The Contribution of Human Mobility to Malaria Transmission in a Malaria Elimination Context in Lusaka District

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MSc. Epidemiology

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DECLARATION

I, **Miriam Lowa**, do hereby declare that this dissertation is a representation of my own work. It has been done in accordance with the guidelines for dissertations for the University of Zambia. It has not been submitted elsewhere for a degree at this or any other university or institution of higher learning.

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CERTIFICATE OF COMPLETION OF DISSERTATION

I, **Miriam Lowa,** hereby certify that this dissertation is the product of my own work and, in submitting it for the Degree of Master of Science in Epidemiology programme, further attest that it has not been submitted to another University in part or whole for the award of any programme.

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Having supervised and read this dissertation, I am satisfied that this is the original work of the author under whose name it is being presented. I confirm that the work has been completed satisfactorily and has been presented to the board of examiners.

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CERTIFICATE OF APPROVAL

The University of Zambia approves this dissertation of Miriam Lowa in partial fulfilment of the requirements for the award of the degree in Master of Science in Epidemiology.

Examiner I

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Examiner II

Signature……. Date …….

Examiner III

Signature……. Date …….

Dedication

To my late Dad Mr. Josias Lowa, MHSRIP, you saw me begin this journey but you were taken into eternity too soon to see me reach my destination. To my beloved husband Darius and my lovely babies Liseli and Leo-Marius, you have been my backbone and have sacrificed so much for my studies, am truly thankful for your support.

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List of Abbreviations

CSO	Central Statistical Office
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Mosquito Net
MDG	Millennium Development Goals
MIS	Malaria Indicator Survey
MOH	Ministry of Health
RBM	Roll back malaria partnership
RDT	Rapid Diagnostic Test
UNPF	United Nations Population Fund
UNZABREC	University of Zambia Biomedical Research Ethics Committee
USAID	United States Agency for International Development
WHO	World Health Organization
ZDHS	Zambia Demographic Health Survey

CHAPTER 1

1.0 ABSTRACT

Background: Malaria is a major public health problem globally with an estimated 214 million cases and 438,000 deaths of which 90% occurred in sub Saharan Africa in 2015. Over 4 million cases were confirmed and 3000 deaths were reported in Zambia in 2013. Efforts to reduce the incidence of the disease are often undermined by a number of factors such as human mobility which may lead to introduction of imported infections. This study sought to determine the prevalence of imported cases in Lusaka district, identify risk groups, and investigate the association between mobility and malaria transmission by identifying factors associated with malaria importation.

Methods: Using a cross sectional study, data was collected from 260 patients who presented with malaria and whose status was confirmed by rapid diagnostic test (RDT) or microscopy. Five health centers within Lusaka district were randomly sampled. Each confirmed malaria case was interviewed using a structured questionnaire to establish their demographic characteristics, travel history and preventive measures. Data was entered and analyzed using Stata software version 12.

Results: Of the 260 malaria positive cases investigated, 245 (94.23%) were classified as imported cases while 15 (5.77%) as local cases based on travel history. Age distribution ranged from 0 to 68 with a median age of 15 years (IQR 8 - 27). Imported cases came from all the provinces with Copperbelt province as the highest contributor (40.93%). Age group 0 to 14 was the most affected among the cases with a travel history (62.45%). A logistic regression analysis showed that factors associated with malaria importation by residence include use of prophylaxis AOR = 0.22 (95% CI: 0.60; 0.78), duration of stay AOR = 1.07 (95% CI: 1.03; 1.12) and frequency of travel AOR = 3.95 (95% CI: 1.35; 11.55).

Discussion/Conclusion: Mobility has influenced malaria transmission in Lusaka district by importing malaria leading to onward transmission and posing a challenge to malaria elimination and control. Taking of prophylaxis before travelling to a highly endemic region was protective. Residents who took anti-malarial drugs prior to travel were less likely to import. Children were more susceptible due to their weaker immunity. For every increase in the duration of stay in an endemic area there was an 8% chance of importing malaria.

Key words: Lusaka district, malaria importation, human mobility, elimination

CHAPTER 2

2.0 Introduction

2.1 Background

Malaria is an infectious disease caused by an intracellular protozoan transmitted through the bite of a female anopheles mosquito (Walker and Zunt, 2005). It is caused by four plasmodium species in humans. These are *Plasmodium falciparum, Plasmodium ovale, Plasmodium vivax and Plasmodium malariae.* Of these species, *P falciparum* is known to cause the highest mortality. Incidence of malaria has been increasing in the recent past because of drug and insecticide resistance and also social and environmental changes. Malaria elimination refers to the reduction of the incidence of infection to zero in a defined geographical area as a result of deliberate efforts (World Health Organisation, 2014). Imported infections often represent the majority of cases of malaria in countries pursuing elimination and these infections lead to resurgence, sustained transmission and mortality (Sturrock et al., 2015). Imported infections either cross border or within a country have continued to challenge strategies to eliminate malaria (Buckee et al., 2013).

2.2 Malaria Burden

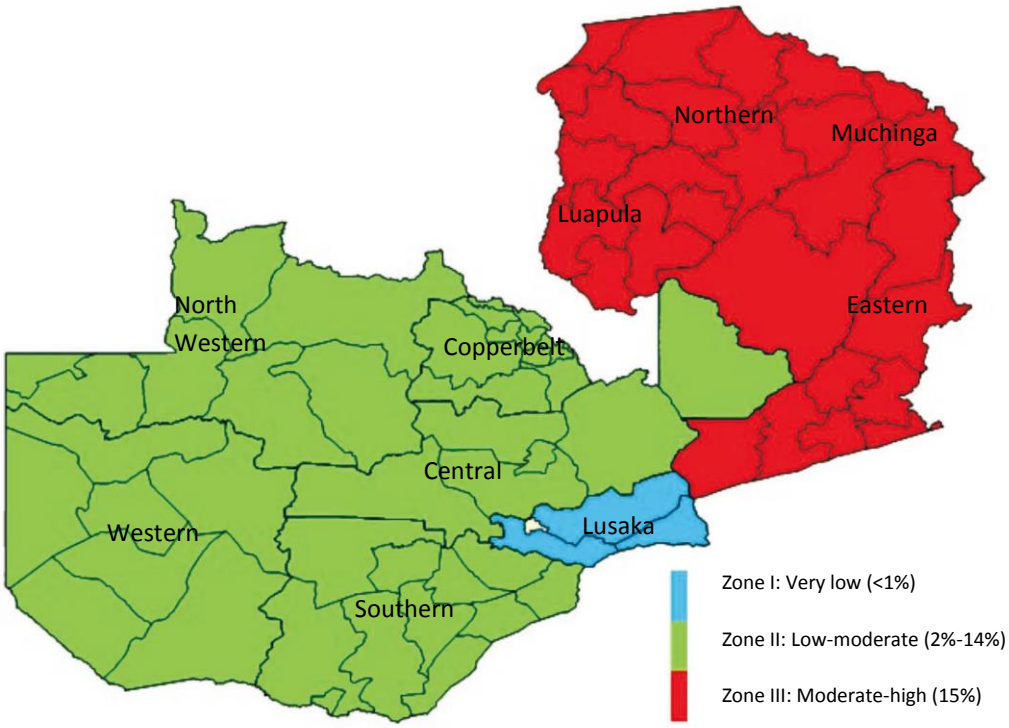
Malaria continues to be a major public health problem globally. It is one of the leading causes of death from infectious disease worldwide (Ward et al., 2013). There were about 300–500 million annual cases of malaria worldwide with 1–3 million deaths (Malaria, 2005). As of the year 2014, statistics indicated a decline in these figures as indicated in the Roll Back Malaria (RBM) of 2014. Recorded in 2014 alone were 584,000 deaths of which 90% occurring in sub Saharan Africa. An estimated 78% of these deaths occurred in children under five. A total of 3.2 billion people were at risk and 97 countries had ongoing malaria transmission (World Health Organisation, 2014). In 2015 however, malaria reported cases globally stood at 214 million, 88% of which occurred in WHO Africa region and 438 000 deaths of which 90% occurred in WHO Africa region(World Health Organisation, 2015). These figures, however, show a great improvement from the 2 billion deaths per year as of the year 2000. Despite this drop in the mortality rates due to malaria, these numbers are still alarming and much still needs to be done especially that the Millennium Development Goals (MDGs) on infectious diseases particularly in

