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Integrated Approach to the Control of Lymphatic Filariasis, Schistosomiasis, and Soil-Transmitted Helminthiasis in Liberia, West Africa

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DECLARATION

I declare that this research is my original work and it has not been presented for the award of a degree at any other university. I wish to acknowledge support staff at the Ministry of Health, Neglected Tropical Diseases Unit and laboratory technicians at the Ministry of Health who participated in the collection of my data during the fieldwork reported here. At my selected schools, principals and schoolteachers were present and they helped me organize and supervise the school children during the surveys.

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Louise Cleopatra Mapleh Kpoto **Signed:**  **Date:** 5 May 2020

ABSTRACT

In Liberia, the most common neglected tropical diseases (NTDs) are: lymphatic filariasis (LF); schistosomiasis (SCH); soil-transmitted helminthiasis (STH); and onchocerciasis (Oncho). My research sought to explore an integrated approach for the control of these NTDs to assist the Ministry of Health (MoH) in establishing a better co-ordinated, economical and cost-effective intervention. As a result of my research, the MoH, in collaboration with the Centre for Neglected Tropical Diseases (CNTD) at the Liverpool School of Tropical Medicine, progressively unified the disease-specific vertical programmes into a single umbrella, entitled: 'The Integrated NTDs Programme'**.** Previously, Oncho control was the only tropical disease programme established within the MoH and acted as a stand-alone. Steps towards integration were first tailored upon the existing vertical delivery mechanisms for Oncho i.e., Community-Directed Treatment with Ivermectin (CDTI) through existing drug distribution networks and school-based programmes.

The aim of my study was to develop and implement an integrated strategy for LF, SCH and STH first using the CDTI Oncho networks to obtain data on the prevalence and risk factors for these diseases simultaneously. During my study period, certain activities within the MoH were suspended due to the emergency response to the Ebola epidemic. This eventually led my thesis to be structured into two parts, pre- and post-epidemic. **Pre-epidemic – *LF:*** The first national baseline disease mapping by immunochromatographic test (ICT) cards and baseline microfilaria pre-Mass Drug Administration (MDA) in Liberia. This provided epidemiological data for the entire country, which was used by the MoH to identify implementation units for MDA. The overall ICT prevalence was 24.0% with the highest percentage prevalence observed in the coastal region. The study also revealed that LF was endemic in 13 out of the 15 counties in Liberia. The baseline microfilaria result reported, in the study, a 6.0% prevalence rate. A total of 1,498 men were examined for the clinical manifestation of the disease, of which, 12.0% hydrocele and 6.0% lymphoedema cases were observed. A population-based knowledge and compliance study on LF was carried out in Bong County. Analysis of the results showed that more than 60.0% of the participants were aware of the disease, but only 43.0% of the participants admitted to taking both Albendazole and Ivermectin, demonstrating low treatment coverage, even though 50.0% of the participants knew the mode of LF transmission. **Post-epidemic – *STH***

and SCH: Parastiological surveillance studies were undertaken in Bong County as a representative epidemiological indicator for the national control programme to provide up-to-date information on SCH and STH. An epidemiological update on urogenital and intestinal SCH was undertaken amongst schoolchildren in Bong County, northern Liberia alongside observations on STH. A cross-sectional study examined 1,003 school-aged children from 10 schools representing eight health districts in the country where MDA campaigns were ongoing. In total, 12.0% of the children were infected with *Schistosoma mansoni* and 11.0% infected with *Schistosoma haematobium,* while general prevalence of STH was much lower with hookworm having the highest prevalence of 3.0%. For the first time, a knowledge attitude and practices survey for SCH, LF and STH was assessed amongst school-aged children in Bong County, northern Liberia, which highlighted the need for better health education and improved sanitation. For example, analysis of data demonstrated that from the 1,003 participants 92.0% had not heard of LF, 86.0% had not heard of STH, and 90.0% had not heard of SCH. Only 9.0% of participants had access to pipe water. To investigate the morbidity associated with SCH, a cross-sectional assessment using portable ultrasound was undertaken, which was the first ever field-based investigation in Liberia. Of the 272 school-aged children examined, morbidity was low (<1.0%) demonstrating little clinical moribidity in this school-based setting.My research was activated and first guided by recommendations from the World Health Organization (Global Plan to Combat NTDs, 2008–2015) to examine ways in which interventions against NTDs could be better co-ordinated and streamlined. The concept of integrated NTD control is attractive in resource poor settings such as Liberia as it can rationalize costs associated with logistics, staffing, and also better delivery of medicines. My research suggests that, the integrated approach to controlling NTDs is possible, cost-effective, and less time consuming. The recommendations made are that, the integrated NTDs programme at the MoH should collaborate with other health service programmes at the MoH, the Ministry of Education, the Liberia water and sewer company, the National Drug Service, and other relevant stakeholders in order to achieve its goal and produce more maintainable impact. The conclusions are that, an integrated disease programme should strengthen and not threaten or compromise the current efforts to efficiently co-ordinate, reduce, eliminate, and ultimately eradicate specific diseases within the NTDs.

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I feel privileged to have had the opportunity to carry out this study as a demonstration of knowledge gained during the period studying for my PhD. It would be impossible not to remember those who in one way or another, directly or indirectly, played a role in the realisation of this research project. Let me therefore thank them all equally. First, I am indebted to the all-powerful GOD for all the blessings He showered me and for being with me throughout my studies. Second, to my supervisors Professor Russell Stothard and Dr Benjamin Koudou – many thanks for your exemplary monitoring and support – this project would not have been a success without your help. My very special thanks and appreciation also goes to the entire Liverpool School of Tropical Medicine, Centre for Neglected Tropical Diseases team. Third, I take this opportunity to express my deep gratitude to my family, and friends who are a constant source of motivation and for their never-ending support and encouragement. Fourth, to the Neglected Tropical Diseases unit of the Ministry of Health headed by Mr Karsor Kollie – I am forever grateful. Finally, to my hard-working research assistants Mrs Lasee Kolee, Mr Stephen M. Gbanyan, Jr. and Mr Mark Zayzay – many thanks.

DEDICATION

This research project is dedicated to my husband Professor Robert M. Kpoto for the unwavering support he rendered me during the course of my study and to all the health care workers who died during the Ebola outbreak in Liberia. To my children Terelouti B. Krangar, Lewis Mapleh, and Rene L. M. Kpoto, I am passing the baton to you all.

THESIS LAYOUT

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LIST OF ACRONYMS

ADLA	Acute dermato-lymphangio-adenitis
AOR	Adjusted odds ratio
APOC	African Programme for Onchocerciasis Control
BPHS	Basic Package of Health Services
CDC	Centers for Disease Control and Prevention
CDD	Community drug distributor
CDTI	Community-Directed Treatment with Ivermectin
CFA	Circulating filarial antigen
CI	Confidence interval
CNTD	Centre for Neglected Tropical Diseases
COR	Crude odds ratio
DALY	Disability-adjusted life year
DEC	Diethylcarbamazine
DNA	Deoxyribonucleic acid
ELISA	Enzyme-Linked Immuno-Sorbent Assay
EPHS	Essential Package of Health Services
EVD	Ebola virus disease
FGS	Female Genital Schistosomiasis
GDP	Gross domestic product
GPELF	Global Programme to Eliminate Lymphatic Filariasis
GPS	Global Positioning System
HIV	Human immunodeficiency virus
ICT	Immunochromatographic test
IDSR	Integrated Diseases Surveillance and Response System
IHR	International Health Regulation
IQR	Interquartile range
ITN	Insecticide-treated net
IU	Implementation unit
KAP	Knowldege, Attitude and Practice
LF	Lymphatic filariasis
LIBR	Liberian Institute for Biomedical Research
LSTM	Liverpool School of Tropical Medicine
MDA	Mass Drug Administration
MoH	Ministry of Health
NCBI	National Center for Biotechnology Information
NTD	Neglected tropical disease
Oncho	Onchocerciasis
PCR	Polymerase chain reaction
SCH	Schistosomiasis
SD	Standard deviation
STD	Sexually transmitted disease
STH	Soil-transmitted helminthiasis
TAS	Transmission Assessment Survey
UNDP	United Nations Development Programme

UNICEF	United Nations Children’s Fund
UNMEER	United Nations Mission for Ebola Emergency Response
USIN	Unique study identification number
WHO	World Health Organization

CHAPTER 1: BACKGROUND

1.1 Introduction

Neglected tropical diseases (NTDs) are a varied group of parasitic, fungal, viral and bacterial envenomicing diseases that prevail in tropical and subtropical conditions. NTDs are found in approximately 149 countries globally and affect an estimated 1.4 billion of the world's poorest people. It is referred to as the 'accent afflictions'. NTDs are often associated with significant physical debilitation that results in lower economic productivity and social ostracism (Hotez, Ottesen, Fenwick, & Molyneux, 2006; Hotez, Fenwick, Savioli, & Molyneux, 2009). In recent years, a number of NTDs have been targeted for control or elimination, with some as early as 2020 (WHO, 2012a).

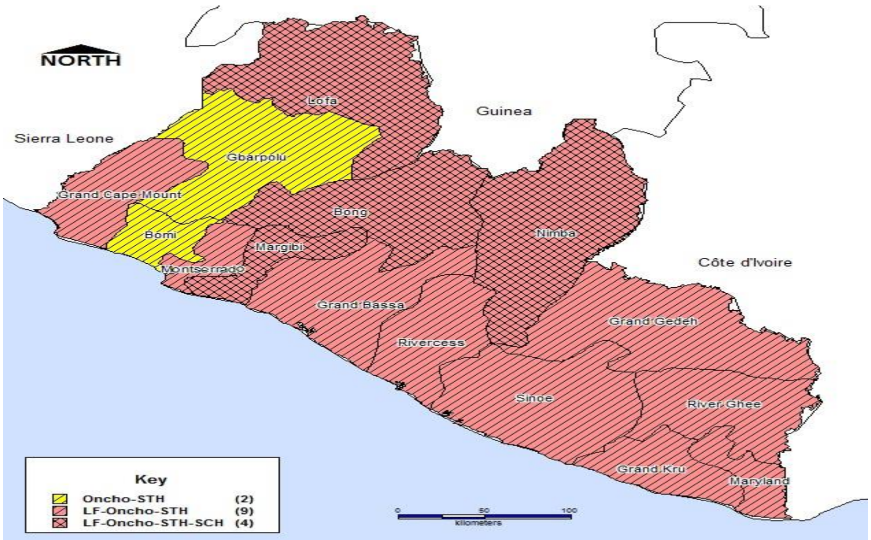
With the help of international partners, some endemic countries are now demonstrating strong ownership and leadership, in variable financial, political and environmental circumstances, to ensure their NTD programmes are successful in meeting 2020 targets, which is inspired by the World Health Organization (WHO) 2011 roadmap on NTDs (WHO, 2011a). Some countries are achieving elimination goals, more people are being reached, and the drug donation programme for NTDs, which is the largest public health drug donation programme in the world, continues to grow (Molyneux, 2004).

In most countries that had started Mass Drug Administration (MDA), efforts to prevent and treat NTDs was through disease-specific programmes that were funded through myriad sources at international level. Strategies for the different NTD programmes were not co-ordinated well to best harmonise activities and resources, and the international donor funding similarly lacked a macro strategy.

To address these shortcomings, the global NTDs community in May 2013, at the sixty-sixth World Health Assembly adopted Resolution WHA66.12 on NTDs to call on Member States to intensify and integrate measures and plan investment to improve the health and social well-being of affected populations (WHO, 2013a). This approach would be unlike the traditional vertical approach, which targeted specific diseases.

