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School of Health Systems and Public Health

**The impact of Malaria Control Program on child health in Malawi:
Using
Propensity-Score Matching analysis**

By

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EXECUTIVE SUMMARY

Malaria is still a major killer in Sub-Saharan Africa, causing about 16 per cent of under-five deaths. In Malawi, a sub Saharan African nation, the disease is the number one cause of hospital admissions and leading cause of death among under-five. Globally, there have been renewed efforts to support public health care services in developing countries to fight malaria, which has resulted in a number of comprehensive integrated malaria control interventions being implemented.

The government of Malawi launched a malaria intervention scale up in (2005 to 2010) with an aim of reducing malaria in the country. The interventions among other things have been designed to achieve Millennium Development Goal four of reducing under-five mortality by two thirds as it is a known fact that malaria highly impacts the health of children in this region.

A number of evaluations have been carried out to assess the impact of Malaria Programme in Malawi; however most of these studies have been descriptive and or qualitative evaluations of the objectives of the programs. Most of these studies as will be shown in the paper, have not taken into account selections bias that are inevitably found as the nature of intervention does not randomly select beneficiaries or are not nationally representative. In this paper, propensity score method is proposed as an evaluation method to control for selection bias by creating control groups for those that benefit from the malaria program interventions. The study will utilise national representative demographic health survey data that was collected by Malawi National Statistics Offices in 2004 and 2010 to evaluate the Malaria control scale up and use anaemia as outcome indicator.

1. INTRODUCTION

The United Nations Millennium Development Goal 4 (MDG 4) calls for a reduction of under-5 mortality by two-thirds" by 2015 (General Assembly of the United Nations, 2000). However, the level of child mortality remains high in many low and middle income countries. The highest rates of child mortality are still in Sub-Saharan Africa—where 1 in 8 children dies before age 5, more than 17 times the average for developed regions (1 in 143)—and Southern Asia (1 in 15). (1) A UNICEF report (Countdown to 2015) reports that only 19 of the 68 countdown countries are on track to achieve MDG 4 with Countdown countries especially in Sub-Saharan Africa far behind. (2) Globally, about 8.8 million children died before the age of five in 2008.

Childhood mortality remains a big issue more especially in developing countries as researchers try to find what the factors are that are contributing to persistent high levels of mortality. Malaria is one of the five leading causes of child death worldwide contributing to about 8% of child death globally. (3) In 2010, an estimated 655,000 people died of malaria of which 86% were children under 5 years of age. (4) The distribution of under-five malaria deaths is highly concentrated in Africa, with more than ninety per cent of the deaths occurring in this region (5). Malaria is still a major killer in Sub-Saharan Africa where it is endemic in the majority of the region, causing about 16 per cent of under-five deaths. (1)

Apart from the direct effect on malaria specific mortality and morbidity, the disease is also linked to other diseases, either as direct causal factor or because it renders individuals more susceptible to other infections. Anaemia, a major cause of poor growth and development among children is greatly contributed by malaria. Malaria-related anaemia affects an estimated 1.5 to 6 million African children, causing a case fatality rate of 15%. (6) Increasingly, malaria is becoming a factor in the transmission of Human Immunodeficiency Virus (HIV), the virus that causes AIDS, as children with severe malaria often require blood transfusions, and much of the blood supply in sub-Saharan African countries is infected with HIV. (7)

There have been renewed efforts globally to support public health care services in developing countries to fight malaria. In sub-Saharan Africa donor funding has increased which has resulted in a number of comprehensive integrated malaria control interventions being implemented. (8; 9) The interventions among other things have been designed to achieve Millennium Development Goal four as it is a known fact that malaria highly impacts the health of children in this region. Without substantial progress in controlling for malaria, MDG 4 will not be achieved (World Malaria 2010 Report). The efforts include control study proven interventions ; (i) vector control through the use of insecticide-treated nets (ITNs), indoor residual spraying (IRS) and, in some specific settings, larval control; (ii) chemoprevention for the most vulnerable populations, particularly pregnant women and infants; (iii) confirmation of malaria diagnosis through microscopy or rapid diagnostic tests (RDTs) for every suspected case, and (iv) timely treatment with appropriate antimalarial medicines (according to the parasite species and any documented drug resistance). (4)