malaria which aimed at ending the incidence of malaria by 2015 (World Health Organisation, 2013) was not met by most countries.

Africa is composed of 50 countries or territories with malaria endemic areas. Forty-seven of these are located in sub-Saharan Africa, which bears most of the global malaria burden (World Health Organisation, 2014). Population expansion and its health impact have been characterized by sub-Saharan Africa thus greatly increasing the absolute numbers of those at risk of malaria infection (UNPF, 1996). Despite the scaling up in funding towards malaria control programs, the problem of malaria transmission is extremely severe in sub-Saharan Africa where at least 85% to 90% of deaths are attributed to the disease (World Health Organisation, 2014). In 2013, there were over 4 million confirmed cases and over 3000 reported deaths due to malaria in Zambia alone. Hence malaria has continued to be a disease of major public health significance in Zambia despite recent successes in scaling up interventions and documented reductions in malaria burden among children (Central Statistical Office (CSO) [Zambia] et al., 2014). Eliminating infection is therefore central to the goal of malaria eradication not only in Zambia but globally.

2.3 Malaria Trends and Control in Zambia

Zambia is a land-locked country with approximately 13.6 million people, 61% of which live in rural areas and 39% in urban (Central Statistical Office (CSO) [Zambia] et al., 2014). Malaria is endemic throughout the country though it has the greatest influence on rural areas. *Plasmodium falciparum* is responsible for most of the disease, including its severe form, and it is transmitted by *Anopheles gambiae (An. gambiae*) complex and *Anopheles funestus* (*An. funestus*). *P. malariae* and *P. ovale* account for less than 5% of recorded parasitaemiea (Plan, 2005). A seasonal pattern of higher transmission is associated with the rains between November and April. Northern, Luapula and Eastern provinces have the highest annual incidence of malaria, while the lowest is found in Lusaka Province, specifically around the capital city. Based on recent malaria parasite prevalence in children and surveys from 2008 to 2010, different trends in the three zones have emerged: Zone I with very low transmission in Lusaka province, characterized by parasite prevalence of less than 1% in children under 5 years old; Zone II with low to moderate stable transmission of parasite prevalence of 2%-14% in children under 5 years old; Zone III with moderate to high transmission of more than 15% parasite prevalence in children under 5 years old (Masaninga et al., 2013).



Source: (Masaninga et al., 2013)

Figure 1: Malaria Transmission Zones in Zambia

Between 1950 and early 1980s, vector control reduced malaria cases to a notifiable disease in most urban areas (Knudsen and Slooff, 1992). Malaria currently accounts for nearly four million clinically diagnosed cases per year, 36% of hospitalizations and outpatient department visits, and from one previous study at University Teaching Hospital, up to 20% of maternal mortality. Malaria is responsible for about 20% of deaths among children under five. Through the National Malaria Strategic Plan 2006-2010, the Government of Zambia and many Roll Back Malaria Partners are committed to increasing coverage of key malaria control interventions and reducing the burden of malaria throughout the country (National Malaria Control Centre, NMCC). Several malaria prevention strategies are currently recommended and implemented in Zambia. These include prevention of malaria during pregnancy, by use of ITNs by pregnant women and intermittent preventive treatment (IPT) during pregnancy and indoor residual spraying (IRS). The national malaria strategic plan aimed for 85% IRS coverage, 100% ownership of ITNs and 80% utilization (Central Statistical Office (CSO) [Zambia] et al., 2014).

2.4 Human Population Movements and Malaria Transmission

Human population movements play a significant role in malaria transmission (Ramlogan, 1996). In industrialized countries, the impact of population movements on malaria risk is mainly related to intercontinental travel (Martens and Hall, 2000). In some regions, malaria risk may increase as a result of a combination of different forms of mobility, as well as other factors unrelated to population movements (Lindsay, Martens: 1998). These human movements contribute to the transmission of malaria. The World Health Organization (WHO), the U.S. Centre for Disease Control and Prevention (CDC), and most countries define imported malaria as any malaria infection whose origin can be traced to a malaria endemic area outside the country in which the infection was identified. Internal importation is the introduction of parasites from one area to another within a country (WHO, 2014). Establishing source of infection requires knowing individual recent travel history (Sturrock et al., 2015). Human migration is common in most parts of the malaria-endemic world and plays an important role in malaria epidemiology. The increase in mobility in the last few decades has led to greater concern about the relationship between mobility and malaria. Importation of malaria parasites to low transmission zones from high transmission zones is a major setback in reducing the malaria burden in areas aiming for elimination (Bradley et al., 2015). Identifying the sources of imported infections due to human travel and identifying high risk sites of parasite importation could greatly improve malaria control programs (Wesolowski et al., 2012).

Though malaria prevalence may be low in certain regions and so amenable to control, elimination programs must account for imported infections to be successful (Snow et al., 2008). Previous small-scale studies also used mobile phones to estimate importation rates of malaria parasites by residents of Zanzibar after journeys to mainland Tanzania, but these data lacked resolution on the infection risk at their journey destinations, as well as information about infected visitors to the island (Snow et al., 2008, Le Menach et al., 2011). A study done in Mauritius used health system surveillance databases to identify the sources of imported infections. This was done through the assessment of patient travel history records and through active surveillance by testing incoming travelers for infections at gateway into countries (Tatarsky et al., 2011).

Form literature, various methods have been used to investigate the contribution of human migrations to malaria transmission. National population census data and household survey data give individual level migration and travel. The use of spatially referenced malaria data and mathematical models can be

employed. Network analysis techniques were used to quantify the demographics of human and malaria movement patterns in Kenya, Uganda and Tanzania (Pindolia et al., 2012) Age and sex differences exhibit substantial variations in terms of the sources, sinks, route of migration and risk factors for infection such as short term travel and bed net use (Sturrock et al., 2015). National surveillance data such as hospital patient records were used to directly quantify features of malaria imported cases, though this tool was found likely to miss asymptomatic parasite carriers and non- health seeking cases. In low income countries were surveillance system is underdeveloped, estimations are primarily based on travel history data from selected population groups or geographic areas with travel studied as a possible risk factor for infection. The relationship between malaria and population movement is undoubtedly complex. Population movement that either place people at the risk for malaria or cause them to pose a risk to others cannot be stopped but they can be tracked and mitigated (Le Menach et al., 2011).