An integrated approach for the NTDs takes into consideration that all of these diseases in a particular country can be incorporated into a single programme, this could potentially make implementation easier and could facilitate an increase in the efficiencies of the delivery of drugs in a co-ordinated fashion and would lead to better costeffectiveness in an already resource-stretched country. It is very important to integrate these diseases because they demonstrate geographical overlap. In addition, drugs used as preventive chemotherapy also treat other diseases, different than those they were targeted against (Molyneux, Hotez, & Fenwick, 2005). It cannot also be over-emphasised that integration reduces cost for the country (Conteh, Engels, & Molyneux, 2010).

Figure 1.1: Overlapping of four of the most common NTDs in Liberia



Source: MoHSW (2017a).

Table 1.1: Four of the most common NTDs co-endemicity in Liberia, by counties

NTDs Counties (+) = present in county (–) = absent in county

	LF	Oncho	STH	SCH
Bomi	–	+	+	–
Bong	+	+	+	+
Grand Bassa	+	+	+	–
Grand Cape Mount	+	+	+	–
Grand Gedeh	+	+	+	–
Grand Kru	+	+	+	–
Lofa	+	+	+	+
Margibi	+	+	+	+
Maryland	+	+	+	–
Montserrado	+	+	+	–
Nimba	+	+	+	+
Rivercess	+	+	+	–
Sinoe	+	+	+	–
River Gee	+	+	+	–
Gbarbolu	–	+	+	–

Source: MoHSW (2017a).

The present integrated strategy promoted by WHO to control NTDs including schistosomiasis (SCH), onchocerciasis (Oncho), lymphatic filariasis (LF) and soiltransmitted helminthiasis (STH) that are amenable to MDA was adopted by the Ministry of Health (MoH) Liberia in 2011, at the inception of the integrated NTD programme at the MoH. However, baseline data from mapping of NTDs in Liberia indicated that there is a high prevalence and overlap of the four most common NTDs in the country: Oncho,

LF, SCH and STH see Figure 1 and Table 1.1

According to the WHO tenth meeting of the Strategic and Technical Advisory Group for NTDs held in 2017, there are 20 NTDs in the world (WHO, 2017a):

1. *Buruli ulcer*
2. *Chagas disease (American trypansomiasis)*
3. *Cutaneous leishmaniasis and cisceral leishmaniasis*
4. *Dengue/Chikungumya*
5. *Echinococcus*

6. *Foodborne trematode infections*
7. *Guinea worm (Dracunculiasis)*
8. *Human African trypanosomiasis*
9. *Leprosy (Hansen disease)*
10. *LF (elephantiasis)*
11. *Mycetoma, chromoblastomycosis and other deep mycoses*
12. *Oncho (river blindness)*
13. *Rabies*
14. *Scabies and other ectoparasites*
15. *SCH (Bilharzia)*
16. *Snakebite envenoming*
17. *STH*
18. *Taeniasis and cysticercosis*
19. *Trachoma (preventable blindness)*
20. *Yaws (Endemic treponematoses)*

While some of the NTDs can be controllable by MDA, others require individual treatment. The NTDs that can be controlled by MDA is as follows: STH; SCH; LF (elephantiasis); Oncho (river blindness); and trachoma (preventable blindness). Guinea worm can be controlled by clean drinking water. NTDs that can be treated on an individual basis are as follows: leprosy; Buruli ulcer; Chagas disease; human African trypanosomiasis; Cutaneous Leishmaniasis; Visceral Leishmaniasis; and Dengue. The zoonotic parasitic diseases are Neurocysticercosis, and *Echinococcus*. Animals that serve as a reservoir for NTDs are: Brucellosis and rabies (Keenan, et al., 2013). The greatest burden of the disease can be found in sub-Saharan Africa (see Table 1.2)

Table 1.2: Prevalent cases of NTDs in 2013 and percent change from 1990 to 2013 according to Global Burden of Disease Study (GBD) 2013

Disease	**Prevalent cases (in millions) in 2013**	**Percent change since 1990**
Ascariasis	804.4	-25.5%
Trichuriasis	477.4	-11.6%
Hookworm	471.8	-5.1%
Schistosomiasis	290.6	30.9%
Foodborne trematodiases	80.2	51.1%
Dengue*+	58.4	610.9%
Lymphatic filariasis	43.9	-32.1%
Onchocerciasis	17	-31.2%
Chagas disease	9.4	22.4%
Cutaneous/mucocutaneous leishamaniasis	3.9	174.2%
Trachoma+	2.4	-39.2%
Cysticercosis+	1	-26.3%
Cystic echinococcosis+	0.8	-15.4%
Leprosy	0.7	61.3%
Visceral leishmaniasis	0.7	35.1%
Rabies*+	0.02	-40.4%
African trypanossomiasis	0.02	-71.1%
Other NTDs	59.7	-5.0%
Total Cases	**2322**	**NA**
Additional NTDs	**Prevalent (in millions) in cases 2013**	**Percentage change since 1990**
Trichomoniasis	67.1	45.6%
Scabies	66.1	24.8%
Typhoid fever*	11	-19.9%
Paratyphiod fever*	6.4	-27.9%

Venomous animal contact*	5.5	-2.7%
Cholera*	2.3	6.1%
Cryptosporidiosis*	1.4	-19.4%
Amoebiasis*	0.4	17.0%
Total cases of additional neglected diseases	**160.2**	**NA**

* Incident cases in 2013 rather than prevalent cases.

\+ Symptomatic cases only.

NOTE: For information on percent change calculations, see GBD 2013 capstone paper on incidence, prevalence, and years lived with disability (YLDs) [3]. All data presented in this table (except for rabies, cholera, cryptosporidiosis, and ameoebiasis) are also available from the instutite for Health Metrics and Evaluation (IHME) website and were previously published [3]. **Abbreviations:** NA, non-applicable. https://doi.org/10.1371/journal.pntd.0005424.t001

At the time when this thesis started in 2010, there was no NTD programme in Liberia, the only vertical NTD programme that was being implemented in the country was for Oncho, where there was community-directed efforts for control of Oncho using Ivermectin. This PhD thesis served as an eye opener to the MoH on the NTDs to initiate and fast track an integrated NTD programme. Table 1.3 gives the disease burden and disability-adjusted life years (DALYs) in sub-Saharan Africa resulting from NTDs.

Table 1.3: Disease burden (DALYs) in sub-Saharan Africa resulting from the NTDs (global burden of disease study)

NTD	**DALYs (in millions) in 2013**	**Percent change for DALYs 2005-2013**	**YLDs (in millions) in 2013**	**YLLS (in millions) in 2013**
Visceral leishmaniasis	4.24	8.7%	0.008	4.23
Foodborne trematodiases	3.63	14.6%	3.63	0
Schistosomiasis	3.06	-13.9%	2.86	0.2
Hookworm	2.18	-0.5%	2.18	0
Lymphatic filariasis	2.02	-14.3%	2.02	0
Ascariasis	1.27	-29.0%	0.93	0.34

Rabies	1.24	-14.6%	0.0001	1.24
Onchocerciasis	1.18	-19.4%	1.18	0
Dengue	1.14	17.0%	0.56	0.58
Trichuriasis	0.58	-12.3%	0.58	0
African trypanossomiasis	0.39	-54.3%	0.005	0.38
Chagas disease	0.34	4.6%	0.1	0.24
Cysticercosis	0.34	-16.4%	0.31	0.03
Cystic echinococcosis	0.18	-14.1%	0.08	0.1
Trachoma	0.17	-18.1%	0.17	0
Cutaneous and mucocutaneous leishamaniasis	0.04	35.9%	0.04	0
Leprosy	0.04	8.6%	0.04	0
Other NTDs	3.13	-11.8%	2.26	0.87
Total NTDs	**25.17**	**NA**	**16.95**	**8.21**
Additional neglected diseases	**DALYs (in millions) in 2013**	**Percent change DALYs for 2005-2013**	**YLDs (in millions) in 2013**	**YLLs (in millions) in 2013**
Typhoid fever	11.13	-13.7%	0.16	10.97
Cholera	5.17	20.1	0.04	5.13
Parathphoid fever	3.82	-8.0%	0.04	3.78
Cryptosporidiosis	3.46	-29.6	0.19	3.27
Venomous animal contact	3	-3.4%	0.15	2.85
Scabies	1.71	4.8%	1.71	0
Amoebiasis	0.38	-23.8%	0.04	0.34
Trichomoniasis	0.11	8.2%	0.11	0
Total deaths from additional neglected diseases	28.78	NA	2.44	26.34

NOTE: For information on percent change calculations, see Global Burden on Disease (GBD 2013) capstone paper DALY [2]. The estimates presented in this tables are all are also available from the Instutite for Health Metrics and Evaluation (IHME) website and were previously published in [2-4]. Information on DALYs and YLDs for cholera, Cryptosporidiosis, and Amoebiasis is not available from IHME website or capestone papers. **Abbreviations:** NA, non-applicable.

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1.2 Objectives

To optimise the current strategies to an integrated approach for the control of NTDs in a post-conflict country and develop a platform for monitoring and evaluation of these diseases in a cost-effective manner.

1.2.1 Specific objectives

- To assess the geographical distribution and prevalence of LF in Liberia.
- To develop an integrated map of LF, SCH and STH.
- To determine the morbidity due to SCH in school-aged children in Bong County by the use of ultrasound.

1.3 General methods

The methodology used for the review of historical data on the distribution and epidemiology of *Wuchereria bancrofti* was based on a systematic review of the literature in four electronic databases and 17 articles were selected to be included in the study. For the study on the baseline mapping of LF the methodology used was that as described in the WHO guidelines for preparing and implementing a national plan to eliminate LF (WHO, 2000a) and WHO operational guidelines for rapid mapping of Bancroftian filariasis in Africa (WHO, 2000b).

For the epidemiology, update started with studies on urogenital and intestinal SCH with observations on STH with a cross-sectional study of 10 schools in Bong County, northern Liberia, were investigated using the Kato-Katz method. A semistructured questionnaire was used to access the knowledge, attitude and practice (KAP) towards STH, SCH and LF amongst school-aged children in Bong County, northern Liberia. For the ultrasound study a Mindary diagnostic system ultrasound Model MS

MR-17003578 with a convex transducer was used to access morbidity due to SCH. The Niamey protocol was used to score lesions within a graded system.

1.4 Justification of the study

At the genesis of this study, Liberia did not have an established NTD programme and had not started MDA for the control of LF and SCH. There was an unco-ordinated distribution of the drug Mebendazole to schoolchildren in an attempt to decrease the burden of worm infestation in the country. The epidemiology and burden of these diseases were not adequately known. Therefore, an integrated approach provided a unique opportunity to properly co-ordinate the NTD activities in the country. The MoH has now developed an integreated approach to NTDs as suggested by this study.

This research project was carried out in collaboration with the national NTD programme at the Ministry of Health and Social Welfare. It looked at the impact of MDA after two rounds of treatment, which could determine when to stop MDA, and the impact of MDA on morbidity control.

1.5 Study area

Liberia is a post-conflict country with 14 years of civil war, which ended in 2003. The deadly Ebola virus disease (EVD) hit the country in 2013 where hundreds lost their lives.
Liberia is located at latitude 60:30 North of the equator and longitude 90:30 West of Greenwich meridian, with a landscape of 111,370 square kilometres. It is bordered by the Atlantic Ocean to the South, Côte d’Ivoire to the East, Sierra Leone to the North-West, and Guinea to the North-East (see Figure 2). Administratively, it is divided into 15 counties with a total population of 3,476,608 in 2008 (see Table 1.4).

