doses of IPTp-SP affect the incidence of LBW has yet to be investigated, along with the effects of other prevention strategies. Using secondary data from the Togo standard DHS 2013–2014, this study explored the associations between dose of IPTp in pregnant women, utilization of LLINs by pregnant women, age of pregnant women, SES of pregnant women, gravidity type of pregnant women, and birth weight in infants. This chapter includes the background,

problem statement, purpose of the study, research questions, and hypotheses. The chapter also covers the theoretical base for the study, the significance of this study, and the implications for positive social change. In Chapter 2, I present a review of the literature on the constructs of dose of IPTp, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women in the context of the hypothetical association between these independent variables and birth weight, which was the dependent variable for the study.

Chapter 2: Literature Review

Introduction

The Who has suggested that a baby who reaches full term and weighs 2.5 kg or less is said to have LBW (Axame et al., 2020). Several studies have associated malaria in pregnancy with LBW (Assane et al., 2020; Lingani et al., 2020; Mohammed et al., 2019; Nkoka et al., 2020). LBW represents a major conclusive risk factor of prenatal and neonatal deaths in SSA (Bater et al., 2020; Bauserman et al., 2019; Ngai et al., 2020). A thorough understanding of the underlying conditions that contribute to LBW outcomes becomes necessary for the success of prevention and intervention programs as well as control strategies. In this regard, several determinants have been reported, including younger and older ages, low family SES, and gravidity type (Seid et al., 2019) as being associated with LBW. In Togo, prevention strategies include encouraging pregnant women to sleep under LLINs and IPTp-SP (Viagbo, 2018). Therefore, the purpose of this study was combine previous determinants with reported strategies to explore potential associations between the independent variables dose of IPTp, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women and the dependent variable, birth weight, in Togo. One study examined the effectiveness of IPTp-SP in reducing LBW and found that this strategy allowed for 8% reduction of relative risk of LBW in women who received one or two doses of the preventive antimalarial chemotherapy. However, using a nationwide data set was needed to determine different types of associations between the identified determinants and birth weight as the outcome within different target groups across the country. The target groups included pregnant women aged less than 20 years, between 20 and 35 years, and more than 35 years who

were either primigravida or multigravida, were from different SES levels, and slept or did not sleep under an LLIN the night before the interview. In this chapter, I discuss the current literature related to the study, including a review of Bronfenbrenner's ecological systems model and research findings on the associations between the IPTp-SP, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women and birth weight in Togo and in SSA at large.

Literature Search Strategy

To find resources related to the topic, I conducted an online search of relevant articles and journals through databases such as Medline, Thoreau, Google Scholar, ProQuest Central, ProQuest Health, EBSCO, PloS One, and PloS Medicine for studies related to malaria in pregnancy and risk of LBW. I used keywords, subject terms, and Boolean phrases to find dissertations and other empirical peer-reviewed studies related to malaria in pregnancy and LBW in SSA.

The key words used included *malaria in pregnancy*, *antimalarial intermittent prophylactic treatment in pregnancy*, *antimalarial intermittent preventive treatment in pregnancy and low birth weight*, *utilization of LLINs and low birth weight in sub-Saharan Africa*, *maternal factors of newborn low birth weight in sub-Saharan Africa*, *determinants of newborn low birth weight in Togo*, *insecticide-treated bed nets*, *malaria in pregnancy*, and *low birth weight in sub-Saharan Africa*.

The primary search period was kept within the last 5 years of publication for most of the studies. However, it was necessary to look beyond the 5-year period in some instances to understand the background of the subject and how the identified factors

could associate to the outcome of interest, which was birth weight in Togo and in SSA at large.

Theoretical Foundation

Bronfenbrenner's ecological systems model was the theoretical foundation that guided this study. Ecological systems theory allows for the researcher to investigate several systems concomitantly and highlight the interdependent relations between these systems at the same time (Eriksson et al., 2018). As suggested in Eriksson et al. (2018), bioecological systems theory offers conceptual and methodological tools relevant for organizing and/or evaluating public health interventions. Bronfenbrenner's ecological systems theory evolved in three phases between 1973 and 2006 (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018).

Per Eriksson et al. (2018), the initial phase was developed during the 1970s and named the "ecological model of human development." In this phase, the theory focused on the constructs of microsystem, mesosystem, exosystem, and macrosystem. Eriksson and colleagues described the microsystem as encompassing the relations between a person and their immediate surrounding environment. The mesosystem represents the interrelations between the different settings containing the person. The exosystem relates to social structures, and the macrosystem represents the laws, regulations, and implicit rules and norms of a particular society.

Bronfenbrenner developed the second phase of the theory between 1980 and the mid-1990s while extending the ecological framework to biology and chronosystems. In this phase, Bronfenbrenner emphasized what he called the "proximal processes," which refer to the close and reciprocal interactions between persons and their immediate

environment. By adding the chronosystem to the theory, Bronfenbrenner allowed for the framework to investigate the changes occurring over time and how these changes affect a person's developmental outcome (Bronfenbrenner, 1986, as cited in Eriksson et al., 2018).

During the final phase of the ecological framework, Bronfenbrenner further specified the nature, operation, and developmental effects of the proximal processes (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018). He suggested that proximal processes operate within the microsystems involving interaction with persons, objects, and symbols, which are three features of the immediate environment (Bronfenbrenner, 1995, as cited in Eriksson et al., 2018). Thus, Bronfenbrenner and colleagues coined the model of process-person-context-time (PPCT) as a guideline that bioecological researchers could use to understand why developmental outcomes vary between different persons (Rosa & Tudge, 2013, as cited in Eriksson et al., 2018). The construct of process involves assessing frequent activities and their interactions with persons, objects, and symbols in the persons' lives. The construct of person involves analyzing how person characteristics (e.g., age, gender, intelligence, etc.) influence the proximal processes. The construct of context involves assessing the influences of different exosystems and/or different macrosystems on the proximal processes. Lastly, the construct of time involves considering at least two measurement points, including the current point of historical time (Tudge et al., 2009, as cited in Eriksson et al., 2018).

Lastly, Bronfenbrenner suggested using at least two different ecological systems in ecological research to help understand a specific developmental outcome (Bronfenbrenner, 1975, as cited in Eriksson et al., 2018).

In this regard, the present study was limited to using the constructs of context and person characteristics. The prophylactic antimalarial intermittent preventive therapy in pregnancy (IPTp) and utilization of LLINs were used as context factors. Age, SES, gravidity type of pregnant women, and birth weight were used as person characteristics. Therefore, I examined potential associations between these different factors and the outcome of interest, which was the birth weight of children born to pregnant women participants in the study.

Literature Review Related to Key Variables

This literature review was guided by the need to find information necessary to address the research questions. Several resources were exploited in the context of SSA regarding issues surrounding the detrimental perinatal outcomes of malaria in pregnancy. The articles reviewed included12 cross-sectional secondary data analysis studies, five case-control studies, and five retrospective cohort studies. All the studies used descriptive, binary, and multiple logistic regression analyses, which were consistent with the scope of the present study.

Malaria Infection in Sub-Saharan Africa

Malaria is a life-threatening but preventable and curable disease that is transmitted through the bite of parasite-infected female *Anopheles*mosquitos (WHO, 2019). Per the WHO, malarial disease is caused by infection with different parasite species, including *Plasmodium falciparum*, *Plasmodium vivax*, *Plasmodium ovale*, *Plasmodium malariae*, and *Plasmodium knowlesi*. Of these, *Plasmodium falciparum* and *Plasmodium vivax* are responsible for the disease in humans, with *P. falciparum* being the most virulent. *Plasmodium falciparum* is also the predominant species in SSA, where

most malaria-related adverse birth outcomes occur (Bauserman et al., 2019). Malaria usually presents as a febrile illness along with other nonspecific symptoms including headache and chills, which appear in about 2 weeks after an infective mosquito bite (WHO, 2018). Infection with *P. falciparum* causes anemia, which can complicate rapidly to severe illness and even to death if left untreated (WHO, 2017). It is quite difficult to have a precise estimation of the burden of malaria in SSA because of uncertainties in the definition of malaria cases and difficulties in retrieving data from routine systems (Gething et al., 2016). However, epidemiological modeling strategies have been leveraged, which have highlighted a peak in *P. falciparum* incidence and mortality between 2002 and 2005, followed by a decline thereafter (Weiss et al., 2019). Trends have shown about a 57% decrease in malaria deaths, which went from 12.5 per 10,000 population in 2000 to 5.4 per 10,000 population in 2015 (Gething et al., 2016). Notwithstanding, over 90.1% of people are still at risk of malaria infection in high-transmission endemic areas of SSA (Weiss et al., 2019). As suggested by Weiss and colleagues (2019), SSA alone accounted for 79.4% of global malaria cases and 87.6% of deaths in 2017. Within areas of high transmission such as Kenya, estimates have highlighted 10% overall prevalence of malaria infection across four different surveys carried out between March 2018 and February 2019 (Kamau et al., 2020). In Togo, malaria is endemic, and infective mosquito bites happen almost any season of the year across the country (Thomas et al., 2020). There were an estimated 233 confirmed malaria cases per 1,000 people in Togo in 2017 with a 4% mortality rate (Dorkenoo et al., 2021).