Malawi, like most developing countries has high mortality rates in under-five. In 1990 Malawi had second highest under-five mortality rate in Eastern Southern Africa (ESA). Since 1990, Malawi has however recorded a decrease in under-five mortality as compared to its most counterparts in the region like, Zambia, Zimbabwe and Kenya, (10) from 218-221 per 1000 live births in 1990 to 120 per 1000 births in 2006 and 110 per 1000 births in 2009. (1; 11) In spite of Malawi's steady decline in U5 mortality, further work still needs to be done if the country is to achieve the millennium development goal of reducing childhood mortality by two thirds by 2015. (12)

Like most sub-Saharan Africa, Malaria poses a major public health problem and is endemic in almost all areas in Malawi; transmission is year round and peaks in rainy season that runs from November to April. In 2009, more than 6 million malaria cases were recorded; contributing approximately 34% of all outpatient visits and 40% of all hospitalization of children under five years old. (13) Children under five, pregnant women and those living with HIV/AIDS represent the most at-risk populations for malaria-related morbidity and mortality. The disease is the leading cause of morbidity

and mortality in children under five years of age and pregnant women in the country.
(13)

All malaria cases in the country are caused by *plasmodium falciparum*, (4) the protozoa that cause most virulent form of malaria. *P falciparum* causes severe malarial anaemia which is responsible for approximately a third of the deaths associated with the disease globally. (14) Anaemia (haemoglobin level < 11g/dL) remains one of the public health problems in malaria endemic countries of Africa. Severe anaemia, most of which attributed to malaria is among the leading cause of hospitalization accounting for 11% of under five children hospitalization in the countries hospitals.

The government of Malawi with funding from Global fund and Presidential Malaria Initiative embarked on scaling up malaria interventions in 2005 with a goal of reducing malaria case figures of 2000 by 50 per cent by 2010. National Malaria Strategic Plan (NMSP) 2005–10 was drafted to guide the implementations. The NMSP included plans to include the highly poor as previous malaria interventions programs proved to side-lined the poor which are said to be the most vulnerable to the disease. NMSP were based on the Abuja Declaration of halving malaria mortality and morbidity by the year 2010. Intervention targets were outlined as follows:

1. At least 80% of those suffering from fever due to malaria have access to and are able to use correct and appropriate treatment within 24 hours.
2. At least 80% of pregnant women have access to appropriate treatment by 2010.
3. At least 80% of pregnant women have access to malaria prevention by 2010.
4. At least 80% of children under five and pregnant women sleep under ITNs by 2010.

All the targets above are linked with child health with target 2 through 4 directly linked to under-five children. It is therefore important to evaluate the effect that the program has on children so far, bearing in mind the increased investment in malaria control. A number of studies have been carried out to evaluate the effectiveness of the program on child health. However most of these studies have shortfalls as they are not representative of the whole population (health facility based, or evaluate part

of the country; (15; 16) they are descriptive as they lack causal inference; (13) did not employ methodologies that take into account selection bias that arise due to the non-random distribution of interventions.

Data from MDHS since 1991 have shown tremendous decline in child mortality, however, since the Government of Malawi has launched several other programs to reduce child mortality, such as vitamin A supplementation and vaccination campaigns, it is unclear to which extent the malaria program has contributed to this decline.

Unfortunately there are few and unreliable outcome indicators that can be used to measure malaria specific impact of various interventions, Malaria Control Program included, at community level. One of the possible and reliable indicator; malaria related mortality, (17) is unfortunately difficult to diagnose and measure at the population level. This has resulted to studies that have evaluated malaria interventions at facility level, which have a shortfall as it only covers a percentage of malaria. There was a need to come up with an indicator that could easily be measured in the field but at the same time have the ability to be measured and quantified.