Table 1.4: Liberia at a glance, April 2011

Topic	Status
Geographic size	111,369 square kilometres
Annual rainfall	4,000 mm (one of the highest in the world)
Natural resources	Iron ore, rubber, timber, diamonds, and gold
Founded	July 26, 1847
Executive	President: Ellen Johnson-Sirleaf (2006)
Legislature	Bicameral (Senate and House of Representatives)
Per capita gross domestic product (GDP)	US$247 (2010 estimate)
GDP growth rate	1.8% (2001–2010 estimates), 5.9% (2010 estimate)
Population living on less than US$1 per day	76.2%
Population	3,476,608 (32% in Monrovia; 2008 Census)
Population growth rate	2.1% (2008 Census)
Life expectancy	59.1 years (UNDP, 2010)
Under-5 mortality rate	114/1000 live births (DHS, 2007)
Maternal mortality rate	994/100,000 live birth (DHS, 2007)
Access to improved drinking water	75.0% (93.0% urban, 58.0% rural) (LMIS, 2009)
Access to adequate sanitation	44.0% (63.0% urban, 27.0% rural) (LMIS, 2009)
Human immunodeficiency virus (HIV) seroprevalence	1.5% (1.8% female, 1.2% male) (DHS, 2007)
Supervised childbirth	46.0% (DHS, 2007)
Institutional deliveries	37.0% (DHS, 2007)
Vaccination coverage (full)	51.0% (2010)
Net enrolment primary school	74.0% male, 58.0% female (2000–2006 average)
Net enrolment secondary school	37.0% male, 27.0% female (2000–2006 average)

Source: Adapted from MoHSW (2011a).

Figure 1.2 Political Map of Liberia

Source: MoHSW (2011a).

CHAPTER 2: LITERATURE REVIEW

2.1 LF

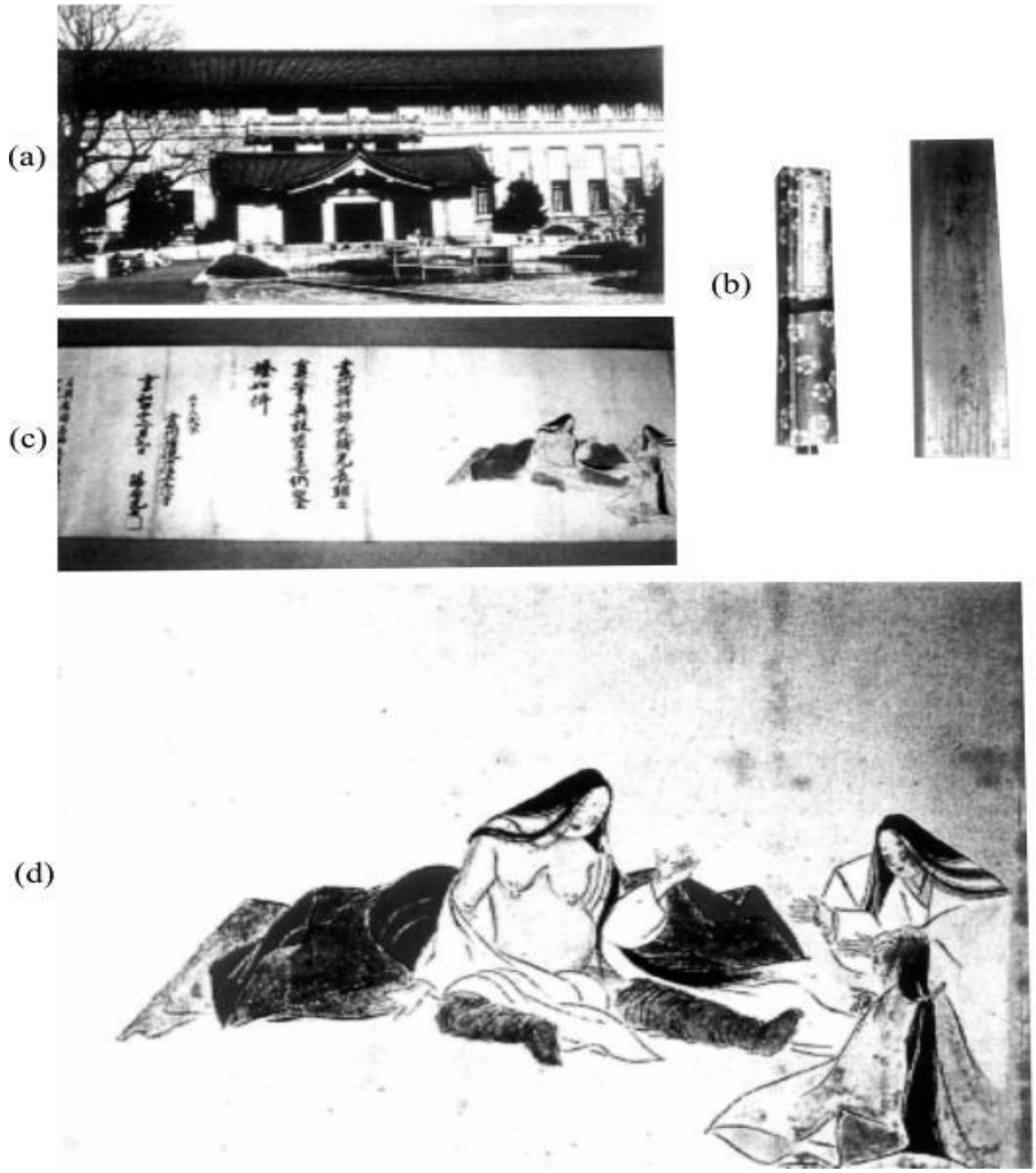
2.1.1 A brief history of LF

LF also known as elephantiasis is one of the ancient diseases and furthermost disfiguring of all the NTDs. There are 73 countries across the globe that are endemic for the disease and an estimated 1.39 billion population live in areas where filariasis is endemic and therefore are at risk of infection and transmission (WHO, 2012a). In the context of control some countries have reached elimination for LF while others have started preventive chemotherapy.

In 1993, LF was recognised as a potentially eradicable disease by the International Task Force for Disease Eradication (Ichimori & Graves, 2017). In 1997, the World Health Assembly recognised LF as a public health problem and targeted it for elimination by 2020; it then approved Resolution WHA50.29 calling on Member States to begin programmes for the elimination of the disease. In 2000, WHO launched the Global Programme to Eliminate Lymphatic Filariasis (GPELF), with the aim to stop the spread of LF infection (interrupting transmission) and alleviate the suffering of affected persons (controlling morbidity) (WHO, 2010a).

The antiquity of LF dates as far back as 600 BC when some Indian and Persian physicians described clear signs and symptoms of LF. In the Temple of Hatshepsut in Egypt (1501–1480) there are drawings on the tomb, which depicts the presence of LF as early as 1500 BC; also at the Tokyo National Museum in Japan, both males and females with LF dating as far back as AD 1100–1200 was found in the 'Disease Picture Scroll' (Otsuji, 2011) (see also Figure 2.1).

Figure 2.1: In Japan, picture of a Japenese woman (d) with elephantiasis-like of the lower limb



Source: History and control of LF (Otsuji, 2011).

In the year 1863, a French surgeon Jean Nicolas Demarquay (1814–1875) was the first to discover microfilaria in the fluid collected from a Cuban with hydrocele. This was followed by the discovery of adult worms in 1876 by Joseph Bancrofti, which is now known as *Wuchereria bancrofti.* Patrick Manson in 1877 was the first to describe the lifecycle of LF. Manson was able to determine that the vector of the disease was mosquitoes. George Carmichael-Low was the first to identify LF transmission mechanism, where he noted that individuals were infected from the bite of infected mosquitoes (Despommier, Gwadz, & Hotez, 1995).

2.1.2 The global burden of LF

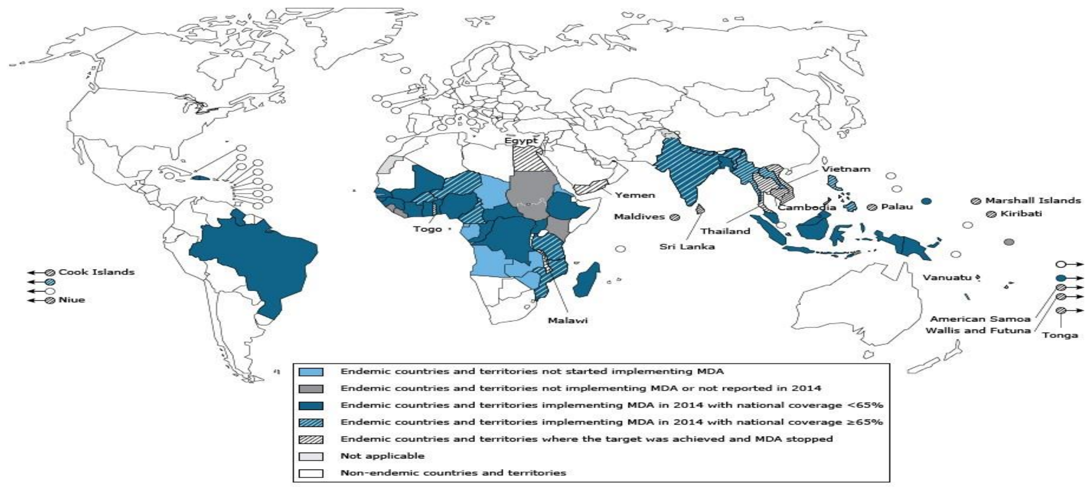
LF is caused by infection with the parasitic filarial nematodes (roundworms) its species are as follows: *W. bancrofti; Brugia malayi;* and *Brugia timori*. The filarial infection is transmitted by mosquitoes and humans are definitive hosts. Once an individual gets infected the infection inhabits the lymphatics and subcutaneous tissues, which eventually leads to damage of the lymphatic vessels, resulting in clinical disease manifested as hydrocele, lymphoedema and elephantiasis. LF is the second leading cause of disability globally with an estimate of about 120 million people infected with the nematodes and approximately 40 million people are suffering from its complications. It is a major cause of disfigurement and disability in endemic areas, leading to significant economic and psychosocial impact (WHO, 2017b).

According to the GPELF 2011 report, nearly 40 million people are suffering from the stigma and incapacitating clinical expressions of the disease, of which 15 million have lymphoedema and 25 million men have urogenital swelling, which is mainly scrotal hydrocele (WHO, 2019).

W. bancrofti is found in sub-Saharan Africa, South East Asia, the Indian subcontinent, parts of the Pacific Islands, parts of Latin America, and the Caribbean.

Brugia malayi occurs mainly in India, Malaysia, the Philippines, Indonesia, and various Pacific Islands where it may co-exist with *W. bancrofti*. *Brugia timori* occurs on the Timor island of Indonesia. Approximately two-thirds of individuals infected with LF are in Asia (see Figure 2.2).

Figure 2.2 Countries where LF is endemic and the status of MDA in those



countries, in 2014

Source: GPELF programme, progress report (2014).

The epidemiology of LF has changed due to the MDA initiated by GPELF to cut the disease transmission. This has led to the reclassification of some countries (e.g., Trinidad and Tobago and Costa Rica) as non-endemic, while others such as Cambodia, China, the Cook Islands, Egypt, Maldives, the Marshall Islands, Niue, Palau, Republic of Korea, Thailand, Togo, Tonga Vanuatu, Vietnam, and Wallis and Futuna have eliminated transmission completely (GPELF progress report 2016; WHO, 2019).

