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Public health challenges facing malaria elimination in developing countries: a review of expert opinions

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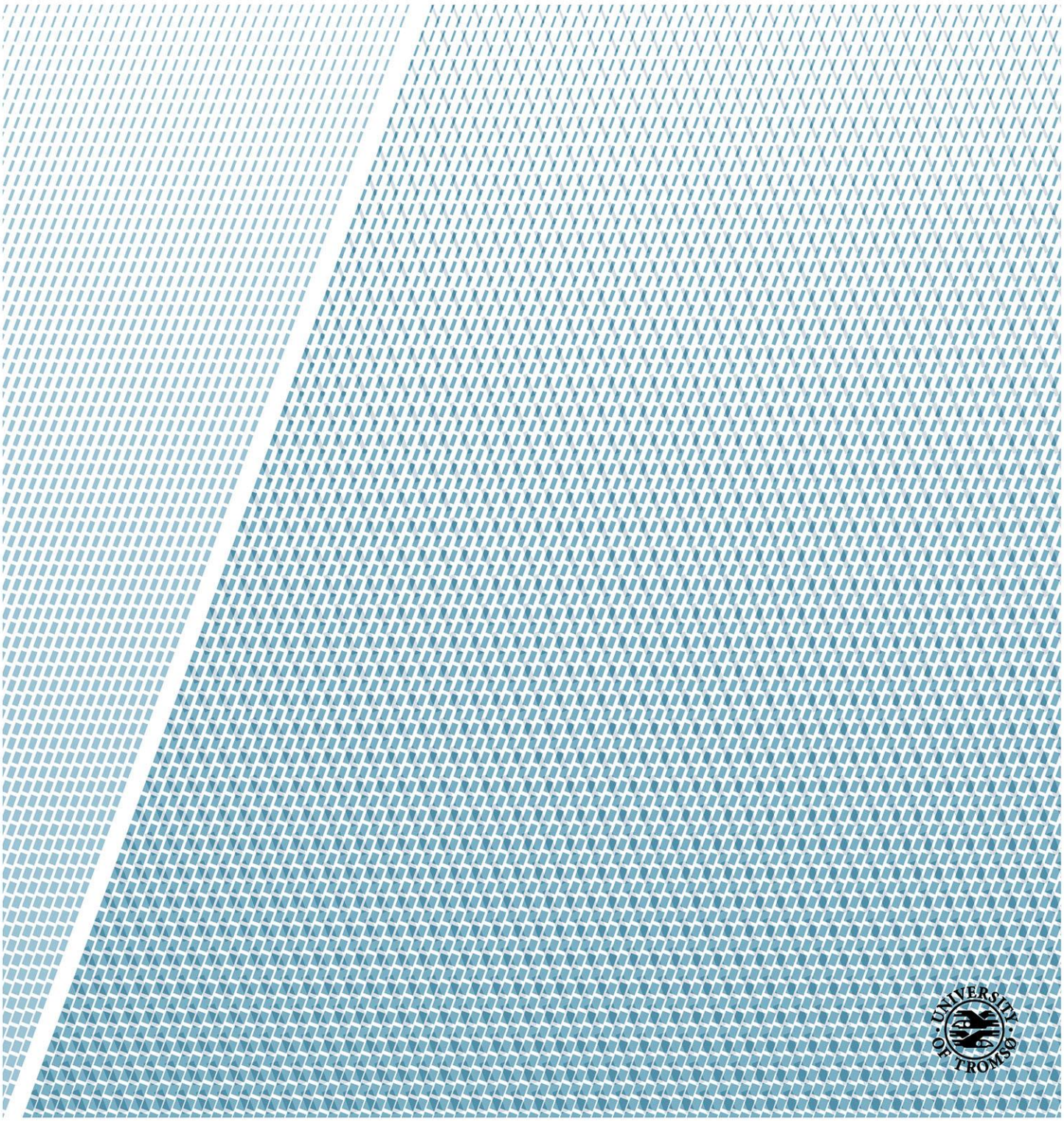

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Abstract

Background: Malaria is Primarily a vector-borne disease caused by the protozoan Plasmodium. Protozoa Plasmodium is unicellular eukaryote parasites. These parasites are mostly transmitted to people through the bites of an infected Anopheles mosquito, called "malaria vectors." Studies have shown that Malaria occurs mostly in the tropical and the subtropical regions of the world. The prevalent of malaria is happening in 106 countries of the developing world, like Africa, Amazon, Central and Southern America, central, south and southeast Asia, and Pacific. However, developing countries are the most affected countries. According to the world Health Organization report, about 3.2 billion People nearly 50 percent of the world population are at risk of malaria infection each year.

Objectives: The researcher reviewed the literature regarding public health challenges facing malaria elimination in developing countries.

Study design: The Cochrane Library, the WHO library, the Google Scholar, were searched for the studies related to public health challenges affecting the elimination of malaria in developing countries. A hand search was also included. The studies included were from developing countries authored in the English language that pointed at challenges that affected the elimination of malaria in developing countries.

Results: Twelve Articles reached the inclusive criteria. All the twelve (articles) demonstrated expert opinions regarding public health challenges affecting malaria elimination in developing countries.

Conclusion: Results based on expert opinion suggest that Parasite-resistant to drugs or insecticides ,weak surveillance systems inadequate health care resources infrastructure ,lack of knowledge of information and understanding of malaria vectors and the parasites, high

malaria transmission intensity, external factor of population and climate change drug related challenges drug- related challenges,and inadequate local budget and donor's dependency are challenges facing malaria elimination in developing countries. Nevertheless, this study is based on expert opinions, and more studies must be done to prove the findings.

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LIST OF ABBREVIATIONS

WHO	-	World Health Organization
ACT	-	Artemisinin-based combination therapy
LLINs	-	long-lasting insecticidal nets
IRS	-	indoor residual spraying
MDG	-	millennium development goals
UN	-	United Nations
HIV	-	Human Immune Virus
ITN	-	Insecticide treated nets
DDT	-	Dichloro diphenyl trichloroethane
JBI	-	Joanna Briggs Institute
PICO	-	Population, Intervention, Comparison, and Outcome
RDT	-	Rapid diagnostic tests
SSA	-	Sub- Sahara Africa

Chapter 1

1.1 Introduction

Malaria is Primarily a vector-borne disease caused by the protozoan Plasmodium. Protozoa Plasmodium is unicellular eukaryote parasites. The parasite is then transmitted to people through the bites of an infected Anopheles mosquitos, called “malaria vectors” (1). The name malaria originated from the Medieval Italian “ mala aria”, meaning “ bad air.” This is because by then, the disease was associated with the air in the swamps and marshland (2).

1.2 Global incidence, prevalence, and epidemiology of malaria

Malaria occurs mostly in the tropical and the subtropical regions of the world. The prevalent is in 106 countries developing countries, in Africa, Amazon. Central and Southern America, central, south and southeast Asia, and Pacific. However, developing countries are the most affected countries.

According to the world Health Organization report, about 3.2 billion People are at risk of malaria infection in developing countries each year about 50 percent of the global population (3). According to the latest information, 214 million cases of malaria occurred globally in 2015 and 438,000 people died because of malaria infections at the same time (3, 4). From 2000 to 2015, malaria incidence among the population group at risk fell by 37% globally. At the same time, malaria incidence mortality rates among the same population at risk decreased by 60%. There were an estimated 6.2 million malaria deaths prevented in 2001 (4, 5).