Temporal Characteristics of Malaria Infection in Sub-Saharan Africa

Within malaria-endemic areas of SSA, transmission follows a seasonal pattern that is strongly associated with rainy seasons (Dorkenoo et al., 2012, as cited in Wang et al., 2020; Kamau et al., 2020). Although infective mosquito bites can happen any season of the year within high-transmission areas, most of the morbidity and mortality occur during or a little after rainy seasons, which justifies the scale up of seasonal malaria chemoprevention (SMC) interventions across countries in SSA (Baba et al., 2020; Kamau et al., 2020). Implementation of SMC interventions has shown protective effectiveness of 88.2% in a case-control study (Baba et al., 2020). Likewise, Baba and colleagues (2020) reported that SMC interventions were associated with decreases in the number of malaria deaths during high-transmission seasons, accounting for 42.4% and 56.6% reductions in malaria deaths in Burkina Faso and The Gambia, respectively (Baba et al., 2020). Studies have highlighted an age pattern of infection in Kenya suggesting that malaria infection increases in communities from childhood, reaches a peak around 12 years of age, and declines after 24 years of age to plateau below 5% through the remainder of adult life (Smith et al., 2005; Smith et al., 2007, as cited in Kamau et al., 2020). In Togo, sentinel surveillance data have highlighted an increase in confirmed malaria cases during rainy seasons in children under and over 5 years of age and in adults (Thomas et al., 2020). On another note, it is worth mentioning that estimates of malaria cases and deaths in the African region of the WHO have highlighted a reduction in malaria case incidence between 2000 and 2019 (WHO, 2020). According to the WHO, malaria case incidence decreased from 363 to 225 cases per 1,000 population at risk over the past two decades, although there were a lot more malaria cases in 2019 than in 2000 (WHO, 2020). The

past two decades have seen population growth in SSA from 665 million in 2000 to 1.1 billion in 2019. This justifies the discrepancy of having lower malaria case incidence in 2019 versus 2000 despite having a higher number of malaria cases in 2019 versus 2000 (WHO, 2020). Lastly, the World Malaria Report (WHO, 2020) highlighted a 44% decrease in malaria deaths, which translated into a 67% decrease in the malaria mortality rate over the past two decades.

Person Characteristics of Malaria Infection in Sub-Saharan Africa

All age groups can be vulnerable to malaria infection outside of malaria-endemic and high-transmission areas due to lack of significant immunity to malaria. Notwithstanding, pregnant women and children under 5 years represent the most vulnerable subgroup in high-malaria-transmission areas of the sub-Saharan African region (WHO, 2017). Contrasting with the significant progress in reducing the prevalence of *P. falciparum* in Africa, women remain at high risk of malaria in pregnancy (WHO, 2019). The World Malaria Report highlighted that roughly 11 million pregnancies were exposed to malaria infection in 2018, of which about 39% occurred in the Democratic Republic of the Congo and Nigeria, 35% occurred in West Africa and Central Africa, and 20% occurred in East and Southern Africa (WHO, 2019). In a double-blind randomized controlled trial of monthly intermittent preventive therapy, Kajubi et al. (2019) found that primigravid women had significantly higher malaria-specific birth outcomes and anemia as compared to multigravida women. Similarly, Kajubi and colleagues reported that adverse birth outcomes were significantly higher in primigravid women as compared to multigravida women. Overall, 35% (11.6 million out of 33.2 million) of pregnancies were exposed to malaria in moderate- to high-transmission areas of SSA in 2019 (WHO,

2020). At the subregional level, Central Africa incurred a 40% prevalence of exposure to malaria during pregnancy, followed by West Africa, with 39% prevalence of exposure to malaria during pregnancy, and East and Southern Africa, with 24% prevalence of exposure to malaria during pregnancy (WHO, 2020).

In Togo, children under 5 years and pregnant women accounted for 34.6% and 3.6%, respectively, of confirmed cases (Dorkenoo et al., 2021). Other sources reported that children under the age of 5 years represented 58.4% of hospitalized severe malaria cases, which generated 69.7% of malaria deaths in 2017 (Thomas et al., 2020). This is consistent with earlier findings that highlighted that children under 5 years old carry the highest burden of malaria infection, accounting for roughly 56% of all reported cases and 73% of all reported deaths (Dorkenoo et al., 2012). A cohort two-arm cluster-randomized controlled study conducted in Côte d'Ivoire between September 2016 and April 2019 highlighted malaria case incidences of 2.29 per child-year and 1.43 per child-year in the intervention and control groups, respectively (Sternberg et al., 2021).

Birth Weight

Birth weight was the outcome variable for the study. Newborns who reach full term and weigh between 2.7 and 4.1 kg are said to have normal weight. The average value of a normal weight is 3.5 kg. Newborns who reach full term and weigh 2.5 kg or less are said to have LBW (Axame et al., 2020). Owing to the ability of *P. falciparum* parasites to accumulate in the intervillous space of the placenta, pregnant women are more vulnerable to malaria infection, which contributes to adverse outcomes including maternal anemia and fetal growth retardation (Schmiegelow et al., 2017). Although not fully understood, the pathogenesis of malaria in pregnancy is believed to cause

detrimental effects on newborns. Indeed, malaria-infested erythrocytes avoid being removed in the spleen by expressing the *P. falciparum* erythrocyte membrane protein 1 (PfEMP1). A variant of this protein (the VAR2CSA) helps to bind the infested erythrocytes to glycosaminoglycans on the syncytiotrophoblasts present in the intervillous space of the placenta (Bauserman et al., 2019; Schmiegelow et al., 2017). Schmiegelow and colleagues (2017) suggested that an inflammatory response follows the anchorage of infested erythrocytes in the intervillous space, which affects fetal growth through a multitude of pathways. One of these pathways involves a succession of events including "infiltration of the mononuclear cells, deposition of malaria pigment, thickening of the trophoblast basement membrane, syncytial knotting, and complement deposition" (Bauserman et al., 2019, p. 2). Bauserman and colleagues (2019) explained that these events disrupt transplacental transportation of glucose and amino acids and uteroplacental blood flow, among others, all of which contribute to impaired fetal growth leading to LBW as a matter of consequence. Several studies have reported the prevalence of LBW as being between 10% and 13% of newborns across the SSA region (Assane et al., 2020; Lingani et al., 2020; Mohammed et al., 2019; Nkoka et al., 2020). Most of these studies have reported LBW to be associated with malaria in pregnancy. The present secondary data analysis highlighted a nationwide distribution of birth weight across the different subgroups targeted in the study.

Dose of Antimalarial Intermittent Preventive Therapy in Pregnancy

Antimalarial (IPTp) is part of the triad of approaches recommended by WHO to control for the detrimental effects of malaria in pregnancy. This approach consists of providing one dose of sulfadoxine and pyrimethamine (SP) to pregnant women each

month up to delivery, starting from the second trimester (Cates et al., 2018). To assess the efficacy of IPTp-SP, several studies have been carried out.

Agbozo et al. (2016) found that risk of LBW was associated with the number of IPTp doses received during ANC visits. They reported an increased risk of LBW in pregnant women who received no or less than two doses of IPTp as compared to their counterparts who received three doses or more.

In a randomized case-control study, Isha et al. (2017) reported similar results with significantly lower parasitemia in pregnant women who received three IPTp doses as compared to their counterparts who received two doses. This translates into 12% incidence of LBW in women on two IPTp doses versus 4.2% in women who received three doses. Several other studies align with this finding which suggests an association between uptake of three or more IPTp doses and normal birth weight babies (Anto et al., 2019; Mohammed et al., 2019; Nkoka et al., 2020).

Indeed, Tshotetsi et al. (2019) reported that the absence of or few numbers of ANC visits predisposed pregnant women to having LBW babies. Lack or limited number of ANC visits also determined the status of IPTp coverage in most settings of SSA (Sangho et al., 2020). This seems to justify the reports that uptake of IPTp is associated with risk of LBW.

Notwithstanding, alternative chemoprevention strategies are being envisioned for a new formula of the IPTp because the IPTp with SP is becoming less effective at preventing fetal growth retardation (Bauserman et al., 2019). In contrast, another study has established elsewhere no statistically significant association between number of doses of IPTp received and risk of LBW although the risk of LBW decreased when doses of

IPTp increased (Lingani et al., 2020). Moreover, taking two or more doses of IPTp has also been associated with increased chances of maternal anemia, which contradicts the finding that increased uptake of IPTp was associated with lower susceptibility to malaria infection in pregnancy (Nekaka et al., 2020). These conflicting findings warranted the need for assessing how the IPTp performs with the current approach that is underway in Togo, hence the reason for including the variable "dose of IPTp" in the present study.

Utilization of Long-Lasting Insecticidal Bed Nets

Utilization of LLINs constitutes a vector control strategy to prevent malaria infection in pregnancy. This strategy aims to control exposure to malaria carrying mosquitoes through a physical barrier (the LLIN) which kills or repels the vectors (Bauserman et al., 2019). The WHO highlighted in 2017 that LLINs constitute an important tool for malaria prevention in SSA. Indeed, the World Malaria Report 2015 estimated that 663 million malaria cases were prevented in the SSA region owing to extensive access to LLINs which accounted for 69% of malaria cases prevented (WHO, 2017). Malaria in pregnancy increases the risk of LBW and placental malaria accounted for roughly 20% of LBW cases in malaria endemic areas including the SSA region (Bauserman et al., 2019). In this regard, sleeping under LLINs is promoted along with the IPTp and management of malaria cases in pregnant women as proven approaches to prevent the detrimental effects of malaria in pregnancy including LBW (Assane et al., 2020; Wafula et al., 2020). Assane and colleagues have reported that not sleeping under LLIN was associated with risk of LBW in Togo and use of LLINs has been shown to reduce LBW by 23% elsewhere in Africa (Assane et al., 2020; Bauserman et al., 2019). However, other studies have established that sleeping under LLINs reduces malaria

incidence, but its prevalence. Moreover, new challenges emerge regarding the efficacy of the vector control approach in preventing LBW owing to pyrethroid (the only insecticide which is used on LLINs) resistance and possibilities of outdoor transmission (Banelli & Beier, 2017; WHO, 2017). From the perspectives listed hereby, it became necessary to investigate any potential association between sleeping under LLINs and risk of LBW in the context of Togo.