The disease was observed to occur intermittently in children. However, in recent years, sensitive diagnostic tests (e.g., ultrasound examination, antigen detection) have now revealed that LF can be acquired in early childhood. About one-third of children infected with LF before the age of 5 remain subclinical for years or present with nonspecific presentations of swollen lymph nodes or glands, but after puberty the clinical manifestation of the disease is seen (Witt & Ottesen, 2001).

A study of 159 Kenyan pregnant women with active *W. bancrofti* infection, their neonates cord blood was tested at birth and was shown not to have the filarialspecific T cell responses, had a 13-fold increased risk of developing childhood LF infection compared to the uninfected controls (Ondigo et. al., 2018).

In endemic areas, it has been observed that the prevalence of the microfilaremia increases with age and by the third or fourth decade of life most people in endemic areas have been exposed. The adult worm does not replicate within the human host, therefore, if an individual leaves an endemic area, the adult worm burden cannot increase, since exposure to infective larvae has ceased (Witt & Ottesen, 2001).

2.1.3 The vector

In 1877, Sir Patrick Manson proved that mosquitoes were the vectors for filariasis, which also indicated an attach point for control. In some sub-Saharan African countries where malaria is endemic, the use of mosquito nets to control LF has been encouraged by some NTD programmes at the MoH in collaboration with the National Malaria Control Programme. Mosquito vectors for *W. bancrofti* include *Aedes, Culex, Coquillettidia, Mansonia* and *Anopheles*. Vectors for *Brugia* are *Aedes* and *Mansonia.* In Africa, the *Anopheles gambiae* complex is the dominant vector for LF. There are reports of urban and rural transmissions of the disease, which is mostly due to travelling, but the transmission is low, and this could be attributed to the use of bednets, mosquito repellents and MDA. Humans are the only host for Bancroftian filariasis in comparison to Brugian filariasis, which infects humans and domestic and wild animals (Mwakitalu, Malecela, Pedersen, Mosha, & Simonsen, 2013).

2.1.4 In sub-Saharan Africa

According to the ranking of NTDs in sub-Saharan Africa by prevalence it is reported that approximately 40.0% of the world's 120 million cases of LF occur in sub-Saharan

Africa, with approximately 46 million to 51 million LF cases. A review of the prevalence and distribution of NTDs reported that and an estimated 6.0% to 9.0% of the sub-Saharan African population is infected with LF with an estimated 382 million to 394 million people are at risk of infection in sub-Saharan Africa, of which this figure includes 176 million children (Hotez, et al., 2006). In sub-Saharan Africa, 39 Member States are endemic of LF. The highest number of people at risk of LF are from Nigeria, Democratic Republic of Congo, Tanzania, Ethiopia and Kenya (WHO, 2008).

NTDs are associated with poverty as it occurs in countries with low economic power and where there is poor sanitation, poor hygiene and a poor health system. NTDs are common amongst the rural communities and in some slum communities in Africa (Hotez, et al., 2007) (see Table 2.1).

Table 2.1: Poverty in sub-Saharan Africa compared to the world

Percentage of population living on less than US$1.25 per day	51.0%
Total population living on less than US$1.25 per day	390.60 million
Percentage of world’s population living on less than US$1.25 per day	28.0%
Total population living on less than US$2 per day	556.7million
Percentage of world’s population living on less than US$2 per day	22.0%

Source: Hotez, et al., (2007).

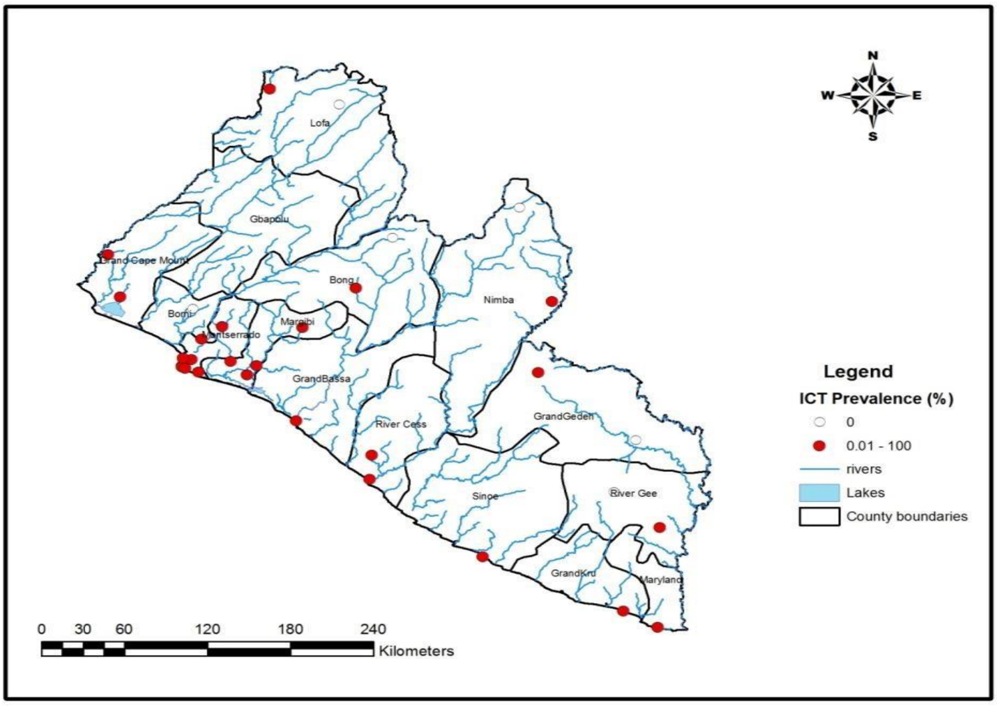
2.1.5 In West Africa

In West Africa, the vectors of malaria, the female *A. gambiae* mosquitoes, are the main vectors of LF. Current practices in the management of LF in West Africa have been influenced by the push for integrated control of NTDs amenable to MDA and vector control is now being encouraged for the prevention, control, elimination and eradication of NTDs (de Souza, et al., 2012).

2.1.6 In Liberia

Historical review conducted for LF in Liberia indicates that the disease dates as far back as the 1900s. Data on LF in Liberia shows the infection is caused by *W. bancrofti* and the parasite is transmitted by *A. gambiae and Anopheles funestus mosquitoes* (see Chapter 3).

Figure 2.3 Prevalence and distribution of LF in Liberia *Source:* MoHSW (2011a).



A nationwide LF mapping exercise was conducted in 2010 by the Liberian MoH and partners with technical and financial assistance from WHO, and the Centre for Neglected Tropical Diseases/Liverpool School of Tropical Medicine (CNTD/LSTM).

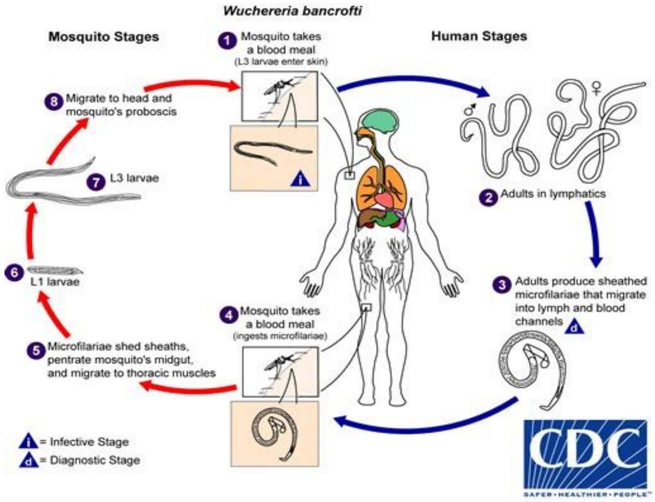
From the results, 13 of the 15 counties were endemic for LF. Clinical evidence of LF has been seen in many parts of rural Liberia, especially along the coastal regions (see Figure 2.3).

2.1.7 The parasite and its life cycle

The Centers for Disease Control and Prevention (CDC) (see Figure 6) provide a vivid description of the life cycle of *W. bancrofti,* the explanation is as follows: The life cycle of filariasis commences after a blood meal when the filarial larvae is injected into human skin by a mosquito. The larvae then travel through the biting site and enter the lymphatic vessels where they reside. After 9 months, the larvae develop into adult worms. The female and male adult worms mate and produce microfilariae. The microfilaria then goes into the lymph and blood vessels of the infected person, who if gets bitten by the mosquito, the microfilaria then develops into third stage larvae and can infect another person if they also get bitten by the infected mosquito.

In some parts of the world, the microfilaria can be visible in the bloodstream during the evening hours, mostly between 22:00 p.m. and 02:00 a.m., where this is called 'nocturnal periodicity'. In the South Pacific, the microfilaria can be found any time in the bloodstream, and this is called 'subperiodic', but they are found in high levels during midday. It takes about 12 months from the bite of a mosquito to the detection of microfilariae in the bloodstream of an infected person. The adult worm lives for about 5 years, but in some few cases can live up to 12 to 15 years (CDC, 2019a).

Figure 2.4 Life cycle of LF



Source: Reproduced from CDC (2019a).

2.1.8 Clinical presentation of LF

The symptoms and signs of LF when contracted in childhood does not manifest itself until adolesence or adulthood. However, there are reports that state that children in endemic regions have suffered lymphoedema of the limbs and acute dermatolymphangio-adenitis (ADLA) signs and symptoms. Approximately 70.0% of people infected with LF may have asymptomatic microfilaremia, while some may progress to the clinical manifestations of the disease and develop lymphatic dysfunction causing lymphoedema, hydrocele, scrotal and elephantiasis. It has also been reported that people who have newly arrived to disease endemic areas may develop afebrile episodes of lymphadenitis and lymphangitis. The common acute clinical presentation of LF is ADLA, which manifests as nocturnal coughing, wheezing, fever, chills, pain in the affected area, vomiting and eosinophilia. Lymphoedema of the lower limb is the most frequent chronic clinical presentation of LF and is graded as:

Grade I: Pitting oedema, reversible on elevation of the affected limb.

Grade II: Pitting or non-pitting oedema, which does not reverse on elevation of the affected limb and there are no skin changes.

Grade III: Non-pitting oedema that is not reversible, with thickening of the skin.

Grade IV: Non-pitting oedema that is not reversible, with thickening of the skin along with nodular or warty excrescences – the stage of elephantiasis.

The other lymphoedema of the upper limb, breast and male genitalia, are less commom

as compared to the lower limb (Kumaraswami, 2000).

2.1.9 Diagnosis of LF

To make a diagnosis of LF, a complete history taken from patients is necessary. A high suspicion of LF should be suspected in anyone with an exposure history who presents with pathognomonic signs and symptoms or unexplained eosinophilia and who have travelled to or live in endemic areas. Definitive diagnosis can be made by various methods, which range from detection of circulating filarial antigen (for *W. bancrofti* infection only), demonstration of microfilariae or filarial deoxyribonucleic acid (DNA) in the blood, to detection of the adult worms located in the lymphatics (Pani, et al., 1995).

2.1.10 Treatment and prevention of LF

The treatment of LF varies from country to country depending on the co-endmicity of some NTDs. Diethylcarbamazine (DEC) is the best treatment for people with LF, but the drawback is that the drug is contra-indicated in patients with Oncho due to the possibility of the Mazzotti reaction and as a result this should be used in caution with patients with Loaiasis (see also Table 2.2).