Malaria is a severe public health problem and remains the leading cause of death in developing countries (4). Developing countries are countries with low human development index (6). Whereas malaria is a preventable disease, recent data shows that the transmission of the disease is now happening in ninety-seven developing countries like Uganda, Kenya, Ghana, Nigeria, Haiti, Tanzania, Malawi among others and children are the most affected

person (5). According to WHO, 3.4 billion people are at risk of malaria, and 1.2 billion are the highest danger of contracting the disease (5).

There were an estimated 207 million cases of malaria reported worldwide in 2012. Around 627,000 people died. 90% of these deaths, happened in the regions of the sub-Sahara Africa, meaning the Africa region is the most affected region globally (5). 482 children under five years died of malaria during the same period (4).

Between 2000 and 2012, malaria interventions helped to reduce malaria incidence rates by 25% globally, and by 31% in the African Region (5, 7). The global malaria mortality rate was reduced by 42% during the same period while the decrease in the African Region was 49%. In the same year 2000 and 2012, malaria interventions saved an estimated 3.3 million lives (4). 90% of these are in the under-five in the regions of the sub-Saharan Africa.

During 2013, there were an estimated 136 million long-lasting insecticidal nets (LLINs) that were given out to malaria-endemic countries. In 2012 around 70 million bed nets that was given out and about200 a million LLINs delivered in 2014.

In 2012, around 135 million people, 4% of the global population at risk of malaria were protected by indoor residual spraying worldwide.

The amount of RDT sales to the public and private sectors within malaria endemic countries improved from 88 million during 2010 to 205 million in 2012. During 2010 to 2012, the number of suspected malaria cases that was given the diagnostic test in the public sector increased to 64% from 44% worldwide, and in African region increased to 61% from 37% in Africa (5, 8).

In spite of all the effort taken to fight malaria prevention, the disease elimination remains a challenge in developing countries.

1.3 Causes and Transmission of Malaria

Malaria is caused by protozoan Plasmodium parasite and is spread by the female Anopheles mosquitoes. The male mosquito feeds on plants and nectars and therefore does not spread the disease. There are four parasite species causing malaria and these are; Plasmodium Falciparum, Plasmodium vivax, Plasmodium malaria, and Plasmodium value. The first two parasites are the most common while Plasmodium falciparum is the most deadly of all the species (1). Recently plasmodium knowlesi was identified as the cause of some human cases of malaria. plasmodium knowlesi is a zoonotic species that cause malaria among monkeys and exist in certain areas of the South East Asia (1) the primary mode of malaria transmission is by the bite of the mosquitoes. There are more than 480 species of Anopheles Gambia, a very efficient species of the mosquito exist in Africa, is responsible for the highest transmission of malaria in Africa. All the important vectors bite at night (1). When a female Anopheles mosquito bites an infected person, it sucks in blood along with the parasites (in the gametocyte form). Inside the gut of the mosquito, the parasite (gametocytes) undergoes sexual reproduction into the sporozoite forms which then migrate into salivary glands of the mosquito. When this mosquito bites again, the parasites (protozoans) travels through the blood vessel into the liver where they multiply rapidly (through asexual reproduction) producing thousands of merozoites. These merozoites infect mostly new blood cells and reproduce inside them and burst the cells. Other merozoites develop into gametocytes which again be spread to other people but the vector. Malaria parasites can also be transmitted by blood transfusion especially in places where malaria is endemic. Mother to fetal transmission has been documented.

The intensity of malaria infection or transmission of the disease depends on the parasites (Plasmodium), the vector) mosquito, the human host, and the environment. There is more intensity transmission in the region where the lifespan of the vector is longer. This is why

about 90 percent of malaria cases happened in developing countries in Africa, more so in the region of the SSA. This is partly because a parasite long life span, the biting habit and the vast of the Anopheles Gambia, which exists in Africa. (1) The climate is also important for malaria transmission. Rainfall pattern, humidity, and temperatures affect the population and the survival of the mosquitoes. Malaria epidemic may occur if the climate and other conditions suddenly favor transmission and in a location where there no immune to malaria; and likewise, when people with low immune go to the region with intense malaria transmission, the example as refugees (1)

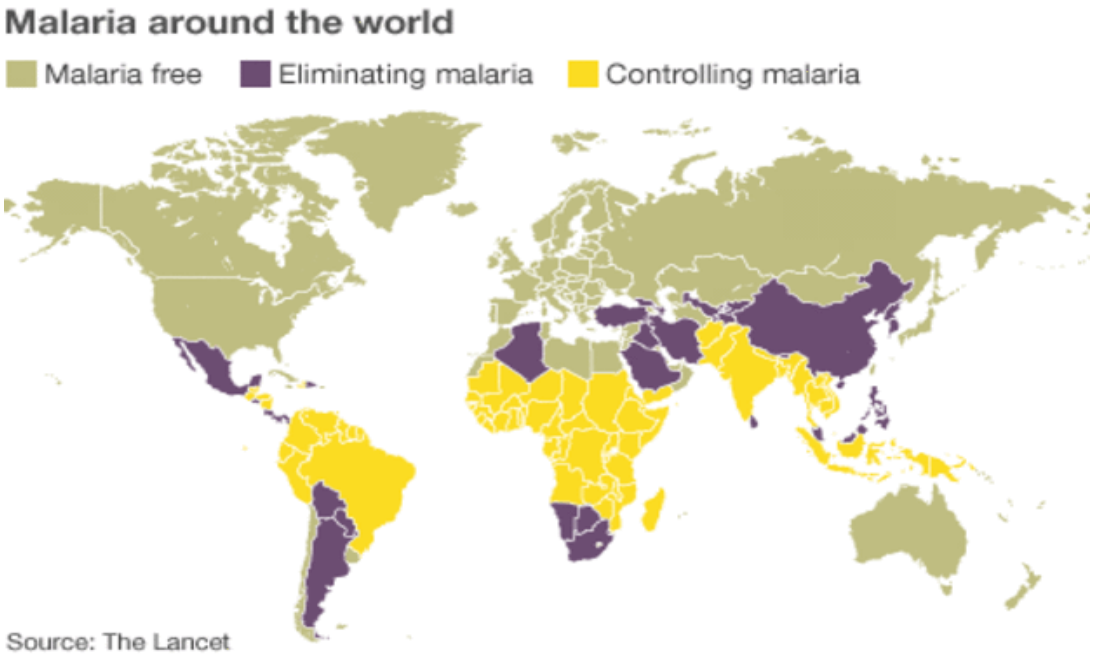
The incidences of Malaria infections are more concentrated in the poorest countries, more so in developing countries (9-11). However, WHO notes that high level of malaria prevalence in developing countries is not because of poverty (9, 12). The geographical location of these countries is partly responsible for the malaria infection. Malaria is geographically specific in nature. This is because the ecological conditions of the locality of these countries support malaria mosquito vectors which determine the distribution of disease intensity (9, 13, 14). A parasite called Plasmodium causes disease. This parasite is responsible for malaria-related deaths in developing countries of the sub-Sahara (8).

In favorable climatic conditions, man-made environmental changes such as water dams, water reservoirs, irrigation systems and afforestation man increase the bleeding place of the mosquitoes and thereby initiating the epidemic.

The immunity of the human host especially among the adults I the region of the moderate to intense malaria transmission is an important factor. This immunity is developed after years of exposure, but it does not guarantee complete protection from malaria but gives a partial immunity. However, it reduces the risk of such individuals from having the several form of the disease, such as cerebral malaria (1, 2). This is one of the reasons most malaria death is developing countries, especially Africa, are among the young children who have not yet

developed a partial immune system (1) the immunity is related to the specific population that is more at risk. This risk group are children who have not developed a partial immune system, pregnant women as malaria cause a high rate of abortion and maternal death, HIV-infected pregnant women with increased rate of passing HIV to babies, an international traveler who lack immunity to malaria and immigrants (1).