Age of Pregnant Women

Several studies have established an association between LBW and age of pregnant women. In Ghana, Mohammed et al. (2020) have reported high risk of LBW in infants born to teenage mothers aged less than 20 years as compared to mothers older than 30 years, although not statistically significant. Likewise, Agbozo et al. (2016) and Manyeh et al. (2016) have reported an association between LBW and maternal ages below 20 years. Seid et al. (2019) reported similar findings in South-Western Ethiopia, suggesting that mothers aged 20 to 24 years accounted for 30.3% of the number of LBW in their study. In Togo, Assane et al. (2020) have reported that maternal age below 18 years was associated with risk of LBW. Notwithstanding, other studies have also associated LBW with extreme maternal age groups. Kamala et al. (2018) have reported in Tanzania that 21% of LBW found in their study were associated with extreme maternal age groups. Their results showed that adolescents and mothers older than 35 years were more likely to deliver LBW babies as compared to their counterparts aged between 20 and 35 years. From their investigation of LBW deliveries in South Africa, Tshotetsi et al. (2019) reported that maternal age was associated with LBW in older women as compared to their teenage counterparts. While no explanation was proposed to justify the frequency of

LBW in older women of this study, it was still questionable how the findings could have suggested otherwise, given that 77% of the sample was made of mothers between 20 and 35 years old. Mohammed et al. (2020) suggested that the risk of LBW was associated with teenage mothers in resource limited countries owing to biological immaturity and other behavioral factors which aggravate the risk when added to maternal malnutrition and inadequate ANC. Lastly, it is worth mentioning that researchers were confident on both sides of these opposite findings when it comes to the credibility of their reports. However, Tshotetsi et al. (2019) suggested that their findings could be more credible because their study involved matching cases to controls versus other studies which exploited entire registries to describe birth outcomes over specific times. The present nationwide secondary data analysis determined the nature of the association between age of pregnant women and risk of LBW in the context of Togo.

Socioeconomic Status of Pregnant Women

SES of pregnant women has been reported to be associated with risk of LBW in infants born to pregnant women in malaria endemic areas of the sub-Saharan African region. In Tanzania, LBW was reported to be more prevalent in women who lived in semi-urban areas versus their counterparts of urban areas considered to be of good SES (Kamala et al., 2018). A similar finding was reported in Ghana wherein Manyeh et al. (2016) indicated a strong association between birth weight and SES. Echoing earlier findings in India which suggested a statistically significant inverse association between income and risk of LBW, Manyeh and colleagues highlighted that poverty was an important determinant of LBW in Ghana. In Ethiopia, unemployed women were reported to be five times more likely to give birth to LBW babies compared to their counterparts

who had a job (Alemu et al., 2019). In the contexts of Malawi and Uganda for instance, it has been reported that adequate IPTp uptake and use of LLIN were more likely for women from wealthy households (Nkoka et al., 2020; Wafula et al., 2020). Moreover, Alemu et al. (2019) explained that women's economic dependency on their husbands was a limiting factor for health care seeking behavior. Limited access to ANC services comes with missing proper education on nutrition and vitamin and mineral supplementations that is critical for healthy pregnancy and favorable perinatal outcomes (Kamala et al., 2018). Indeed, poor maternal nutritional intake has been reported among pregnant women from lower SES. This can lead synergistically along with malaria infection to the onset of anemia and eventually, to LBW because of both intrauterine growth retardation and preterm birth (Bauserman et al., 2019). The impact of SES of pregnant women was yet to be investigated regarding how that affects the effectiveness of prevention of LBW in Togo. This justified my choice to introduce this construct in the present study.

Gravidity Type of Pregnant Women

The gravidity type of pregnant women represents the number of times a woman has been pregnant. Lingani et al. (2020) determined that being primigravida and multigravida with history of stillbirth were positively associated with risk of LBW (*OR* = 8.83, 95% CI: 3.71- 21.01, and *OR* = 5.03, 95% CI: 1.54-16.40 respectively). Similar findings were reported by Nekaka et al. (2020), suggesting that primigravida women were more likely to give birth to LBW babies. Plausible explanation could be found in a couple studies carried out elsewhere. Indeed, Essiben et al. (2016) compared cases of pregnant women who had positive malaria diagnostic tests to controls with negative tests. Their findings showed that gravidity and history of possible malaria infection negatively

affected outcomes of the IPTp-SP intervention. Likewise, Schmiegelow et al. (2017) studied the effects of early exposure to *P. falciparum* in pregnant women. Their results showed a 14% reduction in placental weight in exposed women as compared to nonexposed women. Moreover, they found more severe effects of exposure in primigravida compared to secundigravida and suggested that immunity to malaria infection increases with gravidity. In line with these findings, Bauserman et al. (2019) have also reported greater risk of severe malaria infection in younger mothers versus older mothers because of increased immunity in their elder counterparts. Lastly, it has been established that adult people from malaria endemic areas develop partial immunity from exposure to *P. falciparum.* However, women tend to lose this acquired partial immunity through their first and second pregnancy (Aguzie, 2018). In furtherance, Aguzie (2018) also suggested that anti-VAR2CSA specific antibodies increase in women with the number of pregnancies. Ultimately, this situation blocks the capability of infested erythrocytes to anchorage in the intervillous space of the placenta, which explains a decrease in risk of LBW in multigravida women versus primigravida and secundigravida (Aguzie, 2018). The present study extended on the existing literature in the context of Togo. This also presented a nationwide picture of the trends in the association between gravidity type of pregnant women and risk of LBW.

Summary and Conclusion

In this chapter, I reviewed the literature regarding the constructs of dose of IPTp, use of LLIN, age of pregnant women, SES of pregnant women, gravidity type of pregnant women, and birth weight. The background insight gained from this review highlights that

- Several studies have established an association between malaria in pregnancy and risk of LBW in the sub-Saharan African region.
- Providing three or more doses of the IPTp to pregnant women and consistent use of LLINs during pregnancy were effective in reducing the risk of LBW.
- Depending on different circumstances, the risk of LBW may be associated with either younger or older ages in pregnant women.
- SES and gravidity type of pregnant women are inversely associated with risk of LBW.

It is also worth mentioning that some contradicting findings have been highlighted that were considered while analyzing the nationwide data set in the context of Togo.

In Chapter 3, I presented the research design and research questions for the present study. I then discussed my choice for design, the methodology, and connection to the research questions along with discussing the statistics that I used to address the research questions. Lastly, I discussed potential internal and external threats to validity of my results, among others.

Chapter3: Research Method

Introduction

The purpose of the study was to determine whether an association exists between each of the main independent variables, dose of IPTp and utilization of LLINs, and the dependent variable, birth weight, on one hand, and between each of the covariates, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women, and the dependent variable, birth weight, on the other hand. In this study, I focused on women aged 15 to 49 years from a nationally representative sample of household residents who participated in the third Togo DHS from November 2013 to April 2014. Chapter 3 covers the research design and the rationale for its selection. In addition, I present the setting and the sampling of the population of the study. I also discuss the inclusion and exclusion criteria. The DHS database from ICF International constituted the frame of reference to guide the sections, which include data collection, instrumentation, and power analysis. I then present the research questions and related hypotheses, study variables, sample size determination, and justification as parts of the methodology for the present study. In the data analysis section, I present the statistical tests that were used to answer the research questions. The final section of this chapter refers to the validity of the research and the steps that I used to ensure the protection of study participants. The chapter ends with a summary and transition note to Chapter 4.

Research Design and Rationale

This was a cross-sectional secondary data analysis studyin which I aimed to explore whether there was an association between each one of two main independent variables and birth weight in Togo. The nature of the association was then analyzed while

controlling for three other identified covariates. The two main independent variables were dose of IPTp and utilization of LLINs. The covariates included age of pregnant women, SES of pregnant women, and gravidity type of pregnant women. Birth weight was the dependent variable. Secondary data from the DHS, a program funded by USAID, were used to address the research questions. Eventually, the insight gained from the established associations could help stakeholders to deliver appropriate interventions to address the issue of LBW in Togo. This justified the need for a quantitative cross-sectional study to analyze nationally representative data. The present quantitative study was designed based on Bronfenbrenner's ecological systems model. Bronfenbrenner's ecological systems model provides researchers with appropriate tools to organize and evaluate public health interventions (Eriksson et al., 2018).

Methodology

Located in West Africa, Togo is a country with 56,785 km^2 total mass land. The country is bordered by Ghana, Burkina Faso, Benin, and the Bight of Benin (Central Intelligence Agency, 2022). The World Bank estimated Togo's population at 8.1 million in 2019. According to the World Bank, females represent roughly 50.3% of Togo's total population. Females ages 20–24 represented 8.8% of the total female population while females ages 25–29 represented 7.6% of the total female population in 2019. Togo's health system has a pyramidal structure with three levels including the central level, the regional (intermediate) level, and the peripheral level (Bakai et al., 2020). According to Bakai and colleagues (2020), national malaria control directives and policies are developed at the central level. The National Malaria Control Program (NMCP) is located at the central level. The regional level is responsible for providing technical support to

health districts. This level comprises six regions; from south to north, the regions are Maritime, Lomé-Commune, Plateaux, Centrale, Kara, and Savanes (Thomas et al., 2020). The peripheral level covers 43 health districts and 944 peripheral care units that constitute the operational level of the health system (Bakai et al., 2020).

Target Population

The third standard DHSwas carried out by the Togo Direction Générale de la Statistique et de la Comptabilité Nationale (DGSCN) between November 2013 and April 2014. The target population consisted of women aged 15–49 years, children under 5 years of age, and men aged 15–59 years living in residential households (ICF International, 2012). However, only the data of women aged 15–49 years were exploited in the present study.

Sample Size

A total of 9,955 women aged 15–49 years were successfully surveyed from the sampled households. This included 3,940 women from urban households and 6,015 women from rural households (MPDAT, MS, & ICF International, 2015).

Sampling and Sampling Procedures

The third Togo standard DHS used a sample selected in two stages. Using a stratified two-stage cluster design, data were collected from women aged 15–49 years through face-to-face interviews whereby information was gathered on measures of population health and birth histories. The stratification consisted of separating each study domain into urban and rural areas based on the classification in the 2010 Togo population and housing census. Samples were selected independently in every stratum (MPDAT, MS, & ICF International, 2015).

At the first stage, 330 enumeration areas (EAs) were selected with a probability proportional to the size of each EA. The size of the EA is the number of households that it contains. This sampling strategy aimed to ensure representativeness of the sample at the regional level. Thus, a household list was generated from each EA, and the resulting lists of households represented the sampling frame for selection of households in the second stage (MPDAT, MS, & ICF International, 2015).

At the second stage, 30 households were selected through equal probability systematic sampling from each of the 330 EAs. This generated 9,900 households selected, including 3,840 households from urban EAs and 6,060 households from rural EAs. Overall, 9,955 women aged 15–49 years were surveyed successfully, including 3,940 women from urban EAs and 6,015 women from rural EAs (MPDAT, MS, & ICF International, 2015). Several sociodemographic data were collected during the interviews, including dose of the IPTp, utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women, which were used in the present study. Birth weight (the outcome of interest in the present study) data were collected for the 5 years preceding the survey and recorded in the woman's questionnaire based either on a written record or the mother's report. When birth weight was unknown (which was the case for many infants), mothers were asked to estimate their infant's size at birth. Although subjective, the estimates of infant size at birth could be reasonably used as proxies for birth weight (MPDAT, MS, & ICF International, 2015).