Table 2.2: Current treatment guidelines for LF, STH and SCH

Disease	Drugs and dosages	Threshold for implementation	Frequency of intervention

LF	Albendazole 400 mg for children aged >2 years **plus** DEC 6mg/Kg in countries where Oncho is not coendemic **Or** Ivermectin 150µ/Kg in countries where Oncho is endemic	**Prevalence of >1.0%**	**Annual:** Treatment must be combined with limb care of patients with elephantiasis or hydrocele surgery
STH (i.e., *Ascaris*, hookworms, and *Trichuris trichiura*)	Albendazole 400 mg for children above 2 years, or Mebendazole 500 mg	**Prevalence >50.0%:** treat school-aged children, and adults at high risk, twice yearly **Prevalence >20.0% to <50.0%:** treat school-aged children once per year. **Prevalence <20.0%:** individualised treatment. Preschoolchildren and women of child-bearing age should also be treated (as part of maternal and child health programmes)	**Annual or twice yearly** (depending on prevalence): Water and sanitation strategies must be implemented
SCH	Praziquantel 40 mg/Kg (using dose pole) for children over 4 years (or 94 cms)	**Prevalence >50.0%:** treat all school-aged children. Adults at high risk may also be treated **Prevalence >10.0% to <50.0%:** treat children once every 2 years **Prevalence <10.0%:** individualised treatment	**Annual treatment:** Treatment holidays can be given if prevalence drops. Water and sanitation strategies must be implemented

Source: WHO (2006a).

Ivermectin is effective in reducing the microfilaremia, but this has no effect on the adult worm. Albendazole has no direct effect on microfilariae, but this leads to a slow decline in microfilaremia due to its macrofilaricidal activity against the adult worms. However, side effects due to rapid killing of microfilariae have not been seen when Albendazole is used with Ivermectin during MDA (Partono, Maizels, & Purnomo, 1989). MDA has been the concentration of control of the disease. Vector control with insecticide-treated nets (ITNs) is also useful for *W. bancrofti* elimination, in communities where *Anopheles* mosquitoes transmit the parasite. Unfortunately, there is no vaccine available for LF.

2.2 SCH

2.2.1 A brief history of SCH

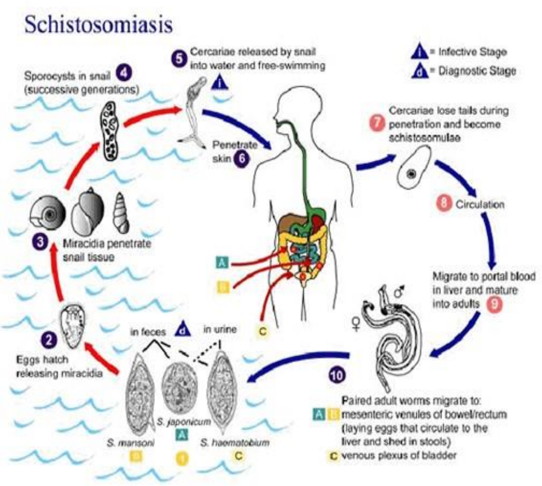
SCH is one of the ancient parasitic infections affecting humans. Symptoms of the disease such as haematuria were first recognised as far back as 1900 BC by Egyptian physicians. They called the disease 'menstruating males of Egypt'. In the year 1851, a German Physician, Theodor Maximilian Bilharz, (1825–1862) was the first to discover the disease by finding long white helminths in the portal vein. The discovery was made while he worked at the Egyptian department of hygiene, he then described long white helminthes in the portal vein of men who died of haematuria in series of autopsies he carried out. He noted that these changes were consistent across the cadavers on which he performed the autopsies. He also noted helminthes eggs in the stools of the cadavers. The disease is also called 'Bilharziasis' named after Bilharz for his contributions to the disease Brazilian Parasitologist, Manuel Augusto. Pirajá da Silva (1873–1961) also made a contribution to the discovery of the life cycle of intestinal SCH ,(Tan & Ahana, 2007).

2.2.2 The global burden of SCH

SCH is a disease caused by infection with parasitic blood flukes. Although it is controlled in some countries, it still remains a major public health problem. There are an estimated 207 million cases of SCH worldwide of which 93.0% occur in sub-Saharan Africa (Steinmann, Keiser, Bos, Tanner, & Utzinger, 2006). The parasites that cause SCH live in certain types of freshwater snail in subtropical and tropical regions. People living around swamp lands, dams and reservoirs are particularly at risk for the disease.

The disease occurs when the skin comes into contact with contaminated water and is penetrated by the schistosome parasite (Brooker, 2007). This is graphically shown in Figure 2.5

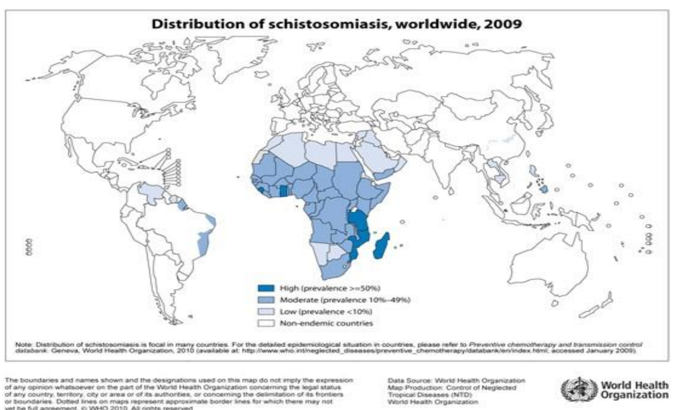
Figure 2.5: Life cycle of SCH



Source: Reproduced from CDC (2019b).

Increasing population and movement have contributed to increased spread and transfer of SCH to new areas. Most endemic countries are amongst the developing countries in the world with poor health systems. Constraints to disease control in these developing countries vary from lack of political commitment to limited or poor infrastructure for public health interventions (Chitsulo, Engels, Montresor, & Savioli, 2000).

Figure 2. 6 Distribution of SCH worldwide in 2009



Source: http://gamapserver.who.int/maplibrary/files/maps/global_schistosomiasis_2009

2.2.3 Epidemiology

It has been reported that there are approximately 207 million people infected with SCH, amongst which 120 million are symptomatic, 20 million have severe disease, about 600 million people are at risk of infection and around 200,000 deaths may occur every year (Ultroska, et al., 1989). This is indeed a public health emergency and should claim the attention of every national government in the world.Figure 2.6 shows the distribution of SCH in 2009.

Table 2.3: Geographical distribution of SCH

	Species	Geographical distribution
Intestinal SCH	*Schistosoma mansoni*	Africa, the Middle East, the Caribbean, Brazil, Venezuela, and Suriname
	Schistosoma japonicum	China, Indonesia, the Philippines
	Schistosoma mekongi	Several districts of Cambodia and the Lao People's Democratic Republic
	Schistosoma guineensis and related *S. intercalatum*	Rainforest areas of Central Africa
Urogenital SCH	*Schistosoma haematobium*	Africa, the Middle East, Corsica (France)

Source: Nicolls, et al., (2008).

Table 2.4: Human schistosome species and snail

Human schistosome	Snail (mollusc) species
S. mansoni	*Biomphalaria*
S. haematobium	*Bulinus*
S. intercalatum	
S. japonicum	*Oncomelania*
S. mekongi	*Tricula*

Every human schistosome species has a special snail as its intermediate host. In addition, the environment plays a significant role in the locality of the fresh water snails (Clements, Moyeed, & Brooker, 2006). Table 8 outlines the human schistosome species and the genus or snail associated with transmission.

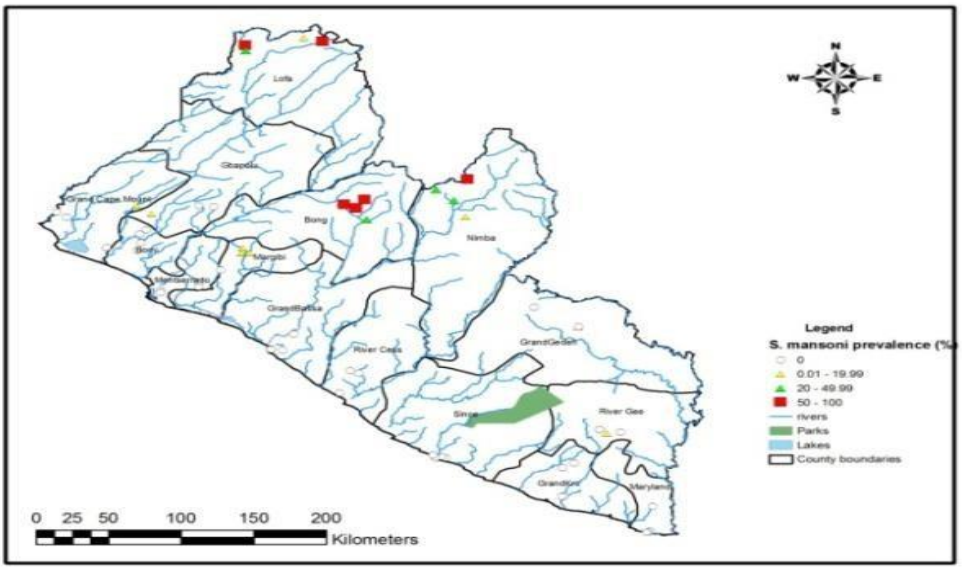
2.2.4 In Africa

SCH is widely distributed in Africa. Of the global 207 million estimated cases of SCH, 93.0% are from sub-Saharan Africa. The following sub-Saharan African countries account for the highest prevalence of SCH and are listed in order of highest prevalence, respectively: Nigeria; Tanzania; Ghana; and the Democratic Republic of Congo (Adenowoa, Oyinloyea, Ogunyinkaa, & Kappo, 2015). Due to MDA using Praziquantel and other successful control projects in a number of countries, the distribution of SCH has altered over the past years. However, despite all the interventions, the number of people infected or at risk of infection remains the same (Steinmann, et al., 2006).

2.2.5 In Liberia

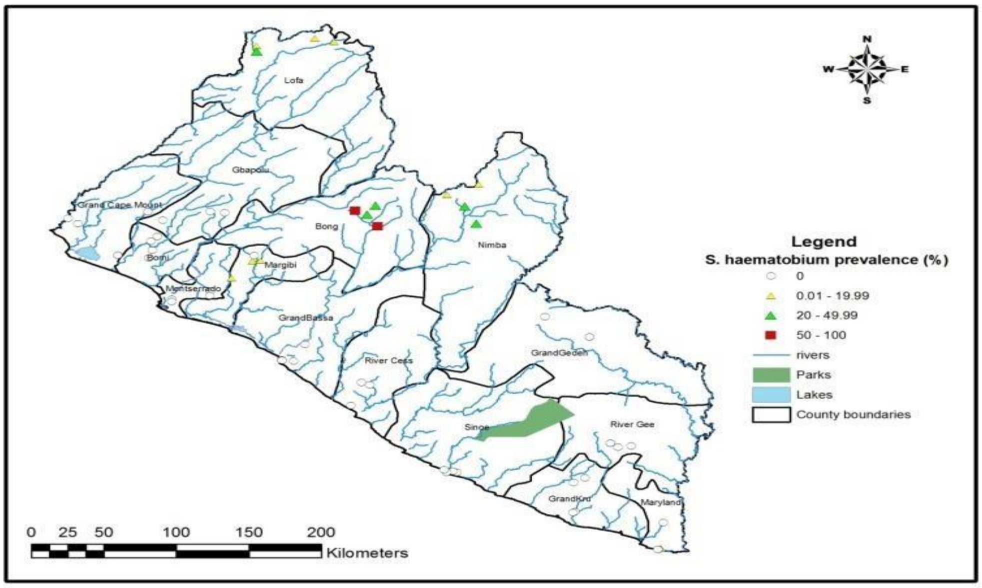
Studies on the epidemiology of SCH were carried out at the Liberian Institute for Biomedical Research (LIBR) from the 1970s to 1989. Many water bodies (streams and ponds) in Lofa, Bong, and Nimba Counties were considered to be the sources of infection. These unpublished reports were lost during the Liberian civil crisis. However, a study was conducted by Dennis et al. in 1983, on the prevalence and intensity of schistosomial infections in Bong County and the bionomics of the snail intermediate hosts, which found some fresh water bodies to be harbouring the snails (*Biomphalaria* and *Bulinus*) species. The study also revealed a higher overall prevalence of *S. mansoni* (25.0%) as compared to *S. haematobium* (23.0%). This result correlated with the 2011 integrated mapping survey for STH and SCH using the Kato-Katz method. The results indicated that SCH was prevalent in Bong County at 63.0% for *S. mansoni* and 56.0% *for S. haematobium*. Figures 9 and 10 show the prevalence and distribution in Liberia for *S. mansoni* and *S. haematobium*.