In response to this need, the WHO and RBM have recommended - based on a quantitative review study carried out by Korenromp et al (18)- anaemia as another indicator to measure malaria interventions at community level. The study showed that in areas of stable malaria transmission, moderate-to-severe anaemia (haemoglobin <8 g/dl) is more sensitive than is parasite prevalence, and may respond more quickly than mortality to changes in malaria exposure due to increasing coverage of malaria interventions such as insecticide-treated bed nets (ITNs), malarial prophylaxis, and indoor residual spraying. Another study done in Malawi to compare anaemia and parasitaemia as indicators of malaria concluded that anaemia may well be a good surrogate indicator for its measurement at the household level in evaluating national malaria control programs. (15)

Africa poses another epidemiological challenge because although it has high mortality rates, existing vital registration systems are not reliable or comprehensive -

most deaths occur outside the formal health service, and national government systems of civil registration in Sub-Saharan Africa are incomplete. (19) This is also true about Malawi. To fill this gap, public malaria surveillance systems have been implemented, however the system has been criticised as imprecise, < 10% of the malaria cases are reported. (20)

2. Aims and objectives of the study

The aim of the study is to evaluate the impact of Malawi malaria control project using quasi-experimental econometric or treatment evaluation technique by evaluating periodic cross sectional datasets to assess intervention effects on the childhood anaemia.

The study objectives are:

- To determine changes in anaemia incidences between 2004 and 2010 among under-fives.
- To determine how much malaria control program has affected childhood anaemia
- To investigate disparities in treatment effect(malaria control program) by
 - Age
 - Sex
 - SES

The sections of the paper are as follows: section 2 provides the overview of the malaria program, government policies in Malawi including interventions adopted. Section 3 describes the data. Literature review is in section 4. Section 5 outlines the methodology to be adopted in this study.

1.2 Program Background

Malawi launched National Malaria Strategic Plan (NMSP) 2005 – 2010 in June 2005 under the National Malaria Control Program (NMCP) to rapidly scale up malaria interventions towards the achievement of the national vision of “a malaria-free

Malawi. The National Malaria Control Program (NMCP) functions under the Directorate of Preventive Health Services in the Ministry of Health (MoH). The plans principle strategic areas include case management, intermittent preventive treatment among pregnant women (IPTp), and insecticide-treated mosquito nets (ITN). IRS is another intervention that is included in the malaria program though still under pilot. These areas of interventions are discussed below;

Case management: In 2006, the MOH selected artemether-lumefantrine (AL) as the first-line drug for the treatment of uncomplicated malaria and amodiaquine-artesunate as the second-line ACT, reserving parenteral quinine for the treatment of severe malaria and oral quinine for the management of malaria in the first trimester of pregnancy. The decision to use the drug came about as a result of malaria resistance to sulphadoxine pyrimethamine (SP).

Malaria in pregnancy: IPTp is a primary intervention against malaria in pregnant women through chemoprophylaxis with an aim of sustaining effective and potent anti-malarial blood level during pregnancy. In high-transmission areas, the main consequences of gestational malaria are anaemia in the pregnant woman and low birth weight in the new born, **Invalid source specified**. which is associated with an increased risk of morbidity and mortality in the first years of life. **Invalid source specified**. As part of a comprehensive, focused antenatal care package, Malawi's policy on (IPTp) recommends the provision of at least two doses of sulfadoxine-pyrimethamine (SP) to pregnant women during the second and third trimester. The policy states that the treatments should be given under direct observation at least one month apart, beginning before the 36th week. Malawi has shown great progress scaling up this intervention. Preliminary results from the country's first MIS show that 60 per cent of women received at least two doses of IPTp during their pregnancy.

ITNs: A number of research trials were carried out in Africa that have concluded that the lives of some 500,000 African children might be saved each year from malaria if the nets, treated with biodegradable pyrethroid insecticide, were widely and properly used. Malawi adopted an ITN policy in 2006 that includes free distribution of ITNs for children born in health facilities, children attending their first visit under the Expanded Program on Immunization (EPI) (if an ITN was not received at birth), and pregnant

women at their first visit to an antenatal care (ANC) clinic. The policy supports time-limited, national, free distribution campaigns every two to three years and targets the most vulnerable populations in Malawi. In February 2008, this policy was amended to include distribution to all children under five attending health facilities. In the period between 2005 and 2010, a total of ITNs have been distributed in the country. Results from Malaria Indicator Survey indicated an increase in ITN possession with 55.4% of all children under -five years of age slept under an ITN the night before the survey among houses with at least one ITN.