Inclusion Criteria

ICF International recommends that DHS samples cover 100% of the target population. In the specific case of the third Togo standard DHS, all women aged 15–49

years living in selected residential households or who slept in the selected households the night before the survey were eligible for interview (MPDAT, MS, & ICF International, 2015).

Exclusion Criteria

The general DHS principles suggest that the surveys cover 100% of the target population. Notwithstanding, exclusion of some areas may occur in some circumstances due to extreme inaccessibility, violence, or instability, all of which must be given full consideration at early stage of the survey before samples are drawn (ICF International, 2012). Full coverage was effective in the case of the third Togo standard DHS (MPDAT, MS, & ICF International, 2015).

Power Analysis and Sample Size

According to Sharma et al. (2020), some basic statistical information is critical for calculating the sample size required for a study. This information includes a set of null and alternative hypotheses, an acceptable significance level, the study power, and the expected effect size, among others. Sharma and colleagues suggested that a 5% or 1% level of significance is conventionally acceptable and considered in biomedical research, standing for 5% or 1% probability that the results observed are due to chance rather than to the intervention. The study power serves to highlight the meaningfulness of findings (Ialongo, 2016). It stands for the likelihood of generalizability of study findings (Sharma et al., 2020). Effect size serves to highlight the relevance of the evidence established through the research (Ialongo, 2016). The G*Power (Heinrich Heine Universitat, Dusseldorf, Germany) calculator was used to determine the minimum sample size necessary to test for the six hypotheses of this study. As suggested in Ialongo (2016), this

application allows for calculating stand-alone effect sizes based on different statistical test families. A power of 0.8 or 80% or greater is considered ideal for determining statistically significant outcomes in clinical trials (Sharma et al., 2020). In an a priori power analysis, I assumed the following inputs into the analysis: alpha = .05, Cohen's *d* effect size of .15, and a prespecified level of statistical power of .80. With five predictors in the model, the return from the calculation was a minimum sample size of 92 participants. Having arrived at this minimum sample size estimation, it was fair taking into consideration the suggestion by Bujang et al. (2018) that studies with sample sizes less than 100 could overestimate effect measures. For this reason, I used the sample size of 92 participants as a minimum guide only. The solution to securing a larger sample size for the present analytical cross-sectional study was provided by the archival data of the third Togo standard DHS, courtesy of ICF International.

Research Instruments

The data for this study were provided by the third Togo DHS data set. The surveys were carried out by the Togo DGSCN and the International Classification Function under the DHS program funded by the USAID. Demographic health surveys aim to collect, process, tabulate, and present a report on a wide range of topics from a representative sample of population in countries that participate. The report often covers the living conditions and demographic and health situation in the country (Croft et al., 2018).

Published in January 2015, the report for the third Togo DHS provided relevant data necessary to answer my research questions, thus its appropriateness for the present study. Permission inquiries were sent to ICF International Maryland.

As stated on the DHS program website, all DHS data sets are free to download and use. The procedure for gaining access to the data set is straightforward. The inquirer is required to complete a short registration form and submit a request to access the desired data set. Requests are usually approved within 24 hours. Upon approval of the request, the desired data set can be downloaded directly from the website (https://dhsprogram.com).

Operationalization of Study Variables

My request was approved, and access was granted to the third Togo DHS data set. This allowed me to process the following independent variables:

- dose of IPTp
- utilization of LLIN
- age of pregnant women
- SES of pregnant women
- gravidity type of pregnant women

These variables were the factors that I analyzed to explore potential associations between each independent variable and birth weight, which represented the dependent variable. The independent variables were used to address the hypotheses and provide answers for each of the research questions. From the DHS data set, data on wealth index were used as a proxy for the variable SES of pregnant women. The wealth index served as a proxy based on data from household's ownership of items including consumer goods, dwelling characteristics, type of drinking water source, toilet facilities, and other items related to SES. Wealth index was measured in quintiles and presented in the data

set as “lowest,” “second,” “middle,” “fourth,” and “highest” wealth quintiles (MPDAT, MS, & ICF International, 2015). Table 2 is a summary of all variables in this study.

Table 2

Summary of Study Variables

Variables	Nature	Type	Coding scheme
Doses of IPTp	Independent	Categorical	IPTp0 = 1 IPTp1 = 2 ITPp2 = 3 IPTp3 = 4
Utilization of LLINs	Independent	Categorical	Yes = 1 / No= 2
Age of pregnant women	Independent	Categorical	< 20 years = 1 20–35 = 2 >35 = 3
SES of pregnant women	Independent	Categorical	Lowest = 1 Second = 2 Middle = 3 Fourth = 4 Highest =5
Gravidity type of pregnant women	Independent	Categorical	Primigravida = 1 Multigravida = 2
Birth weight	Dependent	Interval-ratio	Normal birth weight = 1 Low birth weight = 2

Data Analysis Plan

IBM SPSS statistics version 25 was used to process the data obtained from the DHS program of ICF International. A set of five research questions was used to explore the potential association between each of the five independent variables and birth weight. The sixth research question helped to determine the type of association (if any) between the main independent variable (dose of IPTp) and birth weight while controlling for the other four variables as covariates. The research questions and hypotheses were as follows:

Research Question 1: Is there an association between dose of IPTp (IPTp0, IPTp1, IPTP2, IPTp3, etc.) in pregnant women and birth weight in infants?

H_{10}: There is no association between dose of IPTp in pregnant women and birth weight in infants.

H_{1A}: There is an association between dose of IPTp in pregnant women and birth weight in infants.

Research Question 2: Is there an association between utilization of LLINs by pregnant women and birth weight in infants?

H_{20}: There is no association between utilization of LLINs by pregnant women and birth weight in infants.

H_{2A}: There is an association between utilization of LLINs by pregnant women and birth weight in infants.

Research Question 3: Is there an association between age of pregnant women and birth weight in infants?

H_{30}: There is no association between age of pregnant women and birth weight in infants.

H_{3A}: There is an association between age of pregnant women and birth weight in infants.

Research Question 4: Is there an association between SES of pregnant women and birth weight in infants?

H_{40}: There is no association between SES of pregnant women and birth weight in infants.

H_{4A}: There is an association between SES of pregnant women and birth weight in infants.

Research Question 5: Is there an association between gravidity type of pregnant women and birth weight in infants?

H_{50}: There is no association between gravidity type of pregnant women and birth weight in infants.

H_{5A}: There is an association between gravidity type of pregnant women and birth weight in infants.

Research Question 6: Is there an association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women?

H_{60}: There is no association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age

of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

H_{6A}: There is an association between dose of IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

Answers to the research questions were provided through testing of each hypothesis accompanying the question. Each hypothesis was analyzed in chapter 4 after approval was obtained for the proposal. Overall, the data analysis involved (1) frequency tabulation for each of the variables, (2) cross tabulation of all variables with birth weight, (3) simple logistic regression, and (4) multiple logistic regression. The simple regression model serves to examine the type of association between one independent variable and one dependent variable while the multiple regression model estimates how several independent variables could associate with one dependent variable (Frankfort-Nachmias & Leon-Guerrero, 2016). Simple logistic regression was leveraged to examine the association between each independent variable and birth weight while multiple logistic regression was leveraged to examine the association between the variable dose of IPTp and birth weight controlling for the other independent variables. To achieve this, I recoded the dependent variable into "Low birth weight" for values of 2.5 Kilograms or less and "Normal birth weight" for values greater than 2.5 kg. Different statistic tests have been exploited to find answers for the research questions including classification plots, Homer-Lemeshow goodness-of-fit (H-L test), case wise listing of residuals, and confidence interval for Exp(B) 95%. The value of Exp(B) represents the odds ratio of the

dependent variable which provides the amount of change in odds of the dependent variable that results from one-unit change in the predictor variable. The Homer-Lemeshow test compares the observed cases to the number predicted by the linear regression model. Non-significant values of the H-L test will indicate that the model prediction does not differ significantly from the observed cases while significant values will indicate otherwise (Walden University, n.d.). Odds ratios are often used in biomedical research to compare two or more groups when the focus of the study is to measure the presence or absence of an event or to present the frequency of occurrence of the event (Sroka & Nagarja, 2018). Norton and colleagues have put this in a different way saying that odds ratios relate to the probability of a binary outcome (Norton et al., 2018). The outcome of interest in this study was either the presence of the event (LBW), or its absence (normal birth weight). This justified my choice of odds ratios through simple and multiple logistic regression analyses to explore potential association between each of the independent variables and birth weight in Togo.

Threats to Validity

As suggested in Garver and Mentzer (1999), validity in research refers to a hierarchy of procedures to ensure that the findings of the research can be shared with confidence. Validity is accomplished in a study when both internal and external validity are warranted (Garver & Mentzer, 1999). In the present study, data quality and the statistical methods and/or tests used could present some threats to internal and external validity, respectively. When it came to data quality and internal validity, the question of interest here was whether the content of the construct “birth weight” was effectively represented in the DHS data set by items that cover the domain of meaning for this

construct. When it came to statistical methods and/or tests and subsequent external validity, the question of interest was whether the methods used, and related statistic outputs warranted generalizability of findings to the broader population.

About data quality, Kong et al. (2020) reported that women's survey report is less accurate in capturing birth weight and LBW prevalence as compared to written records at health facilities. Indeed, a study found that survey-reported birth weight coverage underestimated observed coverage by 5% and LBW prevalence by one percent. Moreover, survey-reported birth weight heaping was 1.5 times as higher as the observed heaping (Kong et al., 2020). In the third Togo standard DHS, mothers were asked to estimate their infants' size at birth as a proxy of unknown birth weight. This could bias survey data and constitute a threat for internal validity for the study.