Figure 1. **World map showing malaria distribution**



1.4 Malaria Prevention and Diagnosis

Malaria is confirmed by the microscopic examination of the blood films or by antigen based-based rapid diagnosis tests. The prevention of malaria includes different methods such as vector elimination or control, prevention of bites and medications (Chemoprophylaxis). However, WHO maintains that the best way to reduce malaria transmission at the community level is by vector control (1). According to WHO, people at risk of malaria infection must be protected from malaria infection using malaria vector controls (5).

WHO recommends mostly two forms of vector controls. insecticide-treated mosquito nets, and indoor residual spraying (4).

The WHO shows that for the last 15 years, there has been an increase in the coverage of ITNs in the developing countries, especially in SSA. About 55 percent of the population in SSA were sleeping and protected by ITNs. In comparison with the year 2000, it was only 2% population that is protected. Globally, there were 116 million people who were protected by indoor residual spraying (IRS) and around 55 million people were protected in Africa. 6% of the population at risk of malaria in Africa lives in household protected by IRS (5). WHO recommend people at risk to sleep under the ITN every night and encourage IRS with insecticide spraying as an effective way of rapidly reducing the transmission of malaria (1). This is because mosquitoes rest on the walls or surface of nearby after feeding. So if the insecticides are on the surfaces of the walls, the mosquitoes die while resting before they bite another infected person and transfer the parasites (15). In 2006, WHO approved the use of 12 insecticides for IRS, including DDT (16). The Stockholm Convention banned Persistent Organic Pollution (POPs) on agricultural use but now permits a little amount of DDT for public health reasons in developing countries. (17). Nevertheless, insecticide resistant in IRS and malaria drugs is a major public health challenge facing malaria elimination in developing countries (18).

1.5 Preventive strategies for malaria

Malaria is one of the specific disease that is addressed by the millennium development goals (MDG 6), to "combating HIV/AIDS , Malaria, and other diseases " (19). Malaria prevention includes many methods such as vector elimination, prevention of bites and medication like chemoprophylaxis. However, WHO argue that the best way to reduce malaria transmission at the village level or community is by vector control through (ITNs) and by (IRSs). Between 2000 and 2015, over six million deaths have been averted by with more children lives saved. There were reported reduced mortality rate between 38-58%. The reduction in malaria cases has not been uniform within the developing countries. This is because of the parasite resistant to malaria drugs available and insecticide (20). During 2004-2014 period it's reported that an approximately 900 million insecticide-treated mosquito nets were delivered and utilized in developing countries with Sub-Sahara Africa leading (19). However, the zero targets were not achieved as Malaria remains a bigger challenge in developing countries and more so within the region of the sub-Saharan Africa (SSA). The population-based approach has been identified although individual-based strategies are applied in the prevention of the disease. Several methods are recommended for prevention of malaria in protecting the public. Both individual and population methods have been applied with success. Vector directed methods are used to protect the individual against infective malaria mosquito bites. There is also community impact to reduce the intensity of local malaria transmission at the community level. This is done by reducing the longevity, density, and human-vector contact of the local vector mosquito population (21).

Vector Target is a major intervention involving the process to cut transmission of the malaria-causing parasite. Insecticide-treated nets (ITN) has been acknowledged as the most affordable and efficacious method for protecting the population (22). There is long lasting mosquito treated nets with some reported maintaining biological activity for three years (23). There has

been reported an increase in populations sleeping under ITN in sub-Sahara Africa as more endemic nations adopt policies for promoting universal access. Children under five, pregnant mothers and the elderly are highly vulnerable thus they are prioritized in preventive method (24).

According to WHO, Indoor residual spraying is (IRS) has been applied to large scale approach. There are 12 different types of insecticides used in IRS. Among the insecticides DDT has a long lasting six-month effect and it's the cheapest. Stockholm Convention banned it, but the ban has been lifted meaning it can now be used (22)

Mosquitoes have several development stages and during the larval stage, it's possible to control the stage of growth. At least 48 nations use this method where habitat manipulation or larvicidal applications are used. There has been the use of biological control with fish predators used to control breeding and reproduction of mosquitoes. This method is not measured according to the current WHO available data and its applied mostly in irrigation projects and areas with limited breeding environments (24).

Malaria early diagnosis and treatment are secondary prevention mechanisms applied that have been used as a prevention strategy. Early diagnostic through screening followed by treatment with artemisinin-based combination therapy *(*ACT*)* cuts the transmission. WHO recommends that all the risk persons should sleep under the (ITNs) (24).

1.6 Justification of the study

The reason behind this study is to review public health challenges facing malaria elimination is developing countries based on expert opinion. An Expertise is a professional or a specialist whose information is more reliable than the rest of the population. Alternatively, expertise is

a widely recognized person with vest or extensive knowledge based on research, experience and occupations (25)

Malaria is a fundamental main public health challenge and the leading cause of death developing countries (4, 26). By definition, a developing country is a country with low human development index below other countries (27) the relational behind this review is to find out why malaria elimination has failed in developing countries. For the example; a study done in Bhutan entitled Malaria control in Bhutan embarked on challenges facing malaria elimination, looked at the challenges facing imported malaria from the neighboring countries (28). The study indicated a decrease of malaria cases in Bhutan. The reason was due to increased coverage of indoor residual spraying of mosquitos in a high-risk population and the use of insecticide-treated mosquito nets and long last insecticidal net. Among reasons that contributed to the decline was the economic development and increased access to health care (28). Another done in South Sudan entitled malaria control, strategies, progress and challenges concluded that the prospect of malaria control and elimination is far from over in southern Sudan (7). Weak healthcare systems, poor infrastructures, lack of enough human resource power were among the challenges. Among the two studies, both looked at one country. No study has been done concerning challenges facing malaria elimination in developing countries based on expert opinions (7). The rationale for this study is to review and discuss the literature review of expert opinions on challenges facing malaria elimination in developing countries.

1.7 Aim of the study

The goal of this study is to review the public Health challenges facing malaria elimination in developing countries.

1.8 Specific objective of the study

To determine public health challenges facing malaria elimination in developing countries.

Chapter 2

Method and design

2.1 Research protocol

This research was not registered by any registry. Based on inclusion-exclusion strategy, all articles identified were extracted for the review. The search was implemented, and relevant primary articles were collected for this review.

2.2 Literature search method, strategy and databases

This review is based on secondary data that was published and unpublished in English language and was searched on reputable and recognized web portals like PUBMED, Google Scholar, Cochrane Library and WHO library. The databases were searched to identify the articles for this review. Hand searching was also done to identify articles that could have information for this review. The gray literature search was done to identify unpublished articles for this review. This search was performed in January 2016, and the research search captured the problem, population, place, and period. The interventions of interest which included malaria prevention methods were considered. The search term used where all the same in all databases and these were: malaria prevention strategies, challenges, prevention, public health challenges, malaria infections, malaria disease, Plasmodium falciparum, mosquito infection, last ten years, Humans.

2.3 Inclusion and exclusion of the studies

There were 2484 articles that were retrieved from the primary electronic databases, and two were hand searched which yielded an additional relevance articles. These Articles were systematically screened and excluded for their relevance which reduced the number of articles to 36 articles. This is because many of the articles that were systematically synthesized and identified through the databases had no link on the subject matter, and there was no opinion

from public health experts regarding public health challenges facing malaria elimination in developing countries. When the duplicates were removed, and the full abstracts of the articles were assessed and read for credibility, 15 articles were reviewed and further narrowed to identify the articles that focused on addressing public health challenges facing malaria eliminations in developing countries specifically. This narrowed down the articles to 12 of them. Therefore, twelve articles met the inclusive criteria for the review.