Migration and human mobility from high-transmission areas can result in imported malaria cases and potential re-introduction of malaria into low-transmission or malaria free areas. This may, however, have less impact where the vectors are scarce. Migrants and mobile populations are often difficult to reach and may have limited access to malaria control interventions or be excluded from these interventions. Thus migration is considered a social determinant of health for migrants and other marginalized and vulnerable groups (Ward et al., 2013). China aims to eliminate malaria by 2020. A study by Wang X et al indicated that the burden of malaria is mainly attributed to mobility. A total of 623 confirmed cases of malaria were reported at Public Hospital in Tengchong County over a period of five years and of these cases 568 (91.2%) had a travel history and thus these infections were attributed to human mobility. Only 56 (8.8%) of the infections had no history of travelling to any endemic area over the six months prior to their admission to hospital. Another study by Li et al during the period October 2013 to November 2014, a total of 1420 imported cases were identified and these represented 95.6% of all cases. This study also shows how much human mobility contributes to malaria importation.

A study by Ng'andu et al reported a resurgence of malaria cases in urban and peri-urban Lusaka. In vivo sensitivity tests were conducted with *P. falciparum* patients in Lusaka, but whether these infections were acquired in urban Lusaka itself or in rural areas was not clear. It was established from a study by Chanda et al (2012) that human migration contributed markedly to malaria transmission. Malaria cases in Zambia as of 2011 were 341.96 per 1000 population. Potentially contributing to malaria transmission is population movement. Equally important may be cross-border movement between Nchelenge District,

Zambia and Katanga Province in the Democratic Republic of Congo, suggesting the importance of epidemiological and entomological studies of cross-border malaria (Chanda et al., 2012). The Government of Zambia is committed to creating a malaria-free zone in southern Zambia. Through passive case detection at health care facilities and active case detection through community-based surveys, they have documented a dramatic decline in the burden of malaria in the catchment area of Macha Hospital, Choma District in Southern Province, Zambia from 2008 through 2013. However, focus on transmission exists and the potential for repeated importation remains (World Health Organisation, 2013).

CHAPTER 3

3.0 Rationale

The incidence of malaria has been a major issue of concern over the years in many countries even in areas thought free of the disease. Human movements or mobility is one of the factors contributing to the re-emergence of the disease (Lindsay and Martens, 1998). Many qualitative surveys have explored the impacts of travel on health yet there is a huge deficit of quantitative data on individual mobility especially those focusing on short distance travel between regions (Buckee et al., 2013). Frequent introduction of imported infections can undermine local control or elimination strategies. For instance, even though the prevalence of malaria in Lusaka is quite low (<1%), (Ministry of Health, 2012), elimination does not seem to be attainable and there is insufficient information to account for imported infections in the elimination programs and interventions.

There has not been any documentation of the prevalence or proportion of imported cases in Zambia particularly in Lusaka district. Quantifying these cases will indicate the burden of imported malaria in the district. These infections are either from cross border movements or rural to urban movements. It has however, been seen from literature that not much is documented on the contributions of migrations to malaria transmission in Zambia. The risk posed by imported infections together with the historical potential for vector transmission that determines the severity of local onward transmission forms the mathematical basis of malariogenic potential. This is the overall risk that malaria could return after elimination and is an important measure for all areas aiming for elimination (World Health Organisation, 2013). This study however sought to identify how population movements affect the levels of transmission and consequently the interventions to eliminate malaria in low transmission areas such as Lusaka district.

One of the clearly enunciated goals of the MDGs by the United Nations declaration, in health particularly in the infectious diseases was to halt the incidence of malaria by 2015 (UN; 2009). This was not achieved in countries like Zambia though many interventions were put in place to combat the spread of malaria. This is evident in that many of the districts in Zambia still report alarming cases of malaria. There is need therefore to assess the gaps in the prevention and control of malaria such as determining how human migrations affect efforts to eliminate malaria and consequently leading to onward

transmission and possibly an increase in prevalence of the disease. Identifying and understanding the influence of population movements and identifying factors that influence malaria importation can improve prevention measures and malaria control programs. There is also need to improve methods for identifying and targeting groups most at risk for importing parasites. Identifying the high risk groups in terms of age, sex and perhaps occupation will help target and tailor interventions for elimination. Possible sources once identified can also be targeted. A focus on what role migrations play in the transmission of malaria and how these movements affect the efforts to rule out malaria, will help to understand how feasible it is to eliminate malaria and help policy implementers on how best to address this problem. This can also help inform and target interventions such as distribution of chemoprophylaxis especially to mobile populations so as to prevent reintroduction of the disease should elimination be attained and also help in the improvement of prevention and control measures.

3.1Research Question

How does human mobility contribute to malaria transmission in the context of malaria elimination?