About the statistical methods and/or tests used, the output from simple and multiple logistic regression analyses have generate odds ratios. At the sample level, the odds ratios served to determine the nature of association between each independent variable and birth weight. The logistic regression model allows for a researcher to explore the type of association between a specific factor variable and the outcome of interest while adjusting for the other factors (Norton et al., 2018). However, Norton and colleagues warn that odds ratios can vary within the same study based on the explanatory variables used. In furtherance, odds ratios can vary within the same study when additional explanatory variables are included that are not independent. This represented a potential threat to external validity.

Notwithstanding, the issue of internal and external validity were addressed in the DHS through multi-level stratification and sample weight calculation. Stratification

allows for reducing sampling errors by creating flexible designs that are different for each subgroup but show low internal variability (ICF International, 2012). ICF International recommends to DHS data users to factor sampling weights properly in the data analysis. Doing so will help to avoid bias which can prompt to inconsistent conclusion. Overall, ICF International suggests that sampling weights are critical to ensuring valid statistical inference from DHS data. Sampling weights have been considered in this study.

Ethical Procedures

According to ICF International, the DHS takes confidentiality very seriously when it comes to collecting data on human biomarkers. To this end, DHS surveys are anonymous and do not allow any potential identification of households or individuals in the data file (ICF International, 2012). Given that, the DHS data sets are free to download and use after access is granted. The responsibility fell on me to ensure that the downloaded data was used in conformity with the purpose for acquiring the data set which was to carry out statistical analysis and find responses to my research questions. Given that this objective is achieved, I can now destroy the data set. By all means, I still can have access to the DHS data repository when needed.

Summary

Chapter 3 allowed me to provide readers with information on the setting for the present study, the research design along with the rationale for choosing this design, study variables, and research questions. The methodology was discussed where I elaborated on sampling and sampling procedures, the research instrument (the third Togo DHS data set), and operationalization of study variables. In the data analysis plan, simple and multiple logistic regression were selected to be used for statistical analysis through IBM

SPSS statistics version 27. Then I discussed some potential threats to validity and closed with some thoughts on ethical considerations. Overall, this chapter introduced Chapter 4 where I presented the results of all the statistical tests and processing that I carried out through the SPSS statistical software package.

Chapter 4: Results

Introduction

The purpose of this study was to explore the potential associations between antimalarial IPTp, utilization of LLINs, and birth weight, respectively. I analyzed secondary data from the third Togo standard DHS 2013–2014 that were made available by ICF International, Maryland. Overall, six research questions and hypotheses were tested.

Research Question 1: Is there an association between IPTp in pregnant women and birth weight in infants (LBW = 1 / normal birth weight = 0)?

H_{10}: There is no association between IPTp in pregnant women and birth weight in infants.

H_{1A}: There is an association between IPTp in pregnant women and birth weight in infants.

Research Question 2: Is there an association between utilization of LLINs by pregnant women and birth weight in infants?

H_{20}: There is no association between utilization of LLINs by pregnant women and birth weight in infants.

H_{2A}: There is an association between utilization of LLINs by pregnant women and birth weight in infants.

Research Question 3: Is there an association between age of pregnant women and birth weight in infants?

H_{30}: There is no association between age of pregnant women and birth weight in infants.

H_{3A}: There is an association between age of pregnant women and birth weight in infants.

Research Question 4: Is there an association between SES of pregnant women and birth weight in infants?

H_{40}: There is no association between SES of pregnant women and birth weight in infants.

H_{4A}: There is an association between SES of pregnant women and birth weight in infants.

Research Question 5: Is there an association between gravidity type of pregnant women and birth weight in infants?

H_{50}: There is no association between gravidity type of pregnant women and birth weight in infants.

H_{5A}: There is an association between gravidity type of pregnant women and birth weight in infants.

Research Question 6: Is there an association between IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women?

H_{60}: There is no association between IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

H_{6A}: There is an association between IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women.

In this chapter, I report baseline descriptive and demographic characteristics of the sample. Next, I test for assumptions and organize and report the results of statistical analyses by research question and related hypotheses. Lastly, I present the main results in a summary for this chapter.

Data Collection

This study involved using the third Togo standard DHS 2013–2014 (Togo DHS-VI). Data collection and authorization materials were submitted to the Walden Institutional Review Board (IRB) and approved under the number 07-13-21-0652649.Access to the secondary data was granted by ICF International, Maryland, upon request. The original dataset contained information on women aged 15–49 years, children under 5 years of age, and men aged 15–59 years. The children's data file was used because it provided information on children under 5 years of age whose mothers had been interviewed. However, the information on IPTp antimalarial chemoprevention did not specify the number of doses received by pregnant women. I therefore rephrased Research Question1 to better convey reality. Thus, the initial version of Research Question 1 ("Is there an association between doses of IPTp (IPTp0, IPTp1, IPTp2, IPTp3) in pregnant women and birth weight in infants?") was replaced by "Is there an association between IPTp in pregnant women and birth weight in infants?"

The Togo DHS-VI reported that data were collected for children under the age of 5 years who were born in the past 2 years preceding the interview. These data were accounted for by selecting cases pertaining to the variable "births in the past 3 years" with values greater than zero. Overall, information was available for a total of 5,512 births. Of all the women who reported childbirth within the last 3 years, 133(4.8%) were ages 15–19, 5,527 (66.3%) were ages 20–34, and 947 (28.9%) were ages 35–49. A total of 4,009 birth weights were collected and were included in this study. Of these, 627(15.6%) were between 0.5 and 2.5 kg; 3,382 (84.4%) were 2.5 kg or greater. To satisfy the requirements for logistic regression analysis, the variables have been transformed as shown below:

- Birth weight has been dichotomized (normal birth weight = 0, LBW = 1).
- Age of pregnant women has been categorized and dummy recoded (15–19 = AgeD1, 20–34 = AgeD2, 35–49 = AgeD3).
- SES (wealth index) has been categorized and dummy recoded (Poorest + poor = Lower = SESD1, Middle = SESD2, richer + richest =High = SESD3).
- Gravidity type of pregnant women (birth order number) has been categorized and dummy recoded (BORD = 1 =Primigravida = GravidityD1, BORD =2 = Secundigravida = GravidityD2, BORD >= 3 = Multigravida = GravidityD3).

The variables IPTp and utilization of LLINs were kept as initially presented in the dataset because they were already dichotomous. To assure the representativeness of the sample at the national population level, these data were weighted, and the corresponding

weight was considered in the analyses through a complex sample file. Lastly, a complex sample file was created to factor sampling design into analyses and results. Table 3 summarizes the baseline descriptive and demographic characteristics of the sample.

Table 3

Baseline Descriptive and Demographic Characteristics of the Sample

Variable		Frequency	Percentage
IPTp	No = 0	1,136	23.5%
	Yes = 1	3,704	76.5%
Total *N*		4,840	100%
Utilization of LLINs	No = 0	3,634	54.2%
	Yes = 1	3,072	45.8%
Total *N*		6,706	100%
Age of pregnant women	15–19 years = AgeD1	133	4.8%
	20–34 = AgeD2	5,527	66.3%
	35–49 = AgeD3	947	28.9%
Total *N*		6,707	100%
SES of pregnant women	Low = 1 = SESD1	2,797	41.7%
	Middle = 2 = SESD2	1,347	20.1%
	High = 3 = SESD3	2,563	38.2%
Total *N*		6,707	100%
Gravidity type of pregnant women	GravidityD1	1,561	23.3%
	GravidityD2	1,308	19.5%
	GravidityD3	3,837	57.2%
Total *N*		6,706	100%
Birth weight	Normal birth weight = 0	3,382	84.4%
	Low birth weight = 1	627	15.6%
Total *N*		4,009	100%

To answer the research questions, simple logistic regression analyses were carried out separately. The aim was to sort out the significant predictors, which were then included in a final multiple logistic regression analysis. This helped to determine

the predictor variables, which showed a statistically significant association with the outcome variable.

Results

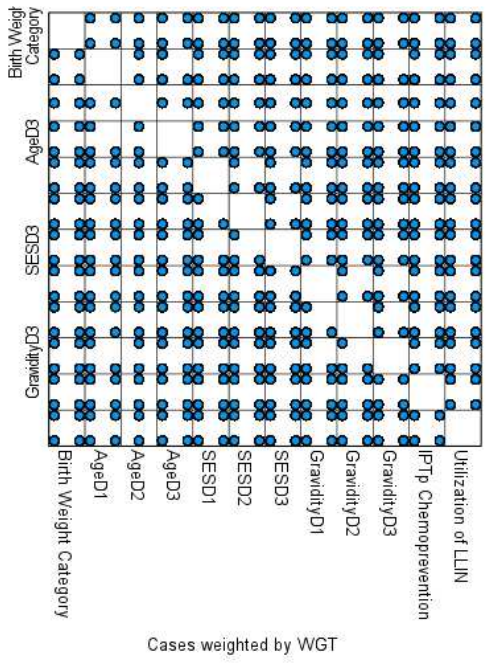
Different diagnostic tests were carried out to assess the assumptions.

Assumption of Linearity

The scatter diagram in Figure 1 indicates an approximately linear relationship among the different variables in the scatterplot matrix. This suggests that the assumption of linearity was met.

Figure 1

Test for the Assumption of Linearity—Scatterplot Matrix



Assumption of Sampling Independence

I used the tolerance and variance inflation factor (VIF) estimates to assess for this assumption. These two estimates are relevant to verify the degree of correlation between

the different predictor variables in the logistic regression model. The return output for the collinearity diagnostic test (Table 4) showed no tolerance value that was less than 0.10 and no VIF value greater than 10, which would otherwise indicate high collinearity. This suggested that there was no interrelationship among the predictor variables present in the model. Thus, the assumption of sampling independence was met.

Table 4

Test for the Assumption of Sampling Independence—Collinearity Coefficients[a]

		Collinearity statistics	
	Model	Tolerance	VIF
1	IPTp chemoprevention	.995	1.005
	Utilization of LLINs	.982	1.018
	AgeD1	.948	1.055
	AgeD3	.908	1.101
	SESD1	.870	1.150
	SESD2	.896	1.116
	GravidityD2	.690	1.448
	GravidityD3	.614	1.629

[a]Dependent variable: Birth weight category.