2.3 Inclusion and exclusion criteria

All articles both published and unpublished were considered if they had public health challenges facing Malaria elimination in developing countries. There was language limitation, and only English written literature was considered. Only expert opinion papers were considered in this review. The intervention and areas of focus of interest were challenges facing malaria elimination in developing countries. Other systematic reviews on malaria were excluded as well as cross-sectional, cohorts, qualitative and case controls. All publications from developed countries were excluded because the population of interest was developing countries. Only studies from 2006 to 2015 were considered in this review because the researcher needed the latest information based on limitation criteria. Too many studies had been done before 2006 which was difficult to hand. The research also laid a review limitation from 2006 to 2015 because more preventive studies are being carried out lately to find out public health challenges facing malaria elimination in developing countries.

2.4 Study selection

All the articles were assessed individually while evaluating the topic headline and content from initial review. Articles that were relevant were selected for further review. An independent review used same search terms to identify any literature relevant to the study. All selected articles were checked parallel by a second reviewer, the researcher's advisor.

2.5 Quality assessment

The textual selected papers were retrieved by two independent reviews while including the author. They were appraised using Joanna Briggs Institute methodology of synthesis checklist (JBI-NOTARI) (29). The disagreement among the two reviewers was reached through a consensus. Any decision made during the appraisal was discussed and documented in this review.

2.6 Data analysis method: Meta-aggregation synthesis method

The measurable qualitative findings from experts were different from various sources. This review targeted answering the challenges experienced in the prevention of malaria in developing countries. The answers were only found with the qualitative expert opinion which was different from different perspectives. Although other previous methods depended on synthesis based on Sandelowski methodology of meta-synthesis, this research had opinions from experts which was different (30). The systematic analysis could bring the findings together while preserving complexity but the ability to pool was unavailable (31). The researchers examined overlaps and common elements in all the studies. The opinions from the experts on the topic were expected to be similar or different, and all the similarities were to be merged making the research findings valuable (32). This review did not interpret the findings but explored similarities and differences between collected data from expert's opinions.

The concept of finding the qualitative themes and findings were considered. The phenomena of malaria control have been ongoing for ages. This research was interested in exploring factors affecting malaria elimination in developing countries. Different researchers had views and research findings from different nations, and since malaria control mechanism are similar, it was the best method of aggregating and pooling the findings together.

2.7 Steps in Meta-aggregation synthesis method

Meta-aggregation is a method a systematic review method that shows the processes of a quantitative review but remains to the traditions and requirements of the qualitative research (33). This approach seeks to generate summaries to determine the credibility of the findings of individual studies regarding their practical consequences (34). The Meta aggregation synthesis method applied by the author consisted of three steps: the results, categories, and synthesized finding and lines of action (33).

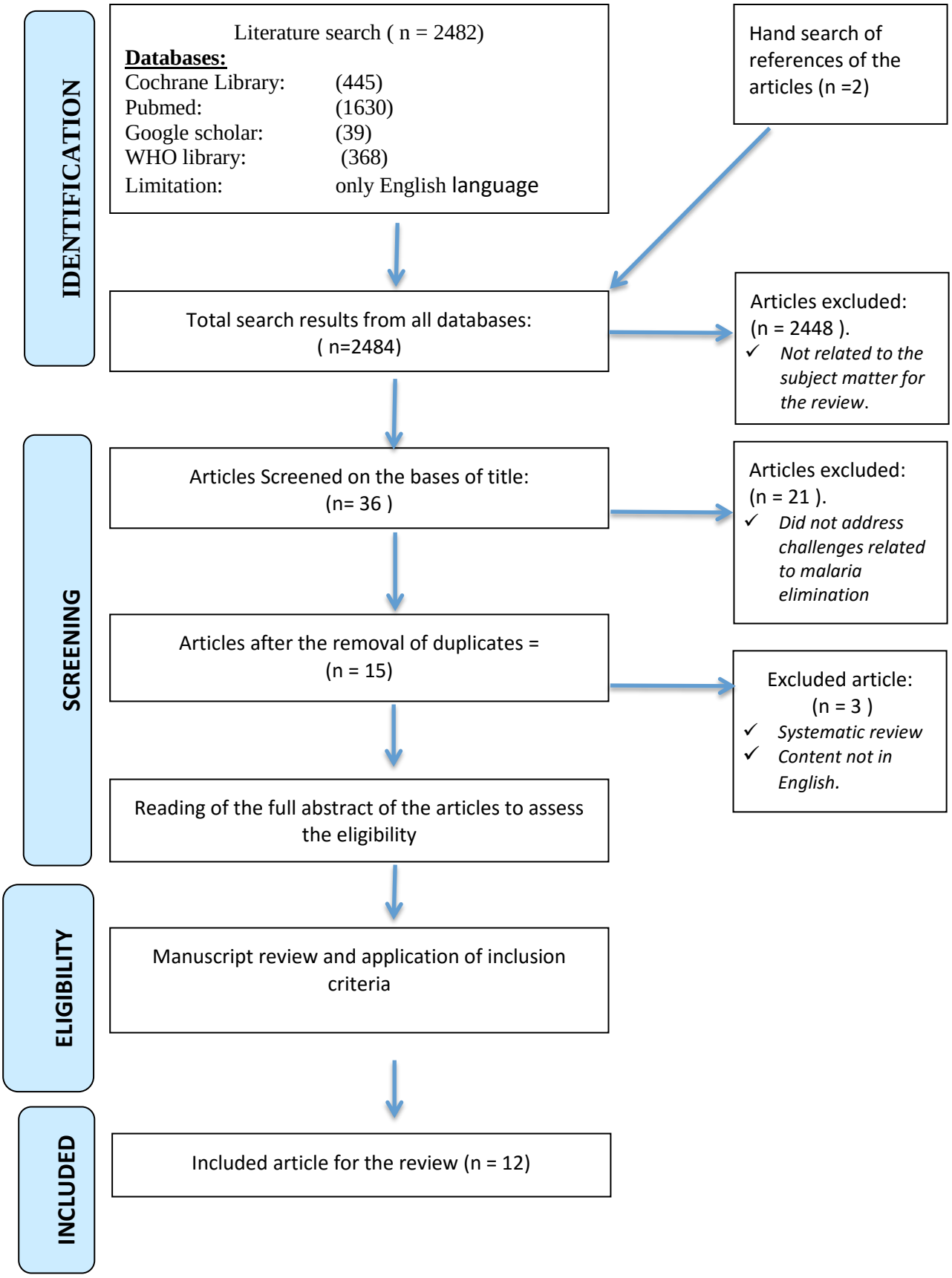
2.8 Extraction

The researcher extracted empirical qualitative findings from the primary studies and judged the ones which were credible. This method was done using an example from Pearson 2004. During the Meta aggregation, the judgment was made on the credibility of each finding by going through all the findings and the results of the included primary studies. This was done to make sure that one the author did not forget the extent contained in the empiric finding (33).

2.9 Categorization and Meta-aggregation

The second stage for Meta aggregation undertaken involved adding empirical findings into categories. This was done by finding out the similarities and differences between the empirical findings. Numbers were used to code similar findings, and all pooled challenges were labeled according to similar grouping (see Table 2). There was relating of a group of empirical findings that had same ideologies. The third level of Meta aggregation was combined with aggregation, and it involved the synthesized findings and lines of action which were an aggregation based on finding the level of credibility.