3.2 Objectives

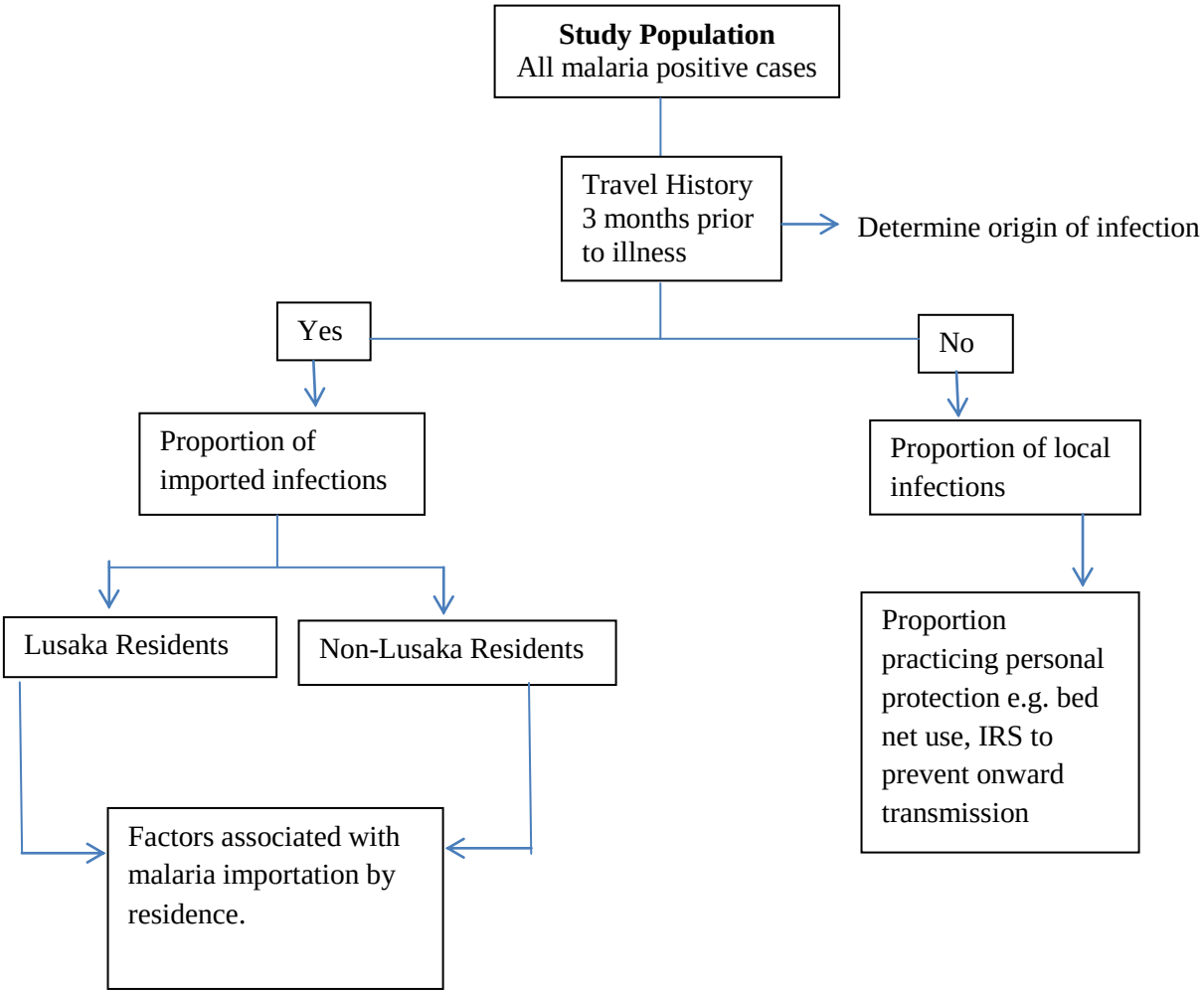
General objective

To determine the contribution of human mobility on malaria transmission in the context of malaria control and elimination.

Specific Objectives

1. To determine how malaria elimination has been affected by human mobility by determining the prevalence of imported cases.
2. To determine which age group and gender is more susceptible to malaria infection among the cases.
3. To investigate the association between mobility (origin of infection) and malaria transmission in relation to control measures by identifying factors associated with malaria importation.

Figure 2: Conceptual Framework



Source: self-developed

Figure 2 shows a conceptual framework from which the underlying structure of concepts relating to malaria importation was developed. From the study population of positive malaria cases, travel history of the patients was determined which established the source or origin of infections. These can be categorised as local or imported cases. Among the imported cases, it is assumed that various factors influence malaria importation. These potential factors as seen from literature include socio-demographic, different forms of personal protection against exposure to both mosquito bites and infection such as use of bed nets, taking of prophylaxis prior to travel, frequency of travel, duration of stay in a highly endemic area etc. Local cases on the other hand show the extent to which personal

protection is practiced so as to prevent onward transmission. These factors show how they affect interventions and thus a conclusion can be drawn to determine whether elimination is feasible or not thus leading to an increase in prevalence of the disease or failure to attain zero prevalence thus elimination.

CHAPTER 4

4.0 Methodology

4.1 Study Design and Setting

This was a cross sectional study. Primary data was collected from five randomly selected health facilities in Lusaka District. These included Chelstone health centre with a catchment population of 123 501, Chawama 1st level hospital with a catchment population 144 462, Chilenje 1st level hospital with a catchment population of 116 510, Kanyama 1st level hospital with a catchment population of 191 056 and Kalingalinga health centre with a catchment population of 90 878. Proportions of those who travelled and those who did not travel were determined. Validity in this study was ensured by enrolling participants from randomly sampled health facilities so as to avoid being biased towards a higher prevalence which could have been the case had this study selected only those facilities that record higher numbers of cases. The coverage of the research based on these facilities was representative enough of the district.

4.2 Study Population

All confirmed malaria cases reported during the data collection period at the selected health facilities from which the study was done.

- **Inclusion Criteria**
  The study included all confirmed malaria cases (microscopy or rapid diagnostic test, RDT) including cases of all those who were found to have travelled outside Lusaka in the last 3 months prior to the illness.
- **Exclusion Criteria**
  All clinical cases

4.3 Sample Size Calculation

To examine what proportion of the cases of malaria is reintroduced by mobile populations, the sample size calculation for a single proportion was used. The following equation was used.

$n = (z/\Delta)^2 p (1-p)$

Since national malaria prevalence was estimated to be 15%, (Central Statistical Office (CSO) [Zambia] et al., 2014), we used $p = 0.15$

Assuming a 95% confidence interval of width ±0.05 within 5% of the true value was required to be achieved.

$Z = 1.96$

$\Delta = 0.05$

$P = 0.15$

Therefore $n = (1.96/0.05)^2 0.15 (1-0.15)$

$= 1536.64 \times 0.1275$

$= 195.92$

Rounding off to 196

Adjusting for non-response assuming 80% response rate,

$n = 196/0.80$

$= 245$

However, there are other sample sizes that can be considered for this study and these are listed in Table 1 below:

Table 1: Different sample sizes

	Prevalence (%)	Sample size (n)
Lusaka	1	20
Zambia	15	245
(Ng'andu et al., 1989) (Chanda et al., 2012)	- -	224 150
Calculated from selected clinics in Lusaka	24*	352

*This figure was arrived at as a proxy by using the actual figures for malaria from the clinics in Lusaka district given the total confirmed and clinical cases in 2014

4.4 Sampling Technique

This study randomly sampled 5 clinics. All health centres in Lusaka district were listed and numbered. Simple random sampling was done by picking a number from the list. This was done as opposed to selecting only the ones with higher numbers of confirmed cases so as to avoid bias towards a higher prevalence. A proportional sampling process was carried out in order to determine the number of participants to be sampled at each clinic. This was done as follows;

Taking the calculated sample size of 245,

Number of participants at clinic A (N) = (Estimated number of confirmed cases at clinic A (for a 3 month period) ÷ sum of estimated number of confirmed cases in all the 5 clinics sampled) × 245

NOTE: 3 months period was the period of data collection

However, considering small malaria prevalence (1%) in Lusaka, in order to achieve a desirable level of precision, the entire population with confirmed malaria cases during data collection period was considered in this study. The participants of the study were enrolled as the positive cases were identified

during the data collection period. This included all positive cases that were confirmed either by RDT or microscopy, the required sample size being the minimum number of participants.

4.5 Data Management

4.6 Data Collection

Data collection was done by interviewing patients identified to have malaria from selected health centres in Lusaka district so as to establish any imported cases. The malaria status of those eligible was determined following a confirmation either by RDT or microscopy. These were then interviewed by the use of a structured questionnaire. This was done with the help of research assistants (nurses/lab technicians) in the data collection process from the different health facilities. Cases were classified as imported or local determined by one's travel history (Wang D, 2015). Those who indicated that they had travelled outside Lusaka in the last three months or were visiting Lusaka from other districts or provinces were treated as imported cases and those who did not travel at all were treated as local cases. The information that was obtained from the interviews was checked for accuracy and completeness before analysis was done.