IRS: This is recent intervention in malaria control that the program adopted in 2009 though it is highly denounced by other stakeholders. IRS was adopted after a successful pilot study in 2007 funded by PMI in chosen highly endemic areas. IRS has since been rolled in only 8 high malaria risks due to financial constraints.

3. LITERATURE REVIEW

Malarial anaemia as an outcome indicator.

Anaemia is a multifactorial condition, however in Malaria endemic areas malaria is a major contributor. A number of studies have revealed the causal relationship between malaria and anaemia. Malaria control and preventions have been linked to reduce anaemia in children in malaria endemic countries. (18) WHO and RBM have since recommended anaemia be used as indicator to monitor malaria burden at community level. In this section some of the studies conducted in malaria endemic that have used anaemia as an indicator in monitoring and evaluating malaria interventions are discussed.

Korenromp et al (18) conducted a systematic review of the impact of malaria interventions (insecticide treated bed nets, malarial prophylaxis, and insecticide residual spraying) on haemoglobin distributions. Results of their analysis of 29 independent studies show that child haemoglobin levels increased significantly in response to malaria interventions after a mean of 1 to 2 years of inception. The review did not reveal any age pattern; however some studies have reported greatest impact on children between 6 to 24 months or 35 months of age. **Invalid source specified.** This study will also explore any pattern in the impact of malaria intervention on age. For the purpose of malaria intervention evaluation, anaemia in children under 6 months is not ideal as children born in malaria endemic areas are protected from malaria protected from severe anaemia in the first 6 months of life due to maternal Immunoglobulin (Ig) and by expression of foetal haemoglobin **Invalid source specified.** and thus do not have the same risk of anaemia as experienced by older children.

In an effort to compare the usefulness of anaemia to parasitaemia as an indicator to malaria intervention scale up, Mathanga et al carried out cross sectional household and health facility surveys in 2005 and follow up in 2008. (15) Between 2005 and 2008, a significant increase of ITN ownership was recorded which was associated with reduced burden in malaria among young children measured by prevalence of parasitaemia and Hb values. The study concluded that anaemia is useful indicator to

malaria treatment and prevention as such interventions are likely to increase Hb values substantially and hence reduce anaemia prevalence in under-five.

The relationship between insecticide-treated mosquito nets (ITNs), malaria parasite infection, and severe anaemia prevalence in children was examined in Luangwa District, Zambia, an area with near-universal ITN coverage, at the end of the 2008 and 2010 malaria transmission seasons. Malaria parasite infection prevalence among children < 5 years old was 9.7% (95% confidence interval [CI] = 8.0–11.4%) over both survey years. Prevalence of severe anaemia among children 6–59 months old was 6.9% (95% CI = 5.4–8.5%) over both survey years. Within this context of near-universal ITN coverage, significant association between malaria parasite or severe anaemia prevalence and ITNs (possession and use) could not be detected.

A randomized controlled trial of insecticide-treated bed nets (ITNs) conducted by Fraser-Hurt et al in an area of high malaria transmission in Tanzania in order to assess the effects of ITNs on infection and anaemia. One hundred and twenty-two children, aged 5 to 24 months, were randomly allocated to 2 groups, one of which received ITNs. Outcome measures, haemoglobin and plasmodium falciparum were assessed in 6 consecutive months with monthly cross-sectional surveys. There was a significant increase in mean haemoglobin values and a significant decrease of 16.4% in microscopically determined *P. falciparum* prevalence in children in the ITN group six months after the start of the trial. Both effects were more pronounced in younger children. However, no significant difference was observed in parasite density or multiplicity of infection among infected children. Comparison with PCR results indicated that microscopically subpatent parasitaemia was more frequently found in children in the ITN group. This, together with the observed similar multiplicity in the 2 groups, suggests that infections are maintained despite ITN use, owing to the chronicity of infections. This study shows that ITNs reduce the risk of anaemia in highly exposed young children. The virtually unchanged multiplicity of infection indicates that the potentially protective concomitant immunity is not compromised.