Figure 2.7: *S. mansoni* prevalence and distribution in Liberia



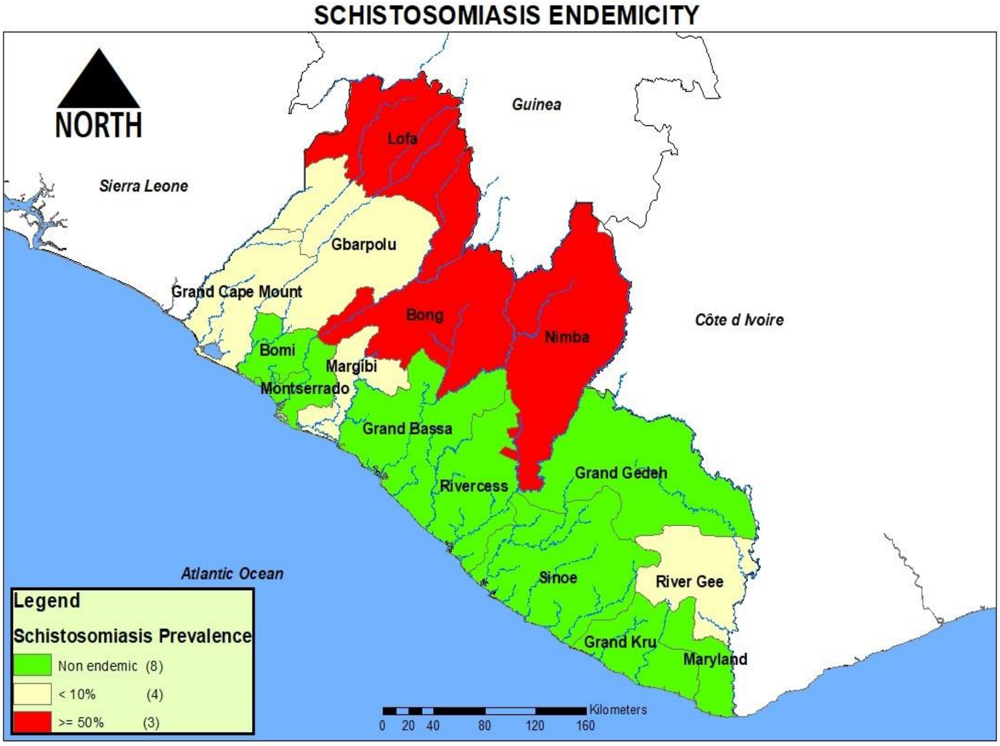
Source: MoHSW (2011a).

Figure 2.8: *S. haematobium* prevalence and distribution in Liberia



Source: MoHSW (2011a).

Figure 2.9: SCH endemicity in Liberia



Source: MoHSW (2011a).

2.2.6 Pathogenesis of SCH

Only few people who become infected with the disease develop symptoms. The natural course depends on the following three factors: i) age of initial exposure; ii) intensity of exposure; and iii) immunity and genetic susceptibility (Gryseels, Polman, Clerinx, & Kestens, 2006). It has been reported in 1998 by Butterworth that, the intensity of the infection increases during the first two decades of life and decreases in adulthood.

2.2.7 Clinical manifestation of SCH

The clinical disease is due to the infected person's response to the migrating eggs, which could sometimes lead to entrapment, inflammation and subsequent fibrosis (Gryseels, 1996). Many times, when the cercariae enter the host, it is associated with fever, diarrhoea or respiratory symptoms. For the intestinal SCH the disease may progress and lead to hepatomegaly or splenomegaly. Heavy infection may lead to periportal fibrosis. Infection with the urogenital SCH, which is *S. haematobium,* the disease may remain in the urinary tract causing dysuria or haematuria. In late stages of the disease, bladder calcifications may be observed, which could lead to an increased risk of bladder cancer (Pollack, 1981).

2.2.8 Diagnosis of SCH

There are many screening tools available for the diagnosis of SCH such as serology, urinalysis and microscopy of urine and/or stools. Some studies have reported that antibodies detection is more sensitive than egg detection for the demonstration of the infection (Stelma, Talla, Verle, Niang, & Gryseels, 1994; Clerinx, Bottieau, Wichmann, Tannich, & Van Esbroeck, 2011).

2.2.9 Treatment and prevention of SCH

There are three important purposes on the treatment of SCH.

1. Preventing complications from the diease.
2. Reduction of egg production.
3. Reversing the chronic or acute disease.

The drug used for the treatment of SCH is Praziquantel, as well as good sanitation and safe drinking water. SCH control strategies include health education, MDA, and improvement of water and sanitation.

2.3 STH

2.3.1 A brief history and global burden of STH

In 1943, Dr Norman R. Stoll (1952 to 1973) an American parasitologist conducted a survey amongst some elementary schoolchildren in Princeton, USA, where he noted that the schoolchildren harboured worm infections. In 1946, de Silva and colleagues also reported that there was a high burden of STH amongst North Americans (de Silva et al. 2003).

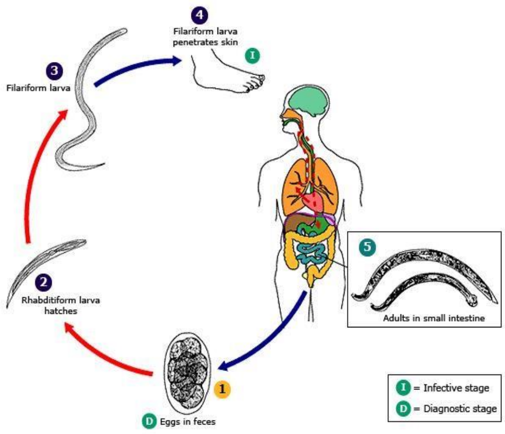
STH is the most prevalent NTD in the world. There are four main nematode species of human STH infections, also known as geohelminths: *Ascaris lumbricoides*, *Trichuris trichiura* (whipworm), and the hookworms *Ancylostoma duodenale* and *Necator americanus*. These infections occur mostly in developing countries especially in tropical and subtropical regions. Their prevalence in these regions can be attributed to: limited clean drinking water; poor health care; and poor sanitation systems (Haque, 2007). WHO in its progress report 2001–2010 and its strategic plan 2011–2020 reported that children aged 1 to 4 years in STH endemic areas are also at high risk for STH infection. The diseases related to infections of STH can be chronic or asymptomatic and include: malnutrition; cognitive development; growth disorders (short stature); and malabsorption of nutrients. This could lead to poor performance in school. According to the WHO estimates, approximately 836 million children around the world are in need of medication for STH. In 2016, WHO in its report on the global health observatory data reported that at least 75.0% of school-aged children had received medication for

STH (Shi, et al., 2015).

2.3.2 Epidemiology and transmission of STH

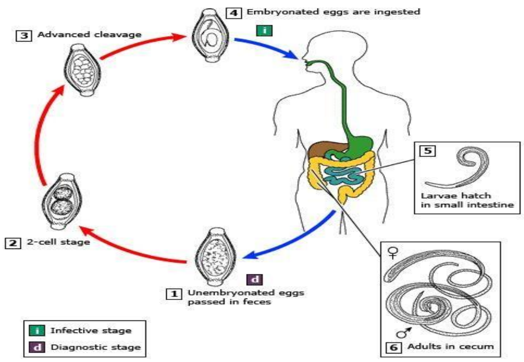
Global estimates of the disease report that around 2 billion people are infected with STH where the highest numbers are in Asia followed by sub-Saharan Africa. According to the CDC, globally 807 million to 1,121 million of the STH infections are estimated to be due to *Ascaris,* 604 million to 795 million are due to whipworm, while 576 million to 740 million are due to hookworms. Transmission of STH is associated with poor sanitation practices, infected persons whose faecal contaminates soil, food or water and who have been barefooted (de Silva, et al., 2003). Figures 2.10, 2.11 and 2.12 illustrate the lifecycle of STH (hookworm, *T. trichiura* and *Ascaris*).

Figure 2.10: The hookworm life cycle



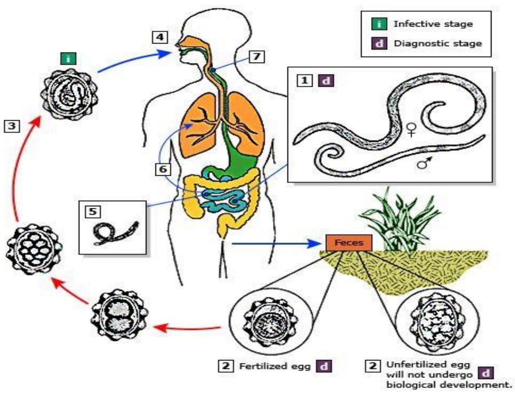
Source: Reproduced from CDC (2019c).

Figure 2.11: The *T. trichiura* life cycle



Source: Reproduced from CDC (2017).

Figure 2.12: *A. lumbricoides* life cycle

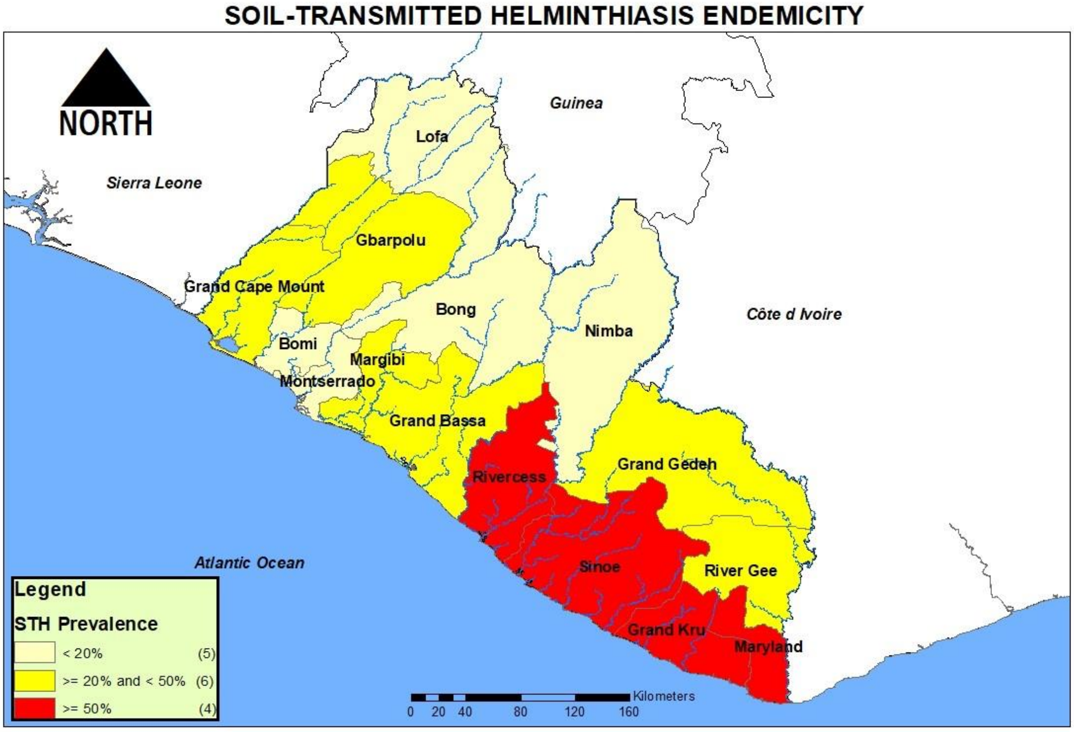


Source: Reproduced from CDC (2019d).