4.7 Data Analysis

To determine the contribution of human mobility to malaria transmission, this study identified the factors that influence malaria importation. Mobile populations were assessed in relation to control measures. To assess associations, malaria status of a patient was determined. This was done by classifying a case as either imported or local based on one's travel history. Analysis based on this variable was done. Analysis was done to assess malaria importation by residence (Lusaka resident/non-resident). Contribution to malaria transmission was determined by assessing factors that influence malaria importation. Categorical variables were analysed by frequency distributions. Chi square test was used to determine associations of categorical independent variables and outcome variables. Logistic regression was used to explore the association between malaria importation and human mobility. Stepwise logistic regression was used to select the best predictors in a multiple logistic regression model.

To avoid loss of power and bias, continuous predictor variables such as duration of stay in weeks were not categorised (Burbos et al., 2010). The influences of the individual predictor variables were expressed

as odds ratios and their associated p-values. These were calculated using statistical software and reported. All statistical analyses were performed using Stata software version 12.

4.8 Ethical Considerations

Before collection of data commenced, the protocol was submitted to the University of Zambia Biomedical Research Ethics Committee (UNZABREC) for review and approval. Permission was also obtained from the Ministry of Community Development Mother and Child Health (MCDMCH). A consent form was used to obtain individual consent and it was signed by the participants so as to acknowledge their participation. Full information about the study and the possible benefits and risks were given to the participants. The study ensured minimal risk such as collection of blood sample from the patients as it was a requirement necessary for treatment.The benefit of this study was that information participants gave helped to identify the possible sources of the infection and also determine the prevalence of imported cases in Lusaka district and factors associated with malaria importation. This will help to inform and target programmes to improve prevention and control measures hopefully leading to malaria elimination. Participation in this study was voluntary. The aim, rationale, benefits and possible risks of the study were highlighted with the help of an information sheet. The data collected was handled with utmost confidentiality. Personal data collected was only accessible to the principal investigator and the research assistants. To ensure confidentiality, participant's names were not recorded on the questionnaire but their data was linked to a code number.

CHAPTER 5

5.0 Results

5.1 Overall Population Description

A total of 260 malaria positive cases from five selected health centres in Lusaka district were investigated during the period November 2015 to February 2016. Of these 260 cases, 245 (94.2%), (95% CI, 90.6% - 96.7%) were classified as imported cases while only 15 (5.77%) were local cases. This classification was based on participants travel history. The median age of the malaria cases was 15 years old (IQR 8 - 27). Males accounted for 50.38% of all cases. The majority among the cases were children (0 – 14 years old). Most of the cases had attained primary education and most of these cases were Lusaka residents and had a travel history. This is shown in table 2 below.

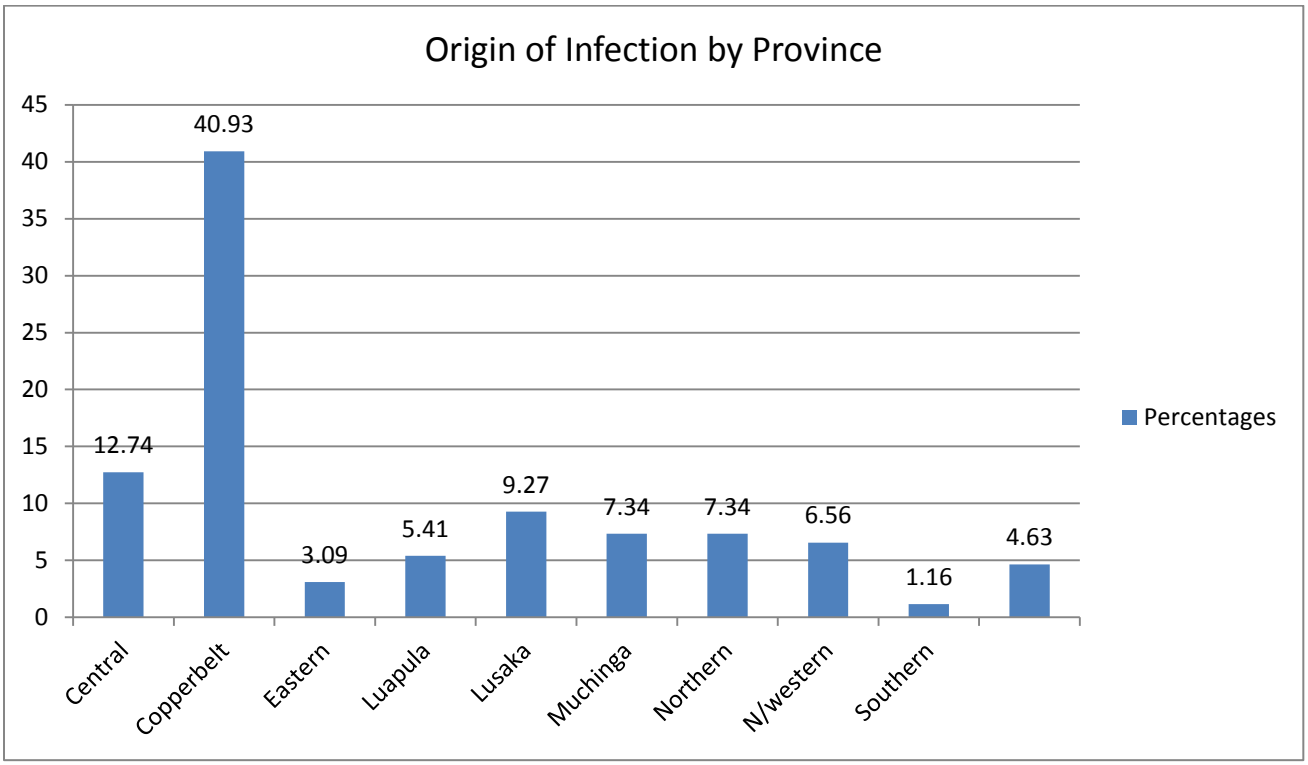
Table 2: Background characteristics of the study participants investigated at selected facilities in Lusaka district

Characteristics	Study Population	
	Frequency (N=260)	Percent (%)
Study site		
Chawama	55	21.2
Kalingalinga	45	17.3
Chilenje	50	19.2
Kanyama	60	23.1
Chelstone	50	19.2
Sex		
Male	131	50.38
Female	129	49.62
Age group		
(0-14)	120	46.15
(15-29)	88	33.85
(30-44)	33	12.69
(45<)	19	7.31
Median age in years = 15 (IQR, 8 - 27)		
Educational level		
Primary	96	36.92
Secondary	82	31.54
Tertiary	24	9.23
Never been	58	22.31
Occupation		
Formal	22	8.46
Informal	47	18.08
Student	94	36.15
Others	97	37.31
Residence		
Lusaka	158	60.77
Other	102	39.23
Travel History/Lusakares		
Travelled	143	90.51
Never travelled	15	9.4

The overall study population showed a near balanced representation of males and females.

5.2 Origin of Infection

The 245 imported cases were found to be coming from different parts of the country (Figure 3) and a few from across the borders. The majority of the cases originated from the Copperbelt province representing 40.93%. The only cross border cases identified in the study were from Angola and Malawi representing 0.39% and 1.16% respectively.