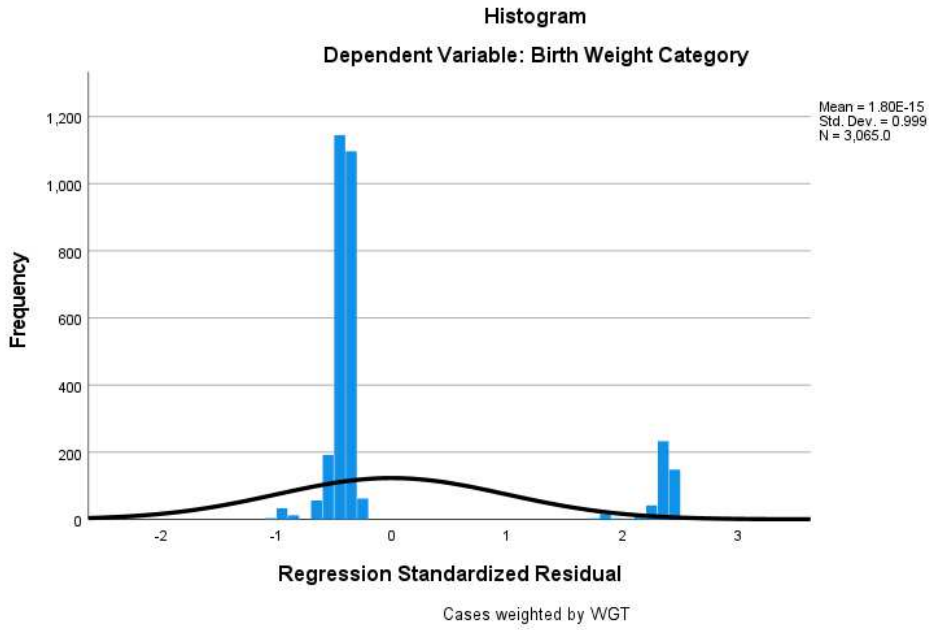
Assumption of Normality

I performed a regression of residuals and leveraged on the histogram and normal probability plot to assess this assumption. Figure 2 shows a distribution of residuals that is approximately normal, although some extreme values are present. This situation was clarified through the scatterplot for regression standardized residuals by regression standardized predicted value (Figure 3). Figure 3 shows two dot-lines that are not totally

horizontal, but the collection of dots clusters around the value of zero. The fact that the lines are tilted at a certain angle could imply that some outliers were present, but these were still not outliers because they did not reach the 3.3 value of standard deviations. These two findings suggest that the outcome variable follows a normal distribution pattern. Thus, the assumption of normality was met.

Figure 2

Test for the Assumption of Normality—Histogram

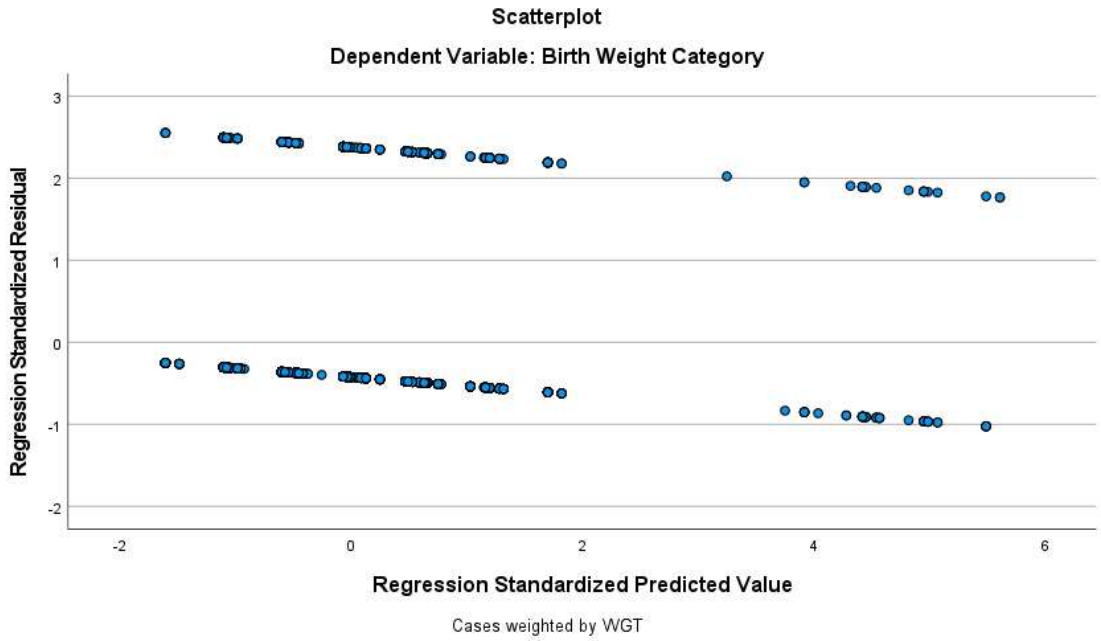


Assumption of Homoscedasticity

This assumption was tested through the scatterplot in Figure 3. As I mentioned earlier, the scatterplot showed a collection of dots clustering around the value of zero. In the case of heteroscedasticity, the collection of dots would have depicted a well distinguished pattern (e.g., U shape). Thus, the assumption of homoscedasticity was met.

Figure 3

Test for the Assumption of Homoscedasticity—Scatterplot of Standardized Residual by Standardized Predicted Value



Research Questions

Research Question 1: Is There an Association Between IPTp in Pregnant Women and Birth Weight in Infants?

I conducted a simple logistic regression analysis on the dataset to determine potential association between IPTp in pregnant women and birth weight in infants. Table 5 shows an odds ratio *OR* = 1.044 (95% CI, .763–1.427). This suggested that the odds of having a LBW infant is 1.044 in pregnant women with zero dose of IPTp as compared to pregnant women who had at least one dose of IPTp. However, the odds ratio seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .788 is > .05 (Table 5). This confirms that IPTp does not have a

statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between IPTp in pregnant women and birth weight in infants. Lastly, it is worth mentioning that an *OR* value > 1.0 suggests that having LBW infants is more likely to happen in pregnant women with zero dose of IPTp (nonexposed group) as compared to pregnant women who had at least one dose of IPTp (exposed group).

Table 5

Summary Table—Birth Weight by Intermittent Preventive Therapy in Pregnancy in Pregnant Women

IPTp in pregnant women	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
IPTp	IPTp = Yes	1.044	.763	1.427	.072	.788	.788

Research Question 2: Is There an Association Between Utilization of LLINs by Pregnant Women and Birth Weight in Infants?

A simple logistic regression analysis was carried out on the dataset to determine potential association between utilization of LLINs by pregnant women and birth weight in infants. Table 6 shows an *OR* = 1.091 (95% CI, .900–1.322). This suggested that the odds of having a LBW infant are 1.091in pregnant women who did not sleep under LLINs during pregnancy as compared to pregnant women who did. However, the odds seem to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .375 is > .05 (Table 6). This confirms that utilization of LLINs by pregnant women does not have a statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between utilization of LLINs by pregnant women and birth weight in infants. Notwithstanding, an *OR* value >

1.0 suggests that having LBW infants is more likely to happen in pregnant women who did not sleep under LLINs during pregnancy as compared with their counterparts who did.

Table 6

Summary Table—Birth Weight by Utilization of Long-Lasting Insecticidal Bed Nets

Utilization of LLINs by pregnant women	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
LLINs	LLINs = Yes	1.091	.900	1.322	.790	.375	.375

Research Question 3: Is There an Association Between Age of Pregnant Women and Birth Weight in Infants?

A simple logistic regression analysis was carried out on the dataset to determine potential association between AgeD1, AgeD2, AgeD3 of pregnant women and birth weight in infants respectively.

For AgeD1, Table 7 shows an *OR* = .335 (95% CI, .189 - .593). This suggested that the odds of having a LBW infant is .335 in pregnant women of AgeD1 (15-19 years) as compared to older pregnant women. This odd seems to be statistically significant because the 95% confidence interval does not include the value of 1. The *p*-value = .000 is < .05 (Table 7). This confirms that AgeD1 (15-19 years) has a statistically significant association with LBW. Thus, I rejected the null hypothesis that there is no association between AgeD1 of pregnant women and birth weight in infants. Consequently, I retained the alternative hypothesis that there is indeed a statistically significant association

between AgeD1 (15-19 years) of pregnant women and birth weight in infants (the reference group being ages 20 years or older).

For AgeD2, Table 7 shows an *OR* = 1.000 (95% CI, 1.000 – 1.000). This situation is typical to instances where there is no association between the predictor variable and the outcome variable. The confidence interval (1.000 – 1.000) implied that no effect is happening here. However, it is equally relevant to mention that such a situation can also happen in the presence of subgroups with very few cases. Because there is no relevant significance to highlight in this case, I failed to reject the null hypothesis that there is no association between AgeD2 (20 – 34 years) of pregnant women and birth weight in infants. This suggests that AgeD2 (20 – 34 years) is not associated with LBW.

For AgeD3, Table 7 shows an *OR* = 1.273 (95% CI, .908- 1.784). This suggested that the odds of having a LBW infant is 1.273 in pregnant women of AgeD3 (35-49 years) as compared with their younger counterparts. This odds ratio seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .161 is > .05 (Table 7). This confirms that AgeD3 (35 – 49 years) of pregnant women does not have a statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between AgeD3 (35 – 49 years) of pregnant women and birth weight in infants. Notwithstanding, an *OR* value > 1.0 suggests that if at all, having LBW infants is more likely to happen in pregnant women AgeD3 (35 – 49 years) as compared with their younger counterparts, those of AgeD2 more precisely.

Table 7

Summary Table—Birth Weight by Age of Pregnant Women

Age of pregnant women	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
AgeD1	AgeD1	.335	.189	.593	14.163	.000	.000
AgeD2	AgeD1	1.000	1.000	1.000	-	-	-
AgeD3	AgeD1	1.273	.908	1.784	1.979	.161	.161

Research Question 4: Is There an Association Between SES of Pregnant Women and Birth Weight in Infants?

A simple logistic regression analysis was carried out on the dataset to determine potential association between SESD1, SESD2, SESD3 of pregnant women and birth weight in infants respectively.