Propensity score matching related literature

Propensity score is utilised in mostly non randomised studies to identify counterfactual outcomes; what would have happened to an individual benefiting from a program had the individual not be involved in the program. It is an alternative to correct bias by creating treated and control groups that are not confounded by differences in observed covariate distributions, (21) so that comparison can be made within matched groups. However some studies use propensity score in randomised studies in cases where randomized interventions are not valid internally. In this section studies that have used propensity score methods are discussed.

A nationwide study was carried out in Madagascar aimed at evaluating the effect of integrating ITN distribution on measles vaccination campaign coverage. Districts were not randomly assigned to receive ITNs during the campaign, but rather ITN distribution was purposively conducted in malaria-endemic areas that had not previously been targeted for net distribution. Because of the non-randomization of the intervention, an assessment of baseline demographics of malaria-endemic areas with ITN distribution (ITN districts) and without ITN distribution (non-ITN districts) was completed. To address imbalances found in observed characteristics between samples in areas with and without ITN distribution, propensity score matching method was used to create a subset of children within the two areas that were more balanced. In brief, logistic regression was used to estimate the predicted probability (i.e. propensity score) of a child being from an ITN district, including household- and child-level demographic factors as independent variables. A 1-to-1 matching algorithm was used to match children in ITN districts to similar children in non-ITN districts based on the propensity score. Several models with different sets of independent variables were fitted, creating unique matched subsets for each. Balance between the ITN district and non-ITN district subsets from each model was assessed by comparing the distributions of (1) each individual independent variable, regardless of whether it was included in the model or not, (2) histograms of propensity scores estimated from the model, and (3) histograms of propensity scores estimated from a refitted model based on the observations in the matched subsets. Based on these assessments, a final model was selected. **Invalid source specified.**

Another matching algorithm that can be used is kernel matching estimator to compute counterfactual outcome for each treated observation. This matching

algorithm estimates counterfactual outcome for each treatment observation based on the weighted average of all comparison observations, with the weights reflecting their relative closeness to the treated observation. (22) To evaluate the effects of health program in Ethiopia, et al used Kernel Matching algorithm to create counterfactuals. **Invalid source specified.** Data was collected from 128 villages (69 treatment village and 59 comparisons). Prior to matching, the mean propensity score was estimated to be 0.64 (standard deviation of 0.21 with a range of 0.090 to 0.972) and 0.40 (standard deviation of 0.22 with range 0.029 and 0.94) for treatment and comparison villages, respectively. After the matched samples were formed, the difference in the mean propensity scores has become extremely small or statistically not significant. Furthermore, the pseudo-R2 value declined by two-percentage points indicating that the matching helped minimize differences in observable characteristics between the two groups.

In cases where it is difficult to find match interventions and controls on 1 to 1 matching using their propensity score, radius matching is appropriate. Radius matching uses the nearest neighbour within each radius, equally weighting all of the comparison members within each radius in order to estimate the expected counterfactual (Chintrakan 2008). A study carried out in Malawi to evaluate Save the Children school program used radius matching. The results were also compared to kernel propensity matching in which each case in the treatment group is matched to a weighted sum of individuals with similar propensity scores, with greatest weight being given to people with closer scores. The variables used in the propensity score matching were identified through consultation with the project stakeholders who were involved in assigning schools for the intervention. A logit model with linear covariates was used to estimate the propensity score for each intervention and comparison school, as described by Dehejia and Wahba (2002)

4. METHOD

4.1 Data Source

The study will use nationally representative data from the Malawi Demographic Health Survey (MDHS) that was collected in 2004 and 2010. The MDHS collected demographic, socioeconomic, child and maternal health data from a national

representative sample of 15,091 households and 27,345 households in 2004 and 2010 respectively. The data was collected using a stratified, two stage cluster survey from a list of enumeration areas (522 clusters in 2004 and 849 clusters in 2010). The clusters formed the first stage sampling and then households comprised the second stage cluster.