2.3.3 In Liberia

STH namely, *A. lumbricoides*, *T. trichiura* and hookworms are widely distributed in Liberia; and are prevalent in all 15 counties. A nationwide study conducted in 2011 on 3,144 schoolchildren in 59 schools, showed that the highest prevalence at 50.0% to 100.0% was found in the south-eastern counties (Maryland, Grand Kru, Sinoe and Rivercess). Maryland, Grand Kru, Rivercess and Sinoe Counties in the central part of Liberia showed moderate prevalence at 20.0% to 50.0%. The lowest prevalence at 0.1% to 20.0% was found in the northern counties including: Lofa; Bong; Gbarpolu; Bomi; Montserrado; and Nimba.

Figure 2.13 STH prevalence and distribution in Liberia



Source: MoHSW (2011a).

Results showed that prevalence of *Ascaris* was 20.0%, hookworm was 9.0% and *T. trichiura* was 3.0%, (MoHSW, 2011a). Table 9 shows the results of the STH prevalence survey conducted in 2010 using the Kato-Katz method.

Table 2.5: Prevalence of STH, by county in Liberia

County	Location/site (GPS co-ordinates)	N	*A. lumbricoides*	Hookworm	*T. trichiura*
Bomi	Klay (6.75566"N-10.85056"W)	100	17(17%)	2(20%)	3(3%)
	Senjeh (6.86498"N -10.8194"W)	100	9(9%)	5(5%)	2(2%)
Sub-total		**200**	**26(13%)**	**7(4%)**	**5(3%)**
Bong	Gbarnga (7.11379"N -9.46214"W)	100	21(21%)	1(1%)	0(0%)
	Suakoko (6.95005"N -9.45022"W)	99	4(4%)	4(4%)	1(1%)
Sub-total		**199**	**25(13%)**	**5(3%)**	**1(1%)**
Grand Cape Mount	Garwula (7.06343"N -10.87632"W)	100	32(32%)	6(6%)	1(1%)
	Tewor (7.06275"N -10.04662"W)	100	17(17%)	3(3%)	0(0%)
Sub-total		**200**	**49**	**9**	**1(1%)**
Grand Bassa	Buchanan (6.00743"N -9.9009"W)	100	13(13%)	11(11%)	2(2%)
	District #3 (5.88508"N)	100	16(16%)	6(6%)	1(1%)
Sub-total		**200**	**29**	**17(9%)**	**3(2%)**
Grand Gedeh	Tchien (6.96887"N -11.31224"W)	100	16(16%)	0(0%)	1(1%)
	Gbarzon (6.71755"N -11.06412"W)	100	22(22%)	5(5%)	6(6%)
Sub-total		**200**	**38(19%)**	**5(3%)**	**7(7%)**
Grand Kru	Barclayville (6.0652"N -8.13602"W)	100	53(53%)	5(5%)	3(3%)
	Buah (5.19103"N -7.96096"W)	100	50(50%)	10(10%)	3(3%)
Sub-total		**200**	**103(52%)**	**15(8%)**	**6(3%)**
Gbarpolu	Bopolu (4.94518"N -8.16542"W)	99	9(9%)	6(6%)	2(2%)
	Gbama (4.67583"N -8.22685"W)	100	6(6%)	13(13%)	3(3%)
Sub-total		**199**	**15(8%)**	**19(10%)**	**5(3%)**
Montserrado	Careysburg(8.41415"N -9.72119"W)	197	13(7%)	10(5%)	1(1%)
	Left Bank (8.38408"N-10.20299"W)	199	6(3%)	7(4%)	5(3%)
Sub-total		**396**	**19(5%)**	**17(4%)**	**6(2%)**
Maryland	Happer (6.67074"N -10.22611"W)	100	56(56%)	8(8%)	33(33%)
	Pleebo (6.71456"N -10.21816"W)	100	53(53%)	17(17%)	11(11%)

Sub-total		**200**	**109(55%)**	**25(13%)**	**44(22%)**
Margibi	Gibi (4.3765”N -7.71116”W)	100	16(16%)	6(6%)	1(1%)
	Kakata (4.38449”N -7.69465”W)	100	11(11%)	10(10%)	0(0%)
Sub-total		**200**	**27(14%)**	**16(8%)**	**1(1%)**
Nimba	Sanniquellie(6.43304”N-1.49024”W)	100	4(4%)	7(7%)	0(0%)
	Saclepea (6.34755”N -7.72861”W)	100	4(4%)	6(6%)	0(0%)
Sub-total		**200**	**8(4%)**	**13(7%)**	**0(0%)**
Lofa	Foya (7.28003”N -8.82301”W)	100	9(9%)	10(10%)	3(3%)
	Voinjama (7.10562”N -8.90699”W)	100	10(10%)	1(1%)	1(1%)
Sub-total		**200**	**19(10%)**	**11(6%)**	**4(2%)**
Sinoe	Greenville (5.52205”N -9.61881”W)	100	22(22%)	44(44%)	5(5%)
	LowerKanyan(5.68675”N -9.50088”W)	100	20(20%)	25(25%)	4(4%)
Sub-total		**200**	**42(21%)**	**69(35%)**	**9(5%)**
Rivercess	Central C (5.2204”N -8.00809”W)	100	40(40%)	25(25%)	8(8%)
	Timbo (5.19608”N -7.38255”W)	50	26(52%)	25(50%)	5(10%)
Sub-total		**150**	**66(44%)**	**50(33%)**	**13(9%)**
River Gee	Gbeapo (5.01103”N -9.03833”W)	100	34(34%)	2(2%)	2(2%)
	Potupo (4.9893”N -8.96154”W)	100	20(20%)	0(0%)	0(0%)
Sub-total		**200**	**54(27%)**	**2(1%)**	**2(1%)**
Grand Total		**3,144**	**629(20%)**	**280(9%)**	**107(3%)**

Source MoHSW (2017a). GPS = global positioning system.

2.3.4 Clinical presentation, diagnosis and treatment of STH

Infected persons initially may at times present with respiratory manifestations. They may also present with vomiting or coughing during the migration of the adult worm (Proffitt & Walton, 1962). Complications of STH vary from iron deficiency anaemia, stunted growth, malnutrition, intestinal obstruction, learning impairment to pancreatitis and hepatobillary involvement.

The diagnosis of STH can be established by good history taking and physical examination. Laboratory diagnosis on stool examinations to detect worm eggs is commonly practised in developed countries. The Kato-Katz method is the most widely used method for the diagnosis of STH. However, there are still no reliable serologic tests available to diagnose STH (Lamberton & Jourdan, 2015). Anthelminthic treatment of STH infection is prescribed as follows: Albendazole (400 mg once) or Mebendazole 100 mg twice daily for 3 consecutive days. (See table 2.2)

2.3.5 Prevention of STH

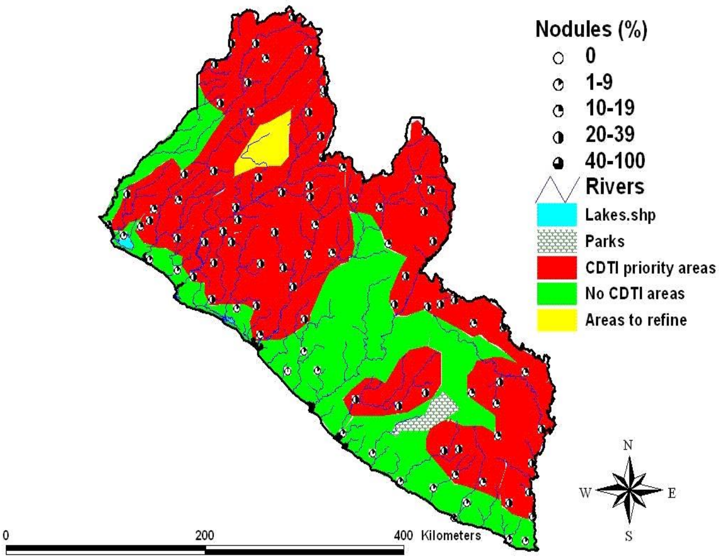
Preventive measures of STH entails good hygiene, access to safe drinking water, proper washing and cooking of food, frequent handwashing and protection of the feet for those in endemic areas. Deworming programmes in schools administering anthelminthic drugs (Albendazole 400 mg for children above 2 years, or Mebendazole 500 mg, see Table 6) and preventive chemotherapy targeting at-risk populations are measures to maintain low individual worm burdens (Albonico, Montresor, Crompton, & Savioli, 2006).

2.4 Prevalence and distribution of onchocerciasis in Liberia

The African program for Onchocerciasis, conducted a rapid epidemiological mapping of Onchocerciasis (REMO) for Liberia in 1999 and reported that the disease is prevalent in all 15 counties. With an estimated 1,113,213 of Liberia's 4 million population at risk. Onchocerciasis in Liberia was first diagnosed by the Harvard expedition to Africa in 1926 – 1927 and was found to be more prevalent in the rainforest region of the country as compared to the coastal regions. *Simulium yahense* has been identified as the *Simulium* species that transmits the disease in Liberia. Since the REMO mapping. The

Ministry of Health and Social Welfare in collaboration with its partners has conducted Mass Drug Administration for onchocerciasis in the country and has achived a therapeutic coverage of 83%. (Ministry of Helath NTD master Plan 2016-2020.)

Figure 2.14 REMO mapping of Liberia 1999



Source: https://www.who.int/apoc/cdti/remo/en/

CHAPTER 3: A CRITICAL ANALYSIS OF HISTORICAL DATA ON THE EPIDEMIOLOGY AND DISTRIBUTION OF *W. BANCROFTI* IN VECTOR AND HUMAN POPULATIONS IN LIBERIA

3.1 Abstract

3.1.1 Background

The filarial infection is transmitted by several species of mosquitoes within the genera *Culex, Aedes* and *Anopheles*. In West Africa, LF is transmitted by Anopheles mosquitoes. Humans are the definitive hosts. The adult worms inhabit the lymphatics and subcutaneous tissues causing damage to them resulting in the clinical manifestation of the disease as hydrocele, lymphoedema and elephantiasis.

3.1.2 Objectives

To examine the epidemiology of LF in humans and the distribution of *W. bancrofti* mosquito populations in Liberia using historical data. This chapter does not contain new data collected by the researcher. The data is based on historical review.

3.1.3 Methods

A systematic review of the literature in four electronic databases (PubMed, University of Liverpool Library, the National Center for Biotechnology Information [NCBI] bookshelf, and WHO Library – Thomas Allen) published before the Liberian civil war, which occurred in 1990, was undertaken. The search terms used were ‘vector’, ‘lymphatic filarisis’ and ‘Liberia’. In total, 1,689 titles and abstracts were identified, where 17 articles were selected to be included in this paper using thematic analysis. To augment the literature on epidemiology of LF and medical entomology, fieldwork was undertaken involving collection of vectors by wild-caught and laboratory-reared mosquitoes and serology was performed by peripheral blood smear.