For SESD1, Table 8 shows an *OR* = 1.018 (95% CI, .821 – 1.262). This suggested that the odds of having a LBW infant is 1.018 in pregnant women of SESD1 (lower wealth index) as compared to richer pregnant women. This odd seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .871 is > .05 (Table 8). This confirms that SESD1 does not have a statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between SESD1 of pregnant women and birth weight in infants. However, an *OR* value > 1.0 suggests that if at all, having LBW infants is more likely to happen in this subgroup of pregnant women.

For SESD2, Table 8 shows an *OR* = .898 (95% CI, .702 – 1.148). This suggested that the odds of having a LBW infant is .898 in pregnant women of SESD2 (middle

wealth index) as compared to their other counterparts. This odd seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .389 is > .05 (Table 8) This confirms that SESD2 does not have a statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between SESD2 of pregnant women and birth weight in infants. In furtherance, an *OR* value < 1.0 suggests that having LBW infants is less likely to happen in this subgroup of pregnant women.

For SESD3, Table 8 shows an *OR* = 1.056 (95% CI, .847 – 1.317). This suggested that the odds of having a LBW infant is 1.056 in pregnant women of SESD3 (high wealth index) as compared to their other counterparts. This odds ratio seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .624 is > .05 (Table 8). This confirms that SESD3 does not have a statistically significant association with LBW. Thus, I failed to reject the null hypothesis that there is no association between SESD3 of pregnant women and birth weight in infants. In furtherance, an *OR* value > 1.0 suggests that if at all, having LBW infants is more likely to happen in this subgroup of pregnant women.

Table 8

Summary Table—Birth Weight by Socioeconomic Status of Pregnant Women

SES of pregnant women	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
SESD1	SESD1	1.018	.821	1.262	.027	.871	.871
SESD2	SESD1	.898	.702	1.148	.745	.389	.389
SESD3	SESD1	1.056	.847	1.317	.240	.624	.624

Research Question 5: Is There an Association Between Gravidity Type of Pregnant Women and Birth Weight in Infants?

A simple logistic regression analysis was performed on the dataset to determine potential association between gravidityD1, gravidityD2, gravidityD3 of pregnant women and birth weight in infants respectively.

For gravidityD1, Table 9 shows an *OR* = .687 (95% CI, .564 - .838). This suggested that the odds of having a LBW infant is .687 in pregnant women of gravidityD1 (primigravida) as compared with secundigravida and multigravida pregnant women. This odd seems to be statistically significant because the 95% confidence interval does not include the value of 1. The *p*-value = .000 is < .05 (Table 9). This confirms that gravidityD1 (primigravida) has a statistically significant association with birth weight. Thus, I rejected the null hypothesis that there is no association between gravidityD1 of pregnant women and birth weight in infants. Consequently, I retained the alternative hypothesis that there is indeed a statistically significant association between gravidityD1 (primigravida) of pregnant women and birth weight in infants (as compared to secundigravida and multigravida pregnant women).

For gravidityD2, Table 9 shows an *OR* = .920 (95% CI, .741 – 1.142). This suggested that the odds of having a LBW infant is .920 in pregnant women of gravidityD2 (secundigravida) as compared to primigravida and multigravida pregnant women. This odds ratio seems to be not statistically significant because the 95% confidence interval includes the value of 1. The *p*-value = .448 is > .05 (Table 9). This confirms that gravidityD2 (secundigravida) does not have a statistically significant association with LBW. Therefore, I failed to reject the null hypothesis that there is no

association between gravidityD2 of pregnant women and birth weight in infants. Lastly, an *OR*< 1.0 suggests that having LBW infants is less likely to happen in this subgroup of pregnant women.

For gravidityD3, Table 9 shows an *OR* = 1.455 (95% CI, 1.215 – 1.742). This suggested that the odds of having a LBW infant is 1.455 in pregnant women of gravidityD3 (multigravida) as compared with primigravida and secundigravida pregnant women. This odd ratio seems to be statistically significant because the 95% confidence interval does not include the value of 1. The *p*-value = .000 is < .05 (Table 9). This confirms that gravidityD3 (multigravida) has a statistically significant association with LBW. Therefore, I rejected the null hypothesis that there is no association between gravidityD3 of pregnant women and birth weight in infants. Consequently, I retained the alternative hypothesis that there is indeed a statistically significant association between gravidityD3 (multigravida) of pregnant women and birth weight in infants. Lastly, an *OR*> 1.0 suggests that having LBW infants is more likely to happen in this subgroup of pregnant women (as compared to the secundigravida subgroup).

Table 9

Summary Table—Birth Weight by Gravidity Type of Pregnant Women

Gravidity type of pregnant women	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
GravidityD1	GravidityD1	.687	.564	.838	13.862	.000	.000
GravidityD2	GravidityD1	.920	.741	1.142	.578	.448	.448
GravidityD3	GravidityD1	1.455	1.215	1.742	16.792	.000	.000

Having performed these four different simple logistic regression analyses, I failed to reject the null hypothesis in all cases except for ageD1 of pregnant women, gravidityD1 of pregnant women, and gravidityD3 of pregnant women. Table 10 below presents a summary of the different cases analyzed, the *p*-value for each case and the decision regarding the corresponding null hypothesis.

Table 10

Summary Table of All Four Simple Logistic Regression Analyses

Independent variable		*p*-value	Null hypothesis
IPTp in pregnant women		.788	Failed to reject
Utilization of LLINs		.375	Failed to reject
Age of pregnant women	ageD1	.000	Rejected
	ageD2	-	Failed to reject
	ageD3	.161	Failed to reject
SES of pregnant women	SESD1	.871	Failed to reject
	SESD2	.389	Failed to reject
	SESD3	.624	Failed to reject
Gravidity type of pregnant women	gravidityD1	.000	Rejected
	gravidityD2	.448	Failed to reject
	gravidityD3	.000	Rejected

Research Question 6: Is There an Association Between IPTp in Pregnant Women and Birth Weight in Infants, Adjusting for Utilization of LLINs, Age of Pregnant Women, SES of Pregnant Women, and Gravidity Type of Pregnant Women?

At this step, I excluded IPTp in this subsequent multiple logistic regression analysis because it proved non-significant through the simple logistic regression analysis. Therefore, I performed a multiple logistic regression analysis on the dataset that includes ageD1 of pregnant women, gravidityD1 of pregnant women, and gravidityD3 of pregnant women as covariates. Table 12 shows that gravidityD1 comes with a *p*-value of .256

which is > .05 and I failed to reject the null hypothesis for this case. Conversely, ageD1 and gravidityD3 remained significant with a *p*-value of .000 and .024 respectively.

Table 11

Summary Table—Birth Weight by ageD1, gravidityD1, and gravidityD3

Independent variable	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
AgeD1	AgeD1	2.425	1.484	3.963	12.501	.000	.000
GravidityD1	GravidityD1	1.147	.905	1.453	1.292	.256	.256
GravidityD3	GravidityD1	.777	.623	.968	5.069	.024	.024

Table 12

Summary of Multiple Logistic Regression Analyses—Birth Weight by ageD1, gravidityD1, and gravidityD3

Independent variable	*p*-value	Null hypothesis
AgeD1 of pregnant women	.000	Rejected
GravidityD1 of pregnant women	.256	Failed to reject
GravidityD3 of pregnant women	.024	Rejected

Having arrived at this step, a subsequent modelling included ageD1 of pregnant women and gravidityD3 of pregnant women as covariates. Table 13 (below) showed a *p*-value of .000 for both covariates, which is < .05 Therefore, the null hypothesis was rejected in both cases. This finding brings me to the conclusion that there is indeed a statistically significant association between ageD1(15-19 years) of pregnant women and birth weight in infants. Likewise, there is indeed a statistically significant association between gravidityD3 (multigravida) of pregnant women and birth weight in infants.

Table 13

Summary Table—Birth Weight by ageD1 and gravidityD3

Independent variable	Reference group	Odds ratio [Exp(B)]	95% confidence interval for odds ratio [Exp(B)]		Wald *F*	Sig. of Wald *F*	*p*-value
			Lower	Upper			
AgeD1	AgeD1	2.546	1.569	4.133	14.317	.000	.000
GravidityD3	GravidityD1	.720	.605	.857	13.588	.000	.000

Table 14

Summary of Multiple Logistic Regression—Birth Weight by ageD1and gravidityD3

Independent variable	*p*-value	Null hypothesis
AgeD1 of pregnant women	.000	Rejected
GravidityD3 of pregnant women	.000	Rejected

Summary

In this Chapter 4, I performed diagnostic tests to assess for the assumptions of linearity, sample independence, normality, homoscedasticity and determined that all assumptions were met. Next, I performed simple logistic regression to explore potential association between IPTp chemoprevention, utilization of LLIN, age of pregnant women, SES of pregnant women, gravidity type of pregnant women and birth weight respectively one at a time.

Through simple logistic regression, I rejected the null hypothesis when it came to potential association between ageD1 of pregnant women and birth weight in infants, gravidityD1 of pregnant women and birth weight in infants, and gravidityD3 of pregnant women and birth weight in infants. The multiple logistic regression confirmed the rejection of the null hypothesis for the cases ageD1 of pregnant women and gravidityD3 of pregnant women. However, I failed to reject the null hypothesis for the case of

gravidityD1 of pregnant women at this final step of the statistical analysis. Chapter 5 consisted of interpretation of the findings for the study along with some recommendations and implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

I conducted this quantitative cross-sectional study to explore the potential associations between IPTp chemoprevention in pregnant women, utilization of LLINs, and birth weight, separately. Because of their importance in the literature, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women were also examined regarding potential associations between these variables and birth weight separately. The objective was to provide policymakers with insight regarding pregnancy-related determinants of LBW in Togo.

Summary of Findings

In this study, I found that there is a statistically significant association between ageD1(15–19 years) of pregnant women and birth weight in infants. Additionally, there is a statistically significant association between gravidityD3 (multigravida) of pregnant women and birth weight in infants. To arrive at this determination, I examined the research questions one at a time.

RQ1. Is there an association between IPTp in pregnant women and birth weight in infants? At this step, I found no statistically significant association.

RQ2. Is there an association between utilization of LLINs by pregnant women and birth weight in infants? At this step, I found no statistically significant association.