*Malaria cases for Lusaka province include Lusaka and chongwe districts

Figure 3: Origin of infection by province as established from patients' travel history

To identify which age group is the risk group for importation, travellers among the patients were categorized by age and the findings showed that children (0 to 14) were the most affected and hence the risk group due to their weaker immunity compared to adults. This group does not include local cases. This is shown in figure 4.

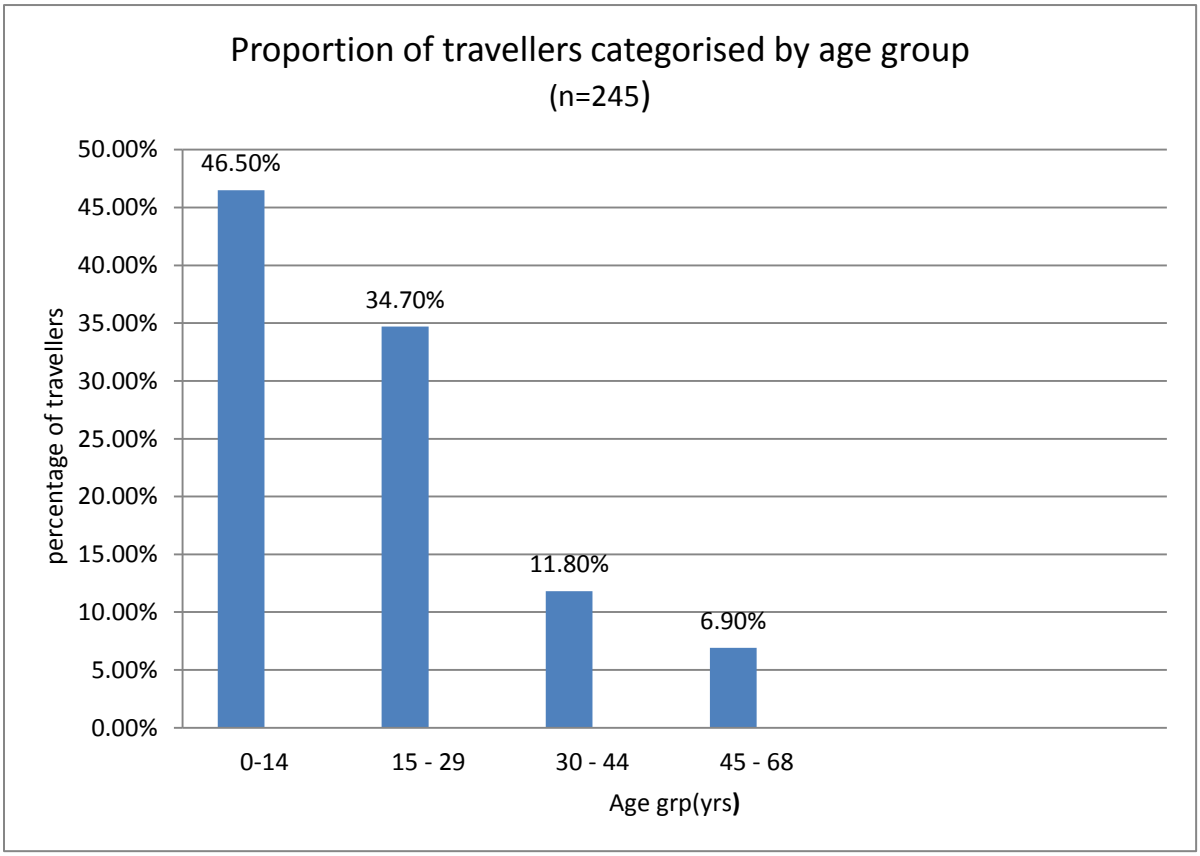


Figure 4: Proportions of Travelers Categorized by Age

Table 3: Association between Malaria Importation and possible predictors of Importation

Variable		Malaria Importation by Residence		p-value (chi2)
		Residents (n=158)	Non Residents (n=102)	
Sex				
	Male	80(50.63%)	51(50%)	0.921
	Female	78(49.37%)	51(50%)	
Age group				
	(0-14)	63(39.87%)	57(55.88%)	0.002
	(15-29)	52(32.91%)	36(35.29%)	
	(30-44)	26(16.46%)	7(6.86%)	
	(45<)	17(10.76%)	2(1.96%)	
Bed net use				
	Yes	42(26.58%)	27(26.47%)	0.984
	No	116(73.42%)	75(73.53%)	
Travel history				
	Never Travelled	15(9.49%)	0(0.00%)	<0.001
	Lusaka residents	143(90.51%)	0(0.00%)	
	Visitors	0(0.00%)	102(100%)	
Education level				
	Never been	36(22.78%)	22(21.57%)	0.612
	Primary	54(34.18%)	42(41.18%)	
	Secondary	54(34.18%)	28(27.45%)	
	Tertiary	14(8.86%)	10(9.80%)	
Occupation				
	Formal	15(9.49%)	7(6.86%)	<0.001
	Informal	41(25.95%)	6(5.88%)	
	Student	42(26.58%)	52(50.98%)	
	Others	60(37.97%)	37(36.27%)	
Prophylaxis				
	Yes	4(2.53%)	10(9.80%)	<0.001
	No	139(87.97%)	92(90.20%)	
Frequency of Travel				
	Once	122(85.31%)	93(91.18%)	0.168
	Twice or more	21(14.69%)	9(8.82%)	
Duration of stay		157(100%)	85(100%)	0.01
Personal Protection				
	Non	133(84.18%)	86(84.31%)	0.976
	Yes	25(15.82%)	16(15.69%)	
IRS				
	No	147(93.04%)	93(91.18%)	0.582
	Yes	11(6.96%)	9(8.82%)	

To investigate the association between malaria importation and variables of interest (table 3), chi square test was used and the results established association in the use of prophylaxis, age, duration of stay, occupation and travel history. These were found to be statistically significant.

Table 4: Univariate and multivariate logistic regression analysis predicting malaria importation by residence

Variable	Univariate OR (95% CI)	P-Value	Multivariate OR (95%CI)	P-Value
Age				
(0-14)	1			
(15-29)	1.31(0.75 – 2.28)	0.345	1.48(0.46 - 4.79)	0.511
(30-44)	3.36(1.36 – 8.33)	**0.009**	1.62(0.30 - 8.84)	0.579
(45<)	7.69(1.70 – 34.76)	**0.008**	8.17(0.77 - 87.0)	0.082
Sex				
Male	1			
Female	0.97(0.59 – 1.60)	0.921	0.85(0.45- 1.62)	0.623
Education level				
Never been	1			
Primary	0.79(0.40 – 1.53)	0.478	0.52(0.15- 1.89)	0.323
Secondary	1.18(0.58 – 2.37)	0.645	0.55(0.11 - 2.66)	0.458
Tertiary	0.86(0.33 – 2.26)	0.752	0.20(0.03- 1.39)	0.104
Prophylaxis				
No	1			
Yes	0.27(0.08 – 0.87)	**0.028**	0.22(0.05- 0.96)	**0.044**
Duration of Stay	1.08(1.04 – 1.12)	**<0.001**	1.10(1.05 - 1.16)	**<0.001**
Frequency of Travel				
Once	1			
Twice or more	1.78(0.78 – 4.06)	0.172	2.29(0.69- 7.59)	0.175
Occupation				
Formal	1			
Informal	3.19(0.92 – 11.03)	0.062	1.33(0.26 - 6.86)	0.736
Student	0.38(0.14 – 1.01)	0.052	0.24(0.05 - 1.26)	0.092
Others	0.76(0.28 – 2.03)	0.580	0.24(0.05 - 1.21)	0.084
IRS				
No	1			
Yes	0.77(0.31 – 1.94)	0.583	0.62(0.18 - 2.05)	0.428
Bed net use				
No	1			
Yes	1.01(0.57 – 1.77)	0.984	1.31(0.62 - 2.77)	0.476
Origin of Infection	1.03(0.95 – 1.12)	0.436	1.01(0.92 - 1.12)	0.809