The MDHS used three questionnaires to collect information from the selected households; household questionnaire, the women's questionnaire and the men's questionnaire. The household questionnaire collected information of all members of the participating households and dwelling characteristics, and was used to identify eligible candidates for the men and women questionnaire.

Using the women's questionnaire, the 2010 MDHS collected data for 13220 women aged 15-49 whereas the 2004 DHS collected data for 11698 women of the same age range. The questionnaires on individuals collected information on the background characteristics of the respondents (age, education, religion, etc.), knowledge and use of family planning methods, reproductive history and on children born 5 years before the survey; antenatal and delivery care, infant feeding practices, including patterns of breastfeeding, childhood vaccinations, recent episodes of childhood illness and responses to illness, especially recent fevers and disease prevention practices. Data was also collected on marriage and sexual activity, fertility preferences, woman's status and decision making, mortality of adults, including maternal mortality, AIDS-related knowledge, attitudes, and behaviour, as well as on her husband's background characteristics.

In a subsample of one third of all households, blood specimens were collected for anaemia testing from children age 6 – 59 months and women aged 15 to 49 who voluntarily consented to the testing. The results of this anaemia test will be used as outcome variables while controlling for other factors that have been documented to have relationship with anaemia.

The study will use a child-based dataset to be constructed from information collected in all children born five years preceding the survey whose anaemia results were recorded. Each child in the dataset will be linked to his or her household information.

Conceptual Framework

The study will employ a conceptual framework (determinates of anaemia among children) to guide in the selection of variables for analysis. The determinants of child health includes exogenous (socio economic) and endogenous (proximate). Within this framework, the study will consider variables that were collected in the MDHS survey.