Figure 2. selection of studies included in the review.



Chapter 3

Research results

3.1 Appraisal outcome

A total of 2484 primary data was identified using search different sites. The researcher went through abstracts retrieving those with the subject of interest. A total of 34 primary data sources were identified and selected, and two more from gray data were hand searched and added as relevant. There were 36 articles in total which were selected for further selection by the researcher, but twenty-one articles were excluded based on inclusion-exclusion criteria stated prior. This is because many of these excluded articles failed to address the core issue of the subject matter and they were irrelevant that they did not address expert opinion on challenges facing malaria elimination in developing countries. There were 15 primary data articles which were further scrutinized by Twelve articles met the appraisal criteria. According to JBI critical appraisal, 12 articles were appraised which met the inclusion criteria. The 12 articles were highly rated with a low level of bias. (35-45).

3.2 Extracted results

Based on extraction criteria of the findings, the twelve articles included were described as Tanzania, India, South Sudan, Haiti, China, South African, Kenya, and Asia. The articles for primary data were authored or edited between 2006 and 2015. Only results and findings were extracted, and a total of 54 challenges were identified. Among them, there were similar and different challenges from the primary data.

Table 1. Extracted data findings

Study authors Year of study	Title of the study	location	Code Number	challenges
Adoke Y., Anne G, et al.: 2012	"Malaria in Uganda: challenges to control on the long road to Elimination. I. Epidemiology and current control efforts."	Uganda	1 2 3 4 5 6 7 3	High malaria transmission intensity. Inadequate health care resources Weaknesses of the health system Inadequate understanding of malaria epidemiology and of the impact and Optimal use of interventions. Increasing resistance of parasites to drugs and of mosquitoes to Insecticides. Inappropriate case management. Inadequate utilization of drugs in malaria prevention Inadequate epidemic preparedness and response
Rajesh B., Rakesh M. Rastogi et al 2013	Malaria successes and challenges in Asia	Asia	5 7	Plasmodium falciparum resistance to artemisinin Counterfeit/substandard drugs and Irrational use of drugs.
Liang C., Guiyun Y., et al 2012	"Challenges and prospects for malaria elimination in the Greater Mekong Sub-region"	Greater Mekong Sub-region, China	4 3 5 4 7	inadequate knowledge of the vector biology and its ecology lack of effective transmission surveillance and control tools parasite resistance to artemisinin drugs The mode of action and the mechanisms of artemisinin resistance are poorly Understood. Counterfeit and substandard artemisinin drugs.
Leonard, E.G., Mboera H., et al 2013	"Towards malaria elimination and its implication for vector control, disease management and livelihoods in Tanzania."	Tanzania	2 5 5 5 2 3 10 6	Loss of protective immunity Patient-provider compliance with Interventions, Misuse of interventions Mosquito resistance Mosquito behavioral changes Parasite resistance Poor Healthcare delivery Weak surveillance system and monitoring and evaluation Inadequate local budget and donor dependency Management of non-malarial fevers lack of community engagement and

				intersectoral collaboration
Emmanuel C., Constantino D., et al 2013	Addressing malaria vector control challenges in South Sudan: proposed recommendations	South Sudan	2 5	lack of infrastructure, human resources Parasite resistance enormous burden of vector-borne diseases including malaria
A P., D., NEENA V., et al 2008	Malaria in India: Challenges and opportunities	India	5 4 1 2 8 9	Insecticide resistance in vectors Drug resistance Lack of information on true disease burden Regular outbreaks in some urban, rural and large project areas Lack of trained manpower and infrastructure at grass root level Clinical misdiagnosis of malaria Counterfeit drugs. Population migration The impact of climate changes on malaria
Leonard E., Mora G., et al., 2007	"Uncertainty in Malaria Control in Tanzania: Crossroads and Challenges for Future Interventions"	Tanzania	6 5 3 4	poor diagnosis for malaria cases drug resistant poor malaria poor surveillance systems socio-economic and human behaviors lack of effective health information regarding malaria
Paul JB, Paul A., et al 2015	Malaria elimination in Haiti by the year 2020: An achievable goal	Haiti	2 8 3 9 4	Poor infrastructures the poor diagnostic system poor surveillance systems large population lack of knowledge about the vector identification
Dev. V., Sharma. V.V., et al., 2009	Malaria Transmission and diseases burden in Assam: challenges and opportunities	Assam, India	6 5 3 8 2 2	poor diagnosis for malaria cases drug resistant poor malaria poor surveillance systems the poor diagnostic system poor record keeping, which should be robust for timely institution of intervention measures. Lack of enough health infrastructures for severe complicated malaria cases.
William J. M., Douglas E. N., et al. 2021	Challenges and Prospects for Malaria Elimination in the Southern Africa Region	Southern Africa	5 5 6 9 4	drug resistant poor malaria change in vector behavior health-related beliefs and practices Human population movement. Inadequate knowledge of the vector biology and its ecology

Githeko.A., EN. O., et al., 2012	Progress towards understanding the ecology and epidemiology of malaria in the western Kenya highlands: opportunities and challenges for control under climate change risk.	Kenya	1 5 3 1 9	climate change insecticide resistance to drugs Poor surveillance. Topography Climate change Human population growth.
Lucille.B., John.F., et al. 2007	Challenges and Prospects for Malaria Elimination in the Southern Africa Region	Souther n Africa	5 10	insecticide- resistance Lack of political donor and community Support.

3.3 Meta- aggregation results

Similar challenges were aggregated, and the final findings were combined as per the synthesis methodology. A total of eleven articles from primary data stated that the major challenge in the fight against malaria was resistance to the drug or the insecticide. There was a total of fourteen responses from the data. The researcher noted that only one primary data source did not explain insecticide and drug resistant to being a challenge.

Surveillance system weakness was noted by six articles with eight responses expressing it as a major reason in Malaria prevention. Primary data indicates that there were inadequate resources with seven responses and five articles giving this as a challenge towards fighting malaria. Lack of information and knowledge was a challenge that made fighting malaria harder as noted by six articles. Poor diagnosis and management of malaria cases were highlighted by five articles while high malaria transmission intensity had four responses and three articles. There were external factors including climate effects were aggregated with three articles from primary data expressing it as a challenge. This research results indicated funding and over dependency on donors and lack of local support to be one of the challenges. However, only one article reported a loss of primary immunity as a challenge in the fight against malaria.