Table 4 shows the univariate and multivariate analysis for importation of malaria by residence using logistic regression. After adjusting for origin of infection, bed net use, IRS, Frequency of travel, occupation, education level, sex and age; duration of stay (p= 0.001) and use of prophylaxis (p = 0.044) were found to be statistically significant.

Table 5: Best Predictors of malaria importation by residence using Stepwise logistic regression

Variable	Adj.OR (95% CI)	P-value
Frequency		
Once	1	
Twice or more	3.95(1.35 – 11.55)	0.012
Prophylaxis		
No	1	
Yes	0.22(0.60 – 0.78)	0.020
Duration of Stay	1.07(1.03 – 1.12)	0.001

Stepwise logistic regression was used to determine the best predictors of malaria importation by residence after adjusting for sex, age, education level, occupation, IRS, bed net use and origin of infection. Frequency of travel, use of prophylaxis and duration of stay were found to be associated with malaria importation by residents and were thus the best predictors in the final model.

CHAPTER 6

6.0 Discussion

Human mobility has contributed to malaria transmission in Lusaka district by introducing imported infections. The findings of this study showed a high prevalence of imported cases. Local cases were also identified in this study. This simply shows the influence of human mobility to malaria transmission lead to onward transmission in the district rather than elimination. Proportion of imported infections found in this study conquers with the findings of other studies from literature. Similar studies done in china also showed a higher prevalence of imported malaria. For example, a study by Li et al indicated that a very high prevalence of the disease burden was attributed to human mobility. Another study by Wang X et al also showed that 91.2% of the disease burden was due to human mobility. This shows that for most regions aiming for elimination, human mobility challenges the efforts to achieve this goal. Literature has shown that malaria importation is indeed a major factor in malaria transmission not only in low transmission setting but also in high transmission setting such as Bioko Island in Equatorial Guinea (Bradley et al., 2015). This study shows that children aged 0 to 14 years were identified to be the risk group and males were the majority among the cases with a travel history compared to females. It also established that frequency of travel, duration of stay and the use of prophylaxis are factors that influence malaria importation. These factors are further discussed to understand the contribution of human mobility to malaria transmission.

This study found that the prevalence of malaria attributed to human mobility declined as the age increased with an indication of children (0 to 14 years) being the majority among infected travellers. It suggests that children were most susceptible to malaria infection due to their weaker immunity compared to adults considering the fact that the study investigated only positive malaria cases. This however does not mean that adults did not travel as much; they were less affected by infection due to their stronger immunity. This simply shows that the group mostly at risk of transmission and consequently importing malaria to Lusaka district are children. This was also shown in a study by (Bradley et al., 2015), that children aged 2 to 14 who had travelled were at greater risk of infection and were more likely to import malaria to Bioko island. A study by Li et al showed that adults aged 21 to 50 years who travelled to endemic areas for work were the risk group and accounted for the majority of the cases.

This study established that those patients who took anti-malarial drugs prior to their travel to highly endemic districts were less likely to import infections. This shows that it is protective for Lusaka residents to take prophylaxis prior to their travel to highly endemic areas. Non-Lusaka residents who are infected and not properly treated prior to travel are also at risk of importing malaria to Lusaka district or even get infections from Lusaka district as they are visiting hence the need to take prophylaxis or ensure complete treatment before travelling. The low utilization of prophylaxis among travellers which led to increased risk of importation was also shown in a study by (Li et al., 2016, Wang X et al., 2016) where only 11.3% of individual travellers who were diagnosed with malaria obtained anti-malarial drugs prior to their travel and 1.3% (8/615) (Wang X et al., 2016) used chemoprophylaxis.

This study also established that duration of stay was significantly associated with malaria importation. It shows that for every increase in weeks for the duration of stay in an endemic area, Lusaka residents visiting highly endemic regions were 7% more likely to import malaria. This was statistically significant. Le Menach et al explain that the overall influence on local malaria transmission by residents and visitors depends on the number of infections brought relative to the duration of infection. Duration of untreated malaria infection is on average 200days (Snow et al., 2002). They further explain that contribution to local transmission depends on local receptivity of the place where infections were imported and the duration of stay.

The study findings further established that frequency of travel was a factor for importation. Results show that residents who travelled two or more times to other districts within the last three months prior to the study were approximately four times more likely to import malaria than those who travelled only once. According to a study by (Li et al., 2016), occupation was one of the significant factors that influence malaria importation. Importation in this particular study was classified by ones travel history outside the country. So the majority who travelled were males travelling for the purpose of work. In our study however, there was not enough evidence to show that occupation was a determinant for importation. Origin of infection is one of the factors investigated and from the descriptive analysis; it was found that imported cases came from all over the country with most of these cases coming from the Copperbelt province. A conclusion cannot be drawn to indicate that Copperbelt province has the highest malaria prevalence in the country. It simply shows that the majority of the cases among the population investigated in the study travelled to or where coming from the Copperbelt province.

IRS is one of the interventions put in place by the national malaria control centre and the ministry of health to combat the spread of malaria. It targets to cover 85% coverage of the households in low to high transmission zones (Ministry of Health, 2012). Results of a ZDHS survey done in 2011 to 2013 show that only 12% of households in Lusaka were sprayed. It was established from this study that only 7.69% of the cases had their homes sprayed in the last one year. According to the WHO world malaria report of 2015, such interventions; in Zambia particularly are funded by the government, global fund and USAID. This shows that it is somewhat dependant on donor funding which could explain the low IRS coverage.

Among the 260 individuals who were found with malaria, only 15.83% practiced some form of personal protection such as the use of repellents, mosquito coils and insecticide spray against mosquito bites other than the use of insecticide treated nets. The majority did not use any form of preventive measures. Of all the patients interviewed, only a quarter of the patients used ITNs despite having strong campaigns on the use of ITNs in the fight against malaria. This shows poor participation in interventions to combat malaria among the locals even if the government plays its role in making such services available. However, the use of ITNs and IRS was not statistically significant to malaria importation in this study but is very relevant in the efforts to control malaria transmission. The relevance of these findings is that low preventive measure practice tends to undermine efforts to control malaria with the hope to eventually attain elimination. The ratio of imported malaria cases for visitors to that of Lusaka residents who travelled was estimated to be approximately 2:3. This shows that there are more cases from residents visiting highly endemic regions than from visitors. This was also established in a study by (Le Menach et al., 2011) that Zanzibar residents travelling to malaria endemic regions were estimated to contribute 1–15 times more imported cases than infected visitors.