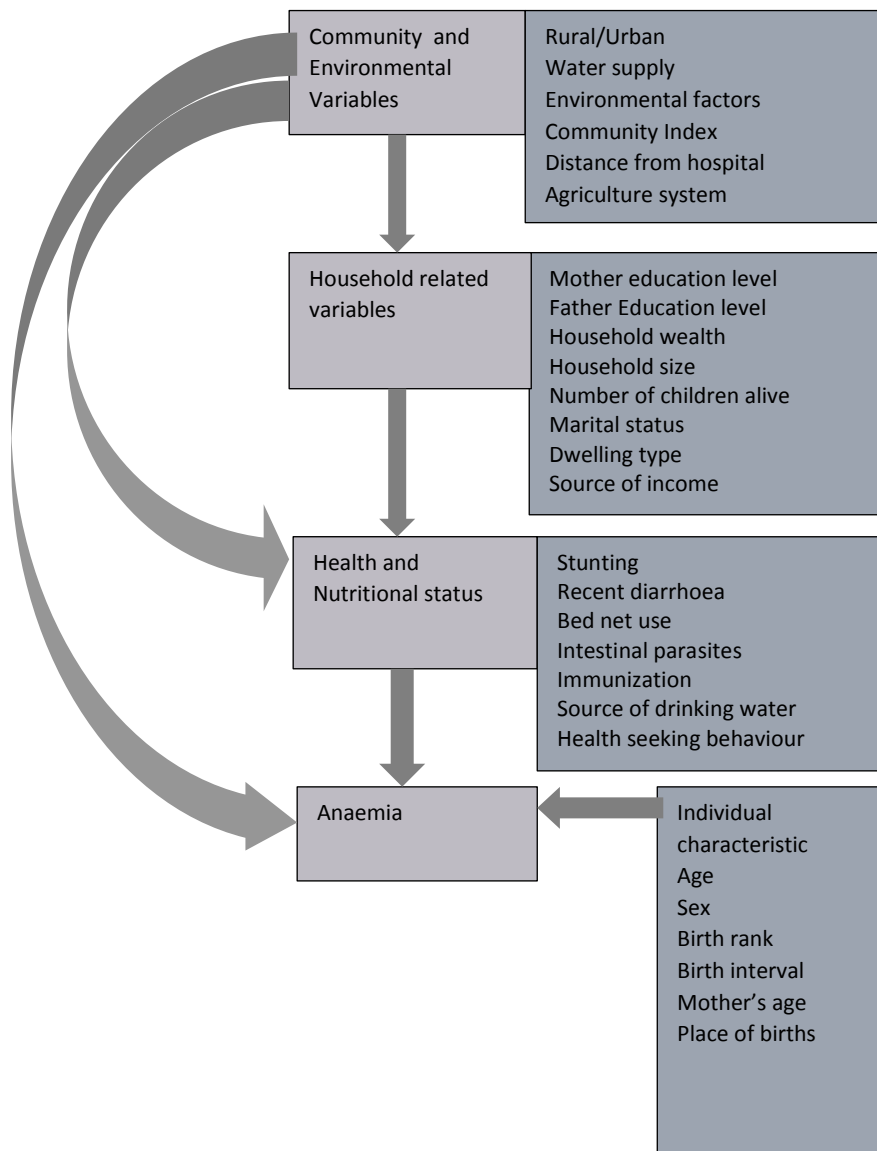


Figure 1: Conceptual framework for determinants of anaemia among children

(Adapted from Ngnie-Teta et al, 2007)

Individual variables

A UNICEF report (sex differentials in infant and child mortality) that analysed trends and differentials in child mortality in 122 countries ; 83 developing and 39 developed reports that in majority of less developed countries females under-five have an advantage in survival to age 5. (23) However in areas where there is male sex preferential, female infant mortality is higher than their counterparts in the same age. In most countries in East, South and Middle Asia there is strong male preference that has contributed to excess female under-five mortality resulting from discrimination of girls and in socio economic and health related variables e.g. nutrition, food and medical care. A study carried out in Kenya found an association between malarial anaemia and gender of a child with males being at greater risk of malaria than their female counterparts; however the significance was a borderline. (24)

A number of studies have shown demographic factors of mother's age, birth interval and parity to determine child health independently or synergetic. Studies have shown a curve linear relationship between maternal age and infant mortality; younger and older women being a high risk to infant survival. (25; 26) In general studies have shown that children born to mothers less than 18 and older than 35, first and higher older births (5and above) and births with shorter inter live birth interval tend to exhibit a higher risk of mortality/morbidity during the first year of live. Children born within short time interval resource are at high risk to illnesses.

Health and Nutritional variables

Anaemia is caused by a number of factors including dietary deficiencies (e.g. lack of iron, folic acid and other micronutrients), helminth infections and other infectious diseases, and blood disorders such as sickle cell anaemia, a mutation of the oxygen-carrying haemoglobin protein, however in sub Saharan Africa where Malaria is endemic, malaria is the main etiological agent responsible for lowering haemoglobin levels and causing anaemia. (27)

Relationship between malnutrition and *p.falciparun* malaria which is a major cause of malarial anaemia remains debatable. Other studies have shown nutrition status of children to have impact on both manifestation and susceptibility to malaria, (28; 29) however some studies have shown malnutrition to have a protective effect against malaria (30; 31).

House related variables

Associations between socioeconomic factors and child health in general and also malarial anaemia have been demonstrated in several studies. (32; 24; 33) In these studies, anaemia which was mainly caused by plasmodium falciparum parasitaemia infection was found to be significantly associated with education level of parents, type of accommodation, occupation of parents and health seeking behaviours. Tshikuka et al found a strong association between prevalence of plasmodia and socio economic status; Plasmodium prevalence was higher in the low socioeconomic status subdivisions than in the high socioeconomic status group. (32)

Community level factors

Factors related to community like whether urban or rural, distance to health centres have exhibited strong relationship with health status of children, public infrastructure like water availability, electricity etc.; children who lived more than 10 km away from the hospital were more likely to be anaemic than children living closer to the hospital. (33)

4.2 Methodology

The objective of this study is to estimate the causal impact of malaria control interventions on child health, indicated by anaemia incidences. However as pointed out by Heckman and Robb, (22) estimating the impact of public interventions like the one at hand has major methodological challenges as it is impossible to observe outcomes for the same individual in both states at the same time; treatment outcome and non-treatment outcome. We cannot, for example, observe the anaemic outcome for the same child sleeping under an ITN and not sleeping under an ITN at the same time. Randomized control trials remain the most acceptable design for implementing effects on interventions; however randomization is not always feasible in all circumstances to evaluate the effects of interventions; it becomes unethical to withhold interventions that have shown capabilities of saving life.