RQ3. Is there an association between age of pregnant women and birth weight in infants? At this step, I found that there is a statistically significant

association between ageD1(15–19 years) of pregnant women and birth weight in infants.

RQ4. Is there an association between SES of pregnant women and birth weight in infants? At this step, I found no statistically significant association.

RQ5. Is there an association between gravidity type of pregnant women and birth weight in infants? At this step, I found that there is a statistically significant association between gravidityD1 (primigravida) of pregnant women and birth weight in infants. Likewise, there is a statistically significant association between gravidityD3 (multigravida) of pregnant women and birth weight in infants.

RQ6. Is there an association between IPTp in pregnant women and birth weight in infants, adjusting for utilization of LLINs, age of pregnant women, SES of pregnant women, and gravidity type of pregnant women? At this last step, I found that there still is a statistically significant association between ageD1(15–19 years) of pregnant women and birth weight in infants. Additionally, there is still a statistically significant association between gravidityD3 (multigravida) of pregnant women and birth weight in infants.

Interpretation of the Findings

Is there an association between IPTp in pregnant women and birth weight in infants? My findings showed no statistically significant association. Per Isha et al. (2017), the effect of IPTp is preventative. This chemoprevention measure mitigates the effects of malaria infection during pregnancy to reduce the risk of LBW consequently (Anto et al., 2019; Mohammed et al., 2019; Nkoka et al., 2020). In line with this, Bakken and Iversen

(2021) found that providing pregnant women with three or more doses of IPTp-SP was associated with a decreased risk of LBW as compared to the standard two-dose regimen. I could not verify this because I did not investigate the effects of different doses of IPTp. However, my findings seem to align with Lingani et al. (2020), who established no statistically significant association between number of doses of IPTp received and risk of LBW.

Is there an association between utilization of LLINs by pregnant women and birth weight in infants? I found no statistically significant association. Utilization of LLINs constitutes a physical barrier strategy to prevent mosquito bites and malaria infection, and LLINs proved effective in protecting from malaria-related morbidity and mortality (Bauserman et al., 2019; Roux et al., 2021). This is in line with Ela et al. (2019), Assane et al. (2020), and Wafula et al. (2020), who reported that giving birth to LBW infants is more likely to happen in pregnant women who did not use LLINs during pregnancy. The present study could not provide any further insight on this because I did not investigate a variation in LBW incidence as that relates to utilization of LLINs.

Is there an association between age of pregnant women and birth weight in infants? My finding showed a statistically significant association between ageD1(15–19 years) of pregnant women and birth weight in infants. Comparing adolescent mothers to their older counterparts, Tessema et al. (2021) found that the odds of LBW among mothers aged 20–29, 30–39, and 40–49 were decreased by 25%, 24%, and 14%, respectively, as compared to mothers aged 15–19 years. This is in accordance with Assane et al. (2020), who reported that maternal age below 18 years was associated with risk of LBW in Togo. Similar findings have been reported within the West Africa region.

Namely, Agbozo et al. (2016) and Manyeh et al. (2016) reported an association between maternal ages below 20 years and LBW in Ghana. Moreover, Mohammed et al. (2020) also reported high risks of LBW in infants born to teenage mothers aged less than 20 years. Chaura et al. (2021) also reported a high proportion of LBW babies born to adolescent pregnant women. However, they suggested that this adverse birth outcome could not be attributed to the age of pregnant women only unless optimal peripartum care were available, which was not the case.

Is there an association between SES of pregnant women and birth weight in infants? My findings showed no statistically significant association. Notwithstanding, Kamala et al. (2018) reported that women living in semiurban areas of Tanzania were more likely to give birth to LBW infants as compared to their counterparts in urban areas that are considered to be of good SES. Indeed, Nkoka et al. (2020) and Wafula et al. (2020) reported that in Malawi and Uganda, for instance, adequate IPTp uptake and use of LLINs were more likely for women from wealthy households. On a concordant note, Alemu et al. (2019) reported in Ethiopia that unemployed women were 5 times more likely to give birth to LBW babies compared to their counterparts who had a job. In a systematic review study covering sub-Saharan African countries, Ngandu et al. (2020) reported that women who had a source of income were less likely to give birth to LBW infants.

Is there an association between gravidity type of pregnant women and birth weight in infants? My findings suggested a statistically significant association between gravidityD1 (primigravida) of pregnant women and birth weight in infants. Likewise, there was a statistically significant association between gravidityD3 (multigravida) of

pregnant women and birth weight in infants. Notwithstanding, the significant association between gravidityD1 (primigravida) of pregnant women and birth weight in infants was not sustained past the last multiple logistic regression analysis. Therefore, I reported that gravidityD3 (multigravida) of pregnant women showed a statistically significant association with birth weight in infants. My findings are in accordance with several instances found in the literature. Lingani et al. (2020) reported that being primigravida and multigravida with history of stillbirth were positively associated with risk of LBW. Nekaka et al. (2020) also concurred with this finding when they reported that primigravida women were more likely to give birth to LBW babies. Although the multiple logistic regression analysis did not confirm the situation with primigravida pregnant women, Aguzie (2018) could warrant a plausible explanation of the case. Indeed, Aguzie reported that pregnant women of malaria-endemic areas acquire partial immunity to *P. falciparum* during their first pregnancies but tend to lose this immunity gradually through subsequent pregnancies. On a discordant note, Tessema et al. (2021) reported that multiparity was associated with reduced occurrence of LBW. Agyemang (2021) reported a similar finding in his doctoral dissertation at the University of Ghana, highlighting that multigravida pregnant women had reduced odds of giving birth to LBW babies as compared to primigravida pregnant women. These findings are in accordance with Wachamo et al. (2019), who reported from their study carried out in Ethiopia that multigravida pregnant women were less likely to give birth to LBW infants as compared to their primigravida counterparts.

While a causal explanation would go beyond the scope of the present study, Togo is a malaria-endemic country and could warrant further investigations to find out why multigravida women are more likely to give birth to LBW babies.

Applicability of Bronfenbrenner's Ecological Systems Model

Several factors interplay to determine children's health trajectories, including the conditions in which they are born, grow up, and live (Halfon et al., 2022). To achieve equity when it comes to child health, Halfon and colleagues (2022) suggested that public health interventions should be grounded on a thorough understanding of these complex, multilayered, and interconnected trajectories that interact with the child and with each other. According to Eriksson et al. (2018), the Bronfenbrenner theoretical framework constitutes a guideline that bioecological researchers could use to understand why developmental outcomes vary between persons. Halfon et al. concurred, adding that Bronfenbrenner's ecological model of human development provides an organizing framework for influences on human development. In the present study, I intended to explore and highlight the many determinants that contribute to the LBW issue in Togo. The expectation was that my findings would provide insight for policymakers to use and disrupt the suboptimal pathways conducive to LBW. Bronfenbrenner suggested that at least two different ecological systems are required in ecological research to help understand a specific developmental outcome (Bronfenbrenner, 1975, as cited in Eriksson et al., 2018). With these perspectives in mind, I think that Bronfenbrenner's ecological systems model fits well within the scope of the present study. Therefore, I used the constructs of context and person characteristics. My findings have established statistically significant associations between age of pregnant women (15–19 years) and birth weight

in infants, gravidityD3 type of pregnant women (multigravida), and birth weight in infants, respectively. In accordance with other researchers such as Agbozo et al. (2016), Manyeh et al. (2016), Mohammed et al. (2020), Lingani et al. (2020), Nekaka et al. (2020), and Assane et al. (2020), the present study highlighted the construct of person characteristics (ageD1 of pregnant women and gravidityD3 type of pregnant women) as a potential suboptimal pathway conducive to the issue of LBW in Togo. To alleviate the issue of LBW in Togo, policymakers could disrupt this suboptimal pathway through IPTp chemoprevention interventions that target adolescent pregnant women and multigravida pregnant women.

Limitations of the Study

As I anticipated, there was limited control over the selection of variables for this study. Indeed, the secondary data that I received from ICF International did not contain information regarding the number of doses of IPTp that pregnant women received during ANC visits. Moreover, data manipulation involved handling continuous variables that were categorized and then dichotomized or dummy recoded in some instances. As suggested by Ranganathan et al. (2017), doing so may produce arbitrary cutoffs and loss of information eventually. Another issue was the relatively important number of missing and/or invalid values. These situations may affect the possibility of inference from the results of the present study.

Recommendations

ICF International did a wonderful job in providing secondary data from the demographic health surveys. While I am grateful for the opportunity to have accessed the data, it will be more convenient if the future Togo demographic health surveys could

manage to collect detailed information about the number of doses of IPTp that pregnant women receive during ANC visits. I therefore call upon health authorities and policymakers in Togo to improve data collection tools at healthcare facilities that provide ANC services. When detailed data become available for the number of doses of IPTp received by each pregnant woman during ANC visits, then it will be recommendable that further research be carried out to investigate how the risk of LBW can be lowered or even totally mitigated through an appropriate number of doses.

Implications of the Findings

The findings of this study offer a little more insight to better target the groups of pregnant women that are more vulnerable to the risk of adverse birth outcomes regarding the issue of LBW in Togo. The present study highlights the need for interventions that target teenage pregnant women and multigravida pregnant women to increase their awareness regarding the importance of full coverage of IPTp doses and other antimalarial preventative measures during pregnancy. At the individual and/or family level, women should be encouraged to get and take good care of ANC visit documents, which can be relevant for future public health projects such as the DHS. These interventions will help to lower the risk of LBW and/or mitigate issues related to this adverse birth outcome. Thus, the present study may contribute to positive social change in Togo.

Conclusion

My research established that there is a statistically significant association between age (15–19 years) of pregnant women and the odds of LBW of newborns in Togo. A statistically significant association has also been highlighted between multigravida women and the odds of LBW in infants. The significance of my findings resides in the

potential to provide Togo policymakers and health authorities with a nationwide picture of vulnerable groups when it comes to the odds of giving birth to LBW babies and other issues related to this adverse birth outcome in the country. With the needs of positive social and behavioral changes in mind, the present research can serve to substantiate the creation or the improvement of policies that better target teenage and multigravida pregnant women in Togo. I hope that my research provides the inspiration and motivation to achieve this needed positive social change.

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