Table 2: Aggregated data and similarities

Aggregated group	Total findings	Authors
Resistance to the drug or insecticide Increasing parasite resistance. Change of mosquito behavior	14	Leonard E., Mora G., et al., 2007, Rajesh B., Rakesh M. Rastogi et al. 2013, Liang C., Guiyun Y., et al. 2012, Leonard, E.G., Mboera H., et al 2013, Emmanuel C., Constantino D., et al. 2013, A P., D., NEENA V., et al. 2008, Leonard E., Mora G., et al., 2007, Dev. V., Sharma. V.V., et al., 2009, William J. M., Douglas E. N., et al. 2021, Githeko.A., EN. O., et al., 2012, Lucille.B., John.F., et al. 2007
Weak Surveillance. Inadequate epidemic preparedness and response. Lack of effective transmission surveillance and control tools	8	Adoke Y., Anne G, et al.: 2012, Liang C., Guiyun Y., et al. 2012, Leonard, E.G., Mboera H., et al. 2013, Leonard E., Mora G., et al., 2007 Paul JB, Paul A.., et al. 2015, Dev. V., Sharma. V.V., et al., 2009, Githeko.A., EN. O., et al., 2012
Inadequate health care resources and infrastructure. Human resource Poor infrastructure Poor healthcare delivery	7	Adoke Y., Anne G, et al.: 2012, Emmanuel C., Constantino D., et al. 2013, Leonard, E.G., Mboera H., et al. 2013, A P., D., NEENA V., et al. 2008, Dev. V., Sharma. V.V., et al., 2009
Luck of knowledge information and understanding of malaria(vector and the parasite) inadequate knowledge of the vector biology and its ecology The mode of action and the Unknown mechanisms of artemisinin resistance are poorly Understood. Lack of information on the true disease.	7	A P., D.,NEENA V., et al 2008, Liang C., Guiyun Y., et al 2012, Adoke Y., Anne G, et al : 2012, Leonard E., Mora G., et al., 2007, Paul JB, Paul A.., et al 2015, William J. M., Douglas E. N., et al. 2021.
Poor diagnosis and management of cases lack of community engagement and inter-sectoral collaboration poor diagnosis for malaria cases	5	Adoke Y., Anne G, et al.: 2012, Leonard, E.G., Mboera H., et al. 2013, Leonard E., Mora G., et al., 2007, Dev. V., Sharma. V.V., et al., 2009 William J. M., Douglas E. N., et al. 2021
High malaria transmission intensity. Regular outbreaks in some urban, rural and large project areas Climate and Topography change	4	Adoke Y., Anne G, et al.: 2012, A P., D., NEENA V., et al. 2008, Githeko.A., EN. O., et al., 2012
External factors of population and climate change The impact of climate changes on malaria. Human population growth and movement.	4	Paul JB, Paul A.., et al. 2015, Githeko.A., EN. O., et al., 2012, William J. M., Douglas E. N., et al. 2021
Drug-related challenges Inadequate utilization of drugs in malaria prevention Counterfeit/substandard drugs and irrational use of drugs	3	Liang C., Guiyun Y., et al 2012, A P., D.,NEENA V., et al 2008
Inadequate local budget and donor dependency	2	Lucille.B., John.F., et al. 2007, Leonard, E.G., Mboera H., et al. 2013

Chapter 4

4.1 Discussion

Malaria elimination in developing countries remains a public health challenge (4).

Among the twelve articles (35-45); all the twelve studies discussed expert opinions on challenges facing malaria elimination in developing countries. Among these studies, one challenge dominated all the twelve articles “insecticide resistance to artemisinin drugs” and insecticide used to kill the vectors. WHO define artemisinin resistance as a delayed parasite clearance that in turn represents a partial resistance that so far affects only ring-stage parasites. Malaria is resistant to all affordable and available antimalarial drugs, and this remains one among the biggest challenge to the entire developing world (35-45).

According to the WHO, two methods (LLINs and ACT) have been used as the best method for malaria control and prevention of disease, and this is supported by IRS(46). These methods have been shown to be crucial in reducing malaria infection but cannot necessarily lead to the elimination of malaria. Despite the increased supply of LLINs, ACT, and IRS in most countries and more especially in Africa, the targeted set number of 80% as recommended by WHO is far below for malaria control and prevention, and this remains one among the challenges facing malaria control (46). There is the procurement of antimalarial medicine through the public health services, but the access to treatment especially of ACT was inadequate in most or all countries (46). According to the housing survey and data obtained by WHO from the national malaria control programs (NMCPs), the coverage of disease intervention in most countries especially in Africa is below the 80% target set by WHO, and this is the biggest challenge for malaria eliminations (46). The Roll Back Malaria initiative was launched and defined by WHO as a tool for moving intervention coverage targets for control of disease as a public health problem (47). This tool emphasizes the strengthening of the local health systems through increased resources through the Global

Fund and the World Bank (47, 48). Despite such effort, however, malaria elimination remain a formidable challenge as elimination in most countries and more especially the African countries is far from over due to poor elimination tools (47, 48)

A qualitative study done in Iran on malaria elimination, importance, and challenges found that equity in reaching the poorest places within the country, lowering the cost of malaria control and the effect of the socioeconomic condition of the poor region was a problem for malaria elimination (49). The study also highlighted a successful story of ME in some countries like Taiwan and Lebanon showing that ME does not depend on the economic status of the country looking at Iran. Iran has the better economic condition than Lebanon and Taiwan yet ME is still a challenge (49). However, the study also noted that high cost of malaria elimination is one among the challenges facing Iran. Much as there has been a decline in parasite reservoir, the necessity for spraying of the insecticides has decreased because of high cost, and this remains a factor affecting malaria elimination.

Surveillance system weakness was noted as a second most challenge towards fighting malaria in developing countries in this study (35-45). Surveillance systems are responsible for the collection of data, analyze data, and interpret data to generate analysis for the biological agents of the diseases and is done to provide information for decision-making (50). According to the WHO, surveillance is the most fundamental factor for malaria elimination. In this study weak public health surveillance systems dominates as a factor affecting malaria elimination in developing nations (35-45).

World health organization had identified malaria in 2000 as a threat to global development and selected malaria as a critical target of the millennium development goals to be eliminated by 2015. This period passed, and still malaria remains a big public health problem for elimination.

Many studies have projected that climate is one of the problems affecting the elimination of malaria in developing countries. With the change of global climate, Malaria transmission will increase in Africa (51) However, the connection between disease outbreak and the climate change happening at the same time is hotly disputed (52-54). The increase in parasite resistance to the front-line drugs for malaria prevention like LLINs and IRS, poverty and the decline in access to health services outlined as the causes affecting the elimination of malaria and its increase in developing countries mores especially in the countries of the SSA(55, 56).

Malaria prevention continues to lag behind in many countries especially in the SSA simply because of the climatically conditions with that favors the parasites which depend on the environmental temperatures that are driven by the warmth (54). The SSA lies in the areas of the tropical climate that favors malaria prevalence in the region, and this makes malaria elimination difficult, and this is why 90% of malaria deaths happen in the region of the SSA.

The challenge is that the continuing burden of malaria continues whereby, in 2015, an estimated 214 million cases of malaria happened and about 438,000 people die of the disease. This review has predominantly noted the resistance of insecticides as a major challenge facing malaria elimination in developing countries (35-45). WHO had noted that malaria control heavily relies on a single pesticide class which is pyrethroids which are used in LLINs and applied in IRS programs but the insecticide resistant to such preventive measures has developed which has increased the intensity of malaria distribution (4).

Poor diagnosis and management of the disease are reported in most research done. Recent studies regarding malaria misdiagnosis entitled the effect on the poor and vulnerable (57), has noted that the efficient and affordable treatment was recommended for all of the malaria cases within hours of the onset illness. In developing countries, most malaria cases are self-diagnosed and treated at home.

Even though it is cost effective to improve the accuracy of disease diagnosis, simple, accurate, affordable, and cheaper methods are not available, in most poor communities of the developing countries (57).

In SSA, over 70% of malaria cases are not performed at the health facilities but rather diagnose and manage at home (57). Poor diagnosis is one of the reasons preventing malaria elimination in developing countries. People can only attend health centers after self-inflicted-treatment fails, and even then they do not receive a good-quality diagnosis (57).

This study also discusses Funding, over dependency on donors, and lack of local support as the factors affecting malaria elimination in developing countries

4.2 Strength and weaknesses of this review.

The sources of the data for this analysis were Journal articles that were manually searched on a topic relevant to the subject matter "challenges facing malaria elimination in developing countries". This was done through a systematic search on reputable electronic databases like; PUBMED, GOOGLE SCHOCOLAR, GRAY and a consultation from WHO website. The broad search of expert opinions gave the findings needed strength as the fight against malaria strategies have more of technical aspect and public health concern. This study is based only on opinions of experts.