In observation studies, unfortunately investigators have no control over treatment assignment as such large differences may exist in the treatment group and control

group resulting into selection bias. This therefore impacts on researchers' ability to make causal inference about treatment effect. One way to deal with selection bias is to use propensity score matching which are defined as subject's probability of receiving a specific treatment conditional on the observed covariates. The methodology, proposed by Rosenbaum and Rubin, (21) is used to assess a counterfactual in a given set of observational data just like in any scientific experiment where the same sample can be used to assess the impact on the outcome if the treatment was not administered.

Let Y_{1i} be the outcome for treated and Y_{0i} the outcome of control households and $D \in \{0,1\}$ the binary indicator of treatment status. The binary indicator takes the following form

$$D = \begin{cases} = 1 & \text{if treated} \\ = 0 & \text{otherwise} \end{cases}$$

The propensity score $p(X)$ defined as the conditional probability of receiving treatment given observed characteristics:

$$p(X) = Pr(D=1 / X) = E(D / X) \quad (1)$$

where X is multidimensional vector of observed characteristics.

Given the propensity score, we then calculate the Average effect of treatment on the Treated (ATT) as:

$$\begin{aligned} ATT &= E \{ Y_{1i} - Y_{0i} \mid D_i=1 \} \\ &= E [E \{ Y_{1i} - Y_{0i} \mid D_i=1, p(X_i) \}] \\ &= E [E \{ Y_{1i} \mid D_i=1, p(X_i) \} - E \{ Y_{0i} \mid D_i=0, p(X_i) \} \mid D_i=1] \quad (2) \end{aligned}$$

Equation 2 above gives the average program impact under the condition independence assumption (CIA) and overlap assumption. Conditional Independence means that conditional on X_i the outcomes are independent of treatment i.e. participation in the program intervention does not depend on the outcome and Overlap means for each X there are both treated and control units .

In this study as already indicated anaemia will be used as outcome variable. The households/children who have “access to malaria program interventions” (the treatment variable) will be matched on to children/households “without access to malaria program interventions” using propensity score that will be generated from variables discussed in the conceptual framework. The propensity score will be estimated using logit regression, with ITN usage as the dependent variable and a number of covariates discussed in the conceptual framework as independent variables. After estimation of propensity score, treated and control cases will be matched.

Descriptive statistics will be carried to describe groups before matching. Prevalence odds ratios (PORs) will be estimated with 95% CIs comparing prevalence odds of anaemic outcomes in the unmatched groups and in propensity score–matched groups of children who slept under a mosquito net or not. Chi square test will be used to compare the differences in anemia occurrences between 2004 and 2010 where the outcome anaemia will be considered a dichotomous outcome (anaemic or not). A difference between groups will be considered statistically significant if the 95% CI does not overlap 1.0 in either direction. STATA software (version 12) will be used for all analyses.

5. ETHICAL AND LEGAL CONSIDERATION

Ethic clearance for the study will be obtained from University of Pretoria Faculty of Health Sciences ethics. The data to be used was collected by the Nation Statistical offices in Malawi in collaboration with Measure DHS as such permission for the use of the database will be collected from the Nation Statistical office of Malawi.

6. LOGISTICS AND TIMETABLE

Activity	August	September	October	November	December
Ethics clearance	√				
Obtain permission to use database		√			
Analysis		√	√	√	
Reporting				√	√

7. BUDGET

The study will be funded by the researcher. The table below shows expected cost to be incurred by the researcher in carrying out the study.

Item	Cost
Stationery	R800
Printing	R500
Internet use	R1000
Total	R2,300

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