The limitations to this study were that the proportion of malaria imported cases could have been undermined due to asymptomatic infections. Pathogens can be introduced into an area at four stages. This study only looked at importation through infected visitors and through residents visiting endemic regions. Infections which could have been introduced by infected foreign vectors could not be identified and this could have led to overestimation of local cases. Travel history of the patients was used as a proxy to classify cases as imported or local. However, those who were considered as imported cases could still have been infected locally despite having a travel history. Unfortunately, this study could not carry out any tests to show whether one acquired the infection locally or not. Malaria elimination in

Lusaka can only be feasible by implementing control measures based on detecting imported malaria cases and controlling onward transmission.

6.1 Conclusion

Imported malaria has become a major public health challenge in countries aiming for elimination. The findings of this study show a prevalence of 94.2% of imported cases of all positive cases in Lusaka district. Prevalence of this magnitude suggests that imported cases can consequently increase the number of local cases thus leading to onward transmission. Control measures are put in place but they are not followed as expected such as the low utilization of insecticide treated nets and other protective measures as seen from the findings of this study. This study established sources of infection and identified the risk group which can be targeted by various interventions so as to prevent importation of malaria cases from highly endemic regions. Factors associated with malaria importation established in this study include the use of prophylaxis which has shown that for residents visiting endemic areas is highly protective, duration of stay and frequency of travel.

6.2 Recommendations

Taking of prophylaxis was highly effective in preventing acquisition for people travelling to endemic areas and so it must be encouraged.

Risk groups identified in this study need to be reached by having health education talks in schools to sensitise children on the importance of protection against mosquito bites by sleeping under a mosquito net or using other protective measures especially as they travel to areas that are highly endemic.

Sources of importation must be targeted and included in vector control interventions by the national malaria control centre and other relevant authorities.

The general public need to be educated on the possibility of importing malaria from highly endemic regions and addressing poor participation in interventions to combat malaria through different channels such as the media.

Screening can be introduced at boarder entries and strengthening policy at boarders if boarder areas are to be targeted.

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CHAPTER 7

7.0 APPENDICES

7.1 Appendix I: Informed Consent Information Sheet

INFORMATION SHEET

Study Title: Determination of the Contribution of Human Mobility to Malaria Transmission in a Malaria Elimination Context in selected Health Centres in Lusaka District

My name is Miriam Lowa. I am a student at the University of Zambia, School of medicine. In order to complete my program of study, I am expected to carry out a research which should be able to contribute new knowledge to the existing body of knowledge. The aim of my study is to determine how movement of people from one town or district to another contributes to malaria transmission and how these movements affect efforts to eliminate malaria.

What will happen if I take part?

If you accept to take part in this study, I will ask you a few questions which will include your personal details and travel history in the past 3 months in order establish were the infection could have come from. This will take about 5 minutes. Our discussion will be kept private and your name will not be indicated on any questionnaire or record with regards to this study.

Do I have to participate?

Your participation in this study is voluntary. You are free to withdraw at any point during the interview if you feel you cannot proceed. You do not have to give any reasons and there will be no consequences if you do so.

What will happen to the information I will give?

The information you will give will help in arriving at a conclusion in determining the effect of travelling on malaria transmission and control. The information you will give will be kept private and your name

will not appear on any document. The results that I will get after carrying out this study will be submitted to the University of Zambia, Department of Public Health for academic purposes and the Ministry of Health in form of a report.

Risks/Discomforts

The only risk this study may present is the discomfort you will get as you will be pricked for a blood sample for the malaria test. You may also feel tired as the interview takes place but be rest assured that it will not take more than 5 minutes of your time.

Benefits

There will be no payment for participating in this study but you will be made aware of the possibility of acquiring malaria if you travelled to a place with a high transmission rate. The information you will give will help identify the possible source of the infection and also determine the prevalence of imported cases in Lusaka district. This will help to inform and target programmes to improve prevention and control measures hopefully leading to malaria elimination.

Should you need any clarifications, please feel free to contact me on the following contact:

Miriam Lowa
University of Zambia, School of Medicine
Department of Public Health
P.O. Box 50110, Lusaka
E-mail: miriamlowa@yahoo.com
Mobile: +260-966-777113

You can also get in touch with the Chairperson of the University of Zambia Biomedical Research Ethics Committee for any ethical enquiries on:

Address: UNZA Biomedical Research Ethics Committee
Ridgeway Campus
P.O. Box 50110
Lusaka, Zambia
Telephone: 260-1-256067
Fax: 260-1-250753; E-mail: unzarec@zamtel.zm

7.2 Appendix II: Consent Form

CONSENT FORM

The purpose and process of the study has been explained to me clearly. I fully understand possible benefits and risks of this study. I therefore willingly agree and consent to take part in this research by appending my signature/thumb print below.

Statement of Parental Permission (signature or thumbprint required)

The purpose and process of the study has been explained to me, and I agree to let my child take part.

Participant Name: ……

Signature/thumb print: ……..

Date: …….

Name of Interviewer: ……..

Signature: ……

Date: ……

7.3 Appendix III: Questionnaire

QUESTIONNAIRE

Province _____ Patient's ID number _____

District _____ Date of visit _____

Name of Health Facility _____

Section A: Demographic Data

1. Date of birth (dd-mm-yyyy) _____
   OR Estimated age in Months _____ Years ____

2. Sex (male = 1, Female = 2) _____

3. Marital Status (Married = 1, Single = 2, Divorced = 3, Widowed = 4) _____

4. Occupation (Formal = 1, Informal = 2) _____

   Specify _____

Section B: Travel History

5. Are you a Lusaka resident? (Yes =1, No = 2) _____
6. If your answer to Q5 above is no, state were you come from and proceed to section c. _____
7. Have you travelled to any town outside Lusaka in the last 3 months?
   (Yes =1, No = 2) _____
8. If yes, which town did you visit? _____

9. How long did you stay there? _____
10. How often have you travelled outside Lusaka in the last 3 months? _____

Section C: Personal Protection

11. Do you sleep under a mosquito net? (Yes = 1, No = 2) _____
12. Does every member of your household sleep under a mosquito net?
    (Yes = 1, No = 2) _____
13. What time do you often retire to bed? _____
14. Have you used any of the following over the last 3 months:
    Repellents____ Mosquito coils____ Insecticide spray_____
15. Has your house been sprayed against mosquitoes in the last 3 months?
    (Yes = 1, No = 2) _____
16. On your trip, did you use any form of protection against mosquito bites?
    (Yes = 1, No = 2) _____
17. If yes, specify
    Repellents____ Mosquito coil____ Insecticide spray____ Mosquito Net_____
18. Did you take any form of malaria prevention drugs prior to your travel?
    (Yes = 1, No = 2) _____
19. If yes, please specify _____

END

Thank you for your participation!!!

Appendix IV: Ethical Clearance Letter

Appendix V: Letter of authority; Ministry of Community Development Mother and Child Health (MCDMCH)