Chapter 5

5.1 Conclusion.

This study was conducted to highlighted public Health challenges facing malaria elimination in developing countries. The study was based on 12 selected articles authored by public health expertise to examine challenges facing the elimination of malaria in developing countries. The findings of this study have confirmed that Parasite-resistant to drugs or insecticides resistance to malaria drugs is the main reason and challenge why elimination of malaria is far from over among the developing malaria endemic countries. This study has further noted that a weak surveillance systems, Inadequate health care resources and infrastructure, lack of knowledge on information and understanding of malaria vectors and the parasites, high malaria transmission intensity, external factor of population and climate change, drug- related challenges among others, are the key challenges facing the elimination of the disease.

5.2 RECOMMENDATION

More research must be done to find out on failures and successes of malaria elimination on countries fighting to eradicate the disease and get lessons from other countries that are malaria-free how they succeeded to eliminate malaria.

Developing countries must seek for technical help and put more resources and investments in infrastructure, more in public health sectors to fight and support malaria elimination.

The developing countries must collaboration with developed countries to seek knowledge and coordinate on how to develop more research on developing new insecticides to fight against malaria transmission.

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LIST OF FIGURES

Figure 1. World map showing malaria distribution

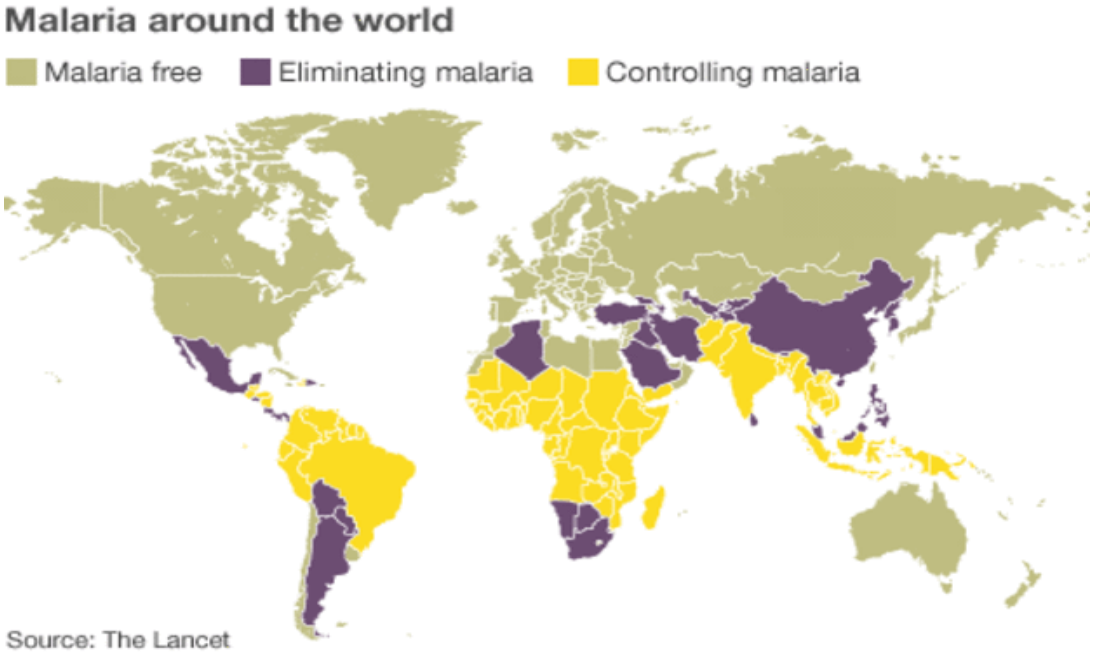
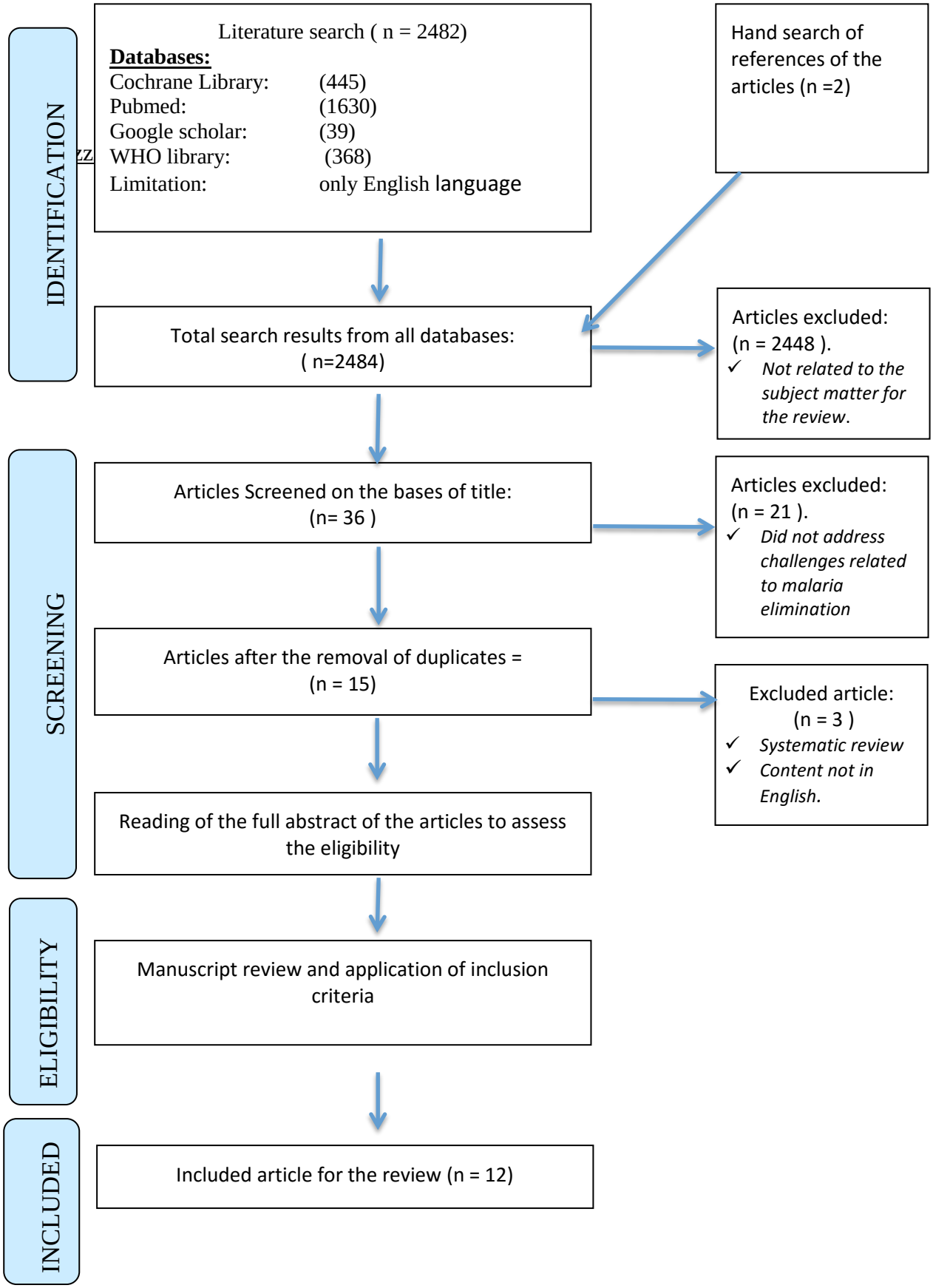


Figure 2 . Selection of studies included in the review.



LIST OF TABLES

Table 1. Extracted data findings

Study authors Year of study	Title of the study	location	Code Number	challenges
Adoke Y., Anne G, et al.: 2012	"Malaria in Uganda: challenges to control on the long road to Elimination. I. Epidemiology and current control efforts."	Uganda	1 2 3 4 5 6 7 3	High malaria transmission intensity. Inadequate health care resources Weaknesses of the health system Inadequate understanding of malaria epidemiology and of the impact and Optimal use of interventions. Increasing resistance of parasites to drugs and of mosquitoes to Insecticides. Inappropriate case management. Inadequate utilization of drugs in malaria prevention Inadequate epidemic preparedness and response
Rajesh B., Rakesh M. Rastogi et al 2013	Malaria successes and challenges in Asia	Asia	5 7	Plasmodium falciparum resistance to artemisinin Counterfeit/substandard drugs and Irrational use of drugs.
Liang C., Guiyun Y., et al 2012	"Challenges and prospects for malaria elimination in the Greater Mekong Sub-region"	Greater Mekong Sub-region, China	4 3 5 4 7	inadequate knowledge of the vector biology and its ecology lack of effective transmission surveillance and control tools parasite resistance to artemisinin drugs The mode of action and the mechanisms of artemisinin resistance are poorly Understood. Counterfeit and substandard artemisinin drugs.
Leonard, E.G., Mboera H., et al 2013	"Towards malaria elimination and its implication for vector control, disease management and livelihoods in Tanzania."	Tanzania	2 5 5 5 2 3 10	Loss of protective immunity Patient-provider compliance with Interventions, Misuse of interventions Mosquito resistance Mosquito behavioral changes Parasite resistance Poor Healthcare delivery Weak surveillance system and monitoring and evaluation Inadequate local budget and donor dependency

			6	Management of non-malarial fevers lack of community engagement and intersectoral collaboration
Emmanuel C., Constantino D., et al 2013	Addressing malaria vector control challenges in South Sudan: proposed recommendations	South Sudan	25	lack of infrastructure, human resources Parasite resistance enormous burden of vector-borne diseases including malaria
A P., D., NEENA V., et al 2008	Malaria in India: Challenges and opportunities	India	5 4 1 2 8 9	Insecticide resistance in vectors Drug resistance Lack of information on true disease burden Regular outbreaks in some urban, rural and large project areas Lack of trained manpower and infrastructure at grass root level Clinical misdiagnosis of malaria Counterfeit drugs. Population migration The impact of climate changes on malaria
Leonard E., Mora G., et al., 2007	"Uncertainty in Malaria Control in Tanzania: Crossroads and Challenges for Future Interventions"	Tanzania	6 5 3 4	poor diagnosis for malaria cases drug resistant poor malaria poor surveillance systems socio-economic and human behaviors lack of effective health information regarding malaria
Paul JB, Paul A., et al 2015	Malaria elimination in Haiti by the year 2020: An achievable goal	Haiti	2 8 3 9 4	Poor infrastructures the poor diagnostic system poor surveillance systems large population lack of knowledge about the vector identification
Dev. V., Sharma. V.V., et al., 2009	Malaria Transmission and diseases burden in Assam: challenges and opportunities	Assam, India	6 5 3 8 2 2	poor diagnosis for malaria cases drug resistant poor malaria poor surveillance systems the poor diagnostic system poor record keeping, which should be robust for timely institution of intervention measures. Lack of enough health infrastructures for severe complicated malaria cases.
William J. M., Douglas E. N., et al. 2021	Challenges and Prospects for Malaria Elimination in the Southern Africa Region	Southern Africa	5 5 6 9 4	drug resistant poor malaria change in vector behavior health-related beliefs and practices Human population movement. Inadequate knowledge of the vector

				biology and its ecology
Githeko.A., EN. O., et al., 2012	Progress towards understanding the ecology and epidemiology of malaria in the western Kenya highlands: opportunities and challenges for control under climate change risk.	Kenya	1 5 3 1 9	climate change insecticide resistance to drugs Poor surveillance. Topography Climate change Human population growth.
Lucille.B., John.F., et al. 2007	Challenges and Prospects for Malaria Elimination in the Southern Africa Region	Souther n Africa	5 10	insecticide- resistance Lack of political donor and community Support.

Table 2. Aggregated data and similarities

Aggregated group	Total findings	Authors
Resistance to the drug or insecticide Increasing parasite resistance. Change of mosquito behavior	14	Leonard E., Mora G., et al., 2007, Rajesh B., Rakesh M. Rastogi et al. 2013, Liang C., Guiyun Y., et al. 2012, Leonard, E.G., Mboera H., et al 2013, Emmanuel C., Constantino D., et al. 2013, A P., D., NEENA V., et al. 2008, Leonard E., Mora G., et al., 2007, Dev. V., Sharma. V.V., et al., 2009, William J. M., Douglas E. N., et al. 2021, Githeko.A., EN. O., et al., 2012, Lucille.B., John.F., et al. 2007
Weak Surveillance. Inadequate epidemic preparedness and response. Lack of effective transmission surveillance and control tools	8	Adoke Y., Anne G, et al.: 2012, Liang C., Guiyun Y., et al. 2012, Leonard, E.G., Mboera H., et al. 2013, Leonard E., Mora G., et al., 2007 Paul JB, Paul A.., et al. 2015, Dev. V., Sharma. V.V., et al., 2009, Githeko.A., EN. O., et al., 2012
Inadequate health care resources and infrastructure. Human resource Poor infrastructure Poor healthcare delivery	7	Adoke Y., Anne G, et al.: 2012, Emmanuel C., Constantino D., et al. 2013, Leonard, E.G., Mboera H., et al. 2013, A P., D., NEENA V., et al. 2008, Dev. V., Sharma. V.V., et al., 2009
Luck of knowledge information and understanding of malaria(vector and the parasite) inadequate knowledge of the vector biology and its ecology The mode of action and the Unknown mechanisms of artemisinin resistance are poorly Understood. Lack of information on the true disease.	7	A P., D.,NEENA V., et al 2008, Liang C., Guiyun Y., et al 2012, Adoke Y., Anne G, et al : 2012, Leonard E., Mora G., et al., 2007, Paul JB, Paul A.., et al 2015, William J. M., Douglas E. N., et al. 2021.
Poor diagnosis and management of cases lack of community engagement and inter-sectoral collaboration poor diagnosis for malaria cases	5	Adoke Y., Anne G, et al.: 2012, Leonard, E.G., Mboera H., et al. 2013, Leonard E., Mora G., et al., 2007, Dev. V., Sharma. V.V., et al., 2009 William J. M., Douglas E. N., et al. 2021
High malaria transmission intensity. Regular outbreaks in some urban, rural and large project areas Climate and Topography change	4	Adoke Y., Anne G, et al.: 2012, A P., D., NEENA V., et al. 2008, Githeko.A., EN. O., et al., 2012
External factors of population and climate change The impact of climate changes on malaria. Human population growth and movement.	4	Paul JB, Paul A.., et al. 2015, Githeko.A., EN. O., et al., 2012, William J. M., Douglas E. N., et al. 2021
Drug-related challenges Inadequate utilization of drugs in malaria prevention Counterfeit/substandard drugs and irrational use of drugs	3	Liang C., Guiyun Y., et al 2012, A P., D.,NEENA V., et al 2008
Inadequate local budget and donor dependency	2	Lucille.B., John.F., et al. 2007, Leonard, E.G., Mboera H., et al. 2013