3.1.4 Results

A total of 17 articles met the inclusion criteria and their results are as follows:

- *Entomology:* Based on the dissections of the mosquitoes for the presence of the infective larvae of *W. bancrofti* incrimination of the main vector for the distribution of LF in Liberia was *A. gambiae* followed by *A. melas*. From the data review, wild-caught mosquitoes produced the greatest number of live mosquitoes e.g., in a study by Gelfand (1955a) the most effective method for mosquito collection was the wild-catch method.
- *Epidemiology:* In humans, LF was reported in all four regions of Liberia with varying endemicity. The microfilariae prevalence is highest in the south-eastern (1.2% to 37.3%) and northern regions (0.5% to 26.2%), and the lowest prevalence was in the rainforest regions.
- *Entomology and Serology data:* High prevalence of infections of *W. bancrofti* in both mosquitoes and human serological data were noted in the coastal region. In a study conducted by Brinkmann (1972), in the Marshall Territory (coastal region), out of the 871 persons tested using night blood smear, a prevalence rate of 12.7% was recorded, while out of 306 mosquitoes dissected the infection prevalence was 27.1%.

3.1.5 Conclusions

Historical documentation on entomological and human population distribution of *W. bancrofti*, has clearly established that the vectors and human distribution of filarial in Liberia is prevalent and is the highest in the coastal region of the county. However, the infection may also be high in other regions of Liberia where no study has been undertaken. Therefore, there is a need for investigation in these regions.

3.2 Introduction

LF is one of the oldest and most debilitating of all the NTDs. It is caused by infection from one of the three species of the parasitic filarial nematodes (roundworms): *W. bancrofti, B. malayi* or *B. timori.* The filarial infection is transmitted by either of the following vectors the mosquito species: *Culex, Aedes* and *Anopheles*. Humans are the definitive host. LF affects populations that are the poorest in the world, mostly those living in communities that have poor water supply and sanitation (Perera, Whitehead, Molyneux, Weerasooriya, & Gunatilleke, 2007).

According to WHO (2016a), an estimated 67.88 million people are infected with the disease, approximately 36 million people are disfigured, and 947 million across the world remain at risk of infection with LF. The life cycle of the microfilarial begins with introduction of third stage filarial larvae onto human skin by a mosquito during a blood meal; subsequently, larvae migrate through the bite wound into the lymphatic vessels. Once a person gets infected, the infection inhabits the lymphatic vessels and subcutaneous tissues and eventually leads to their damage, resulting in clinical diseases manifested as hydrocele, lymphoedema and elephantiasis (CDC, 2014).

In Liberia, according to a study conducted by Young (1953) there is a descending infection percentage prevalence moving from the coast to the rainforest exhibited by the three Bioclimatic zones. The coastal zone of the country has a higher percentage prevalence of LF followed by the savanna zone. The rainforest zone has the lowest infection rate. The common mosquito vectors of LF in Liberia are: *A. gambiae* and *A. melas*. These vectors are in abundance in many localities of the country. Other less common mosquito vectors are: *Anopheles funestus; Aedes aegypti; Cynoscion nebulosus;* and *Mansonia africana* (Briscoe, 1948).

Clinical manifestations of advanced forms of LF can be common and include elephantiasis in the lower extremities and scrotum, particularly amongst the adults in the Kru and Grebo Tribes in the counties of the south-eastern coastal region, than amongst those in the savanna and rainforest zones (Zielke & Chlebowsky, 1979).

A 14 year civil conflict in Liberia tore apart the social fabric costing at least 200,000 lives, of which Liberia is gradually recovering. The entire health system in Liberia was severely affected during the civil conflict, which led to a total collapse of a control on the interventions for all diseases including NTDs.

In the context of controlling for LF, there is currently a need to update information in Liberia and also to reassess the involvement of mosquito transmission in Liberia. To this end, I sought to review the historical literature of the epidemiology of LF in humans and the distribution of *W. bancrofti* mosquito populations and also, where appropriate, to conduct fieldwork to collect contemporary information.

3.3 Methods

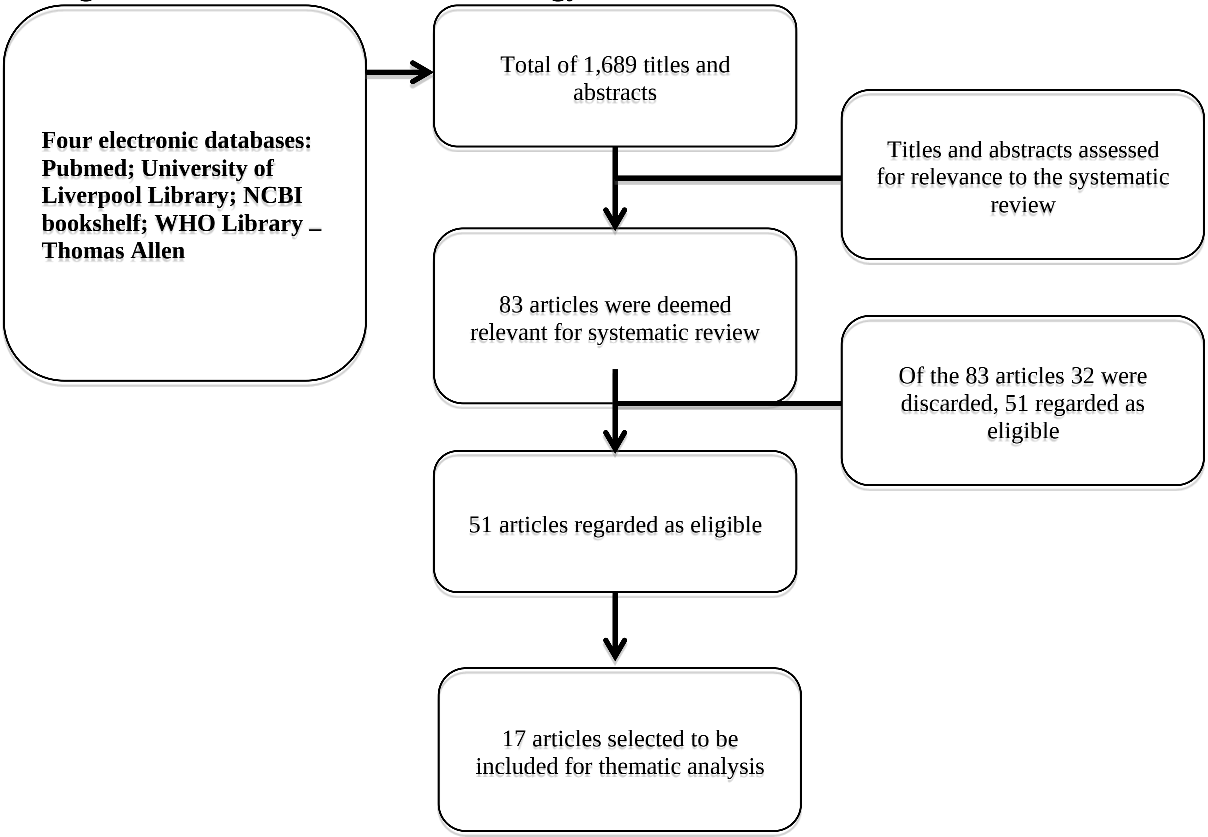
A systematic review of the published literature before the 1990 Liberian civil war was conducted using four electronic databases: (i) PubMed; (ii) University of Liverpool Library; (iii) NCBI bookshelf; and (iv) WHO Library – Thomas Allen. A total of 1,689 titles and abstracts were identified, 83 of these articles were found appropriate for review, 51 articles were selected and 17 articles were included for thematic analysis.

3.3.1 List of articles selected for thematic analysis. This was done by closely examining common themes and topics that was related to epidemiology and distribution of *W. bancrofti* in vector and human population in Liberia.

Table 3.1 The 17 articles selected for the historical review

No	Name of study	Researcher	Type of Study
1	Studies on Bancroftian filariasis in Liberia, West Africa	Zielke & Chlebowsky, 1979	Human MF Sampling
2	Epidemiological investigations of Bancroftioan filariasis in the coastal zone of Liberia	Brinkmann, 1977	Human MF Sampling
3	Distribution and prevalence of *W. bancrofti* in various parts of Liberia	Kuhlow & Zielke, 1976	Human MF Sampling
4	Microfilariae and trypansomes in a blood survey of Liberia	Young, 1953	Human MF Sampling
5	Filariasis bancrofti studies in Liberia	Poindexter, 1950	Human MF Sampling
6	Filariasis in Liberia	Burch & Greenville, 1955	Human MF Sampling
7	The Anopheline mosquitoes of Liberia, West Africa	Gelfand, 1954	Vector Sampling
8	Man-biting mosquitoes in coastal Liberia	Richard Fox, 1958	Vector Sampling
9	Dynamics and intensity of *W. bancrofti* transmission in the savannah forest regions of Liberia	Kuhlow & Zielke, 1978	Vector Sampling
10	Studies on the vectors of *W. bancrofti* in Liberia	Gelfand, 1955a	Vector Sampling
11	Malaria studies on the firestone rubber plantation in Liberia	Barber, Rice, & Brown, 1932	Observation with plasmoquine
12	*A. gambiae* in relation to malaria and filariasis in coastal Liberia	Richard Fox, 1957	Vector Sampling
13	Havard African expedition in Liberia in 1926	Liberianhistory.org, nd	Human MF Sampling
14	Mosquitoes of Liberia: a general survey	W. Peters, 1956	Vector Sampling
15	Distribution of Bancroftian filariasis in Africa	Hawking, 1957	Vector Sampling
16	Microfilariae and Trypansomes found in a blood survey of Liberia	Young, 1953	Vector Sampling
17	Field notes on mosquitoes collected in Liberia, West Africa	Briscoe, 1950	Vector Sampling

Figure 3. 1: Flow chart of methodology



3.3.2 Mosquito collection methods for the entomology survey

Entomology control plays a major role in eliminating LF; therefore, it is important to understand the behaviour of the vectors to develop tools for vector control. Therefore, the examination of the vector, their species, distribution, abundance and infectivity need to be understood before any initiation of the MDA.

The human landing catch is one of the most accurate ways of mosquito collection in Africa, this is because it mimics the real situation of the mosquitoes wanting to bite the individual; however, there are ethical concerns about the collectors being bitten by the mosquitoes, the labour intensiveness, and possible collection bias. There are alternative mosquito collection methods to overcome these ethical concerns such as the Biogents sentinel traps (Govella, Chaki, Mpangile, & Killeen, 2011). In this historical review, most of the methods for mosquito collection bridge the ethical concerns.

For the entomology survey in this historical review, mosquitoes were gathered by two methods: (i) wild-caught mosquitoes; and (ii) laboratory-reared mosquitoes.
The collection of wild-caught mosquitoes involved:

1. Supervised two-man team bait collectors (human landing catch).
2. Trap made of strong framework, covered with screen outside household.
3. Hand collecting on human bait in opened areas.
4. Hand collecting of the mosquitoes resting in the local houses each morning.

To augment field observations experimental infections of mosquitoes were also undertaken. Laboratory-reared mosquitoes of different species were fed on infected participants.

The mosquitoes were than dissected to check for infection with *W. bancrofti*.

3.3.3 Laboratory analysis

All mosquitoes were collected outside the laboratory and were taken to the laboratory. Samples were identified by species (*A. gambiae* and *A. melas*) if possible by the identification of their eggs from the females.

At the time of dissection, each mosquito was teased apart separately, the abdomen was discarded and the head and thorax were dissected in saline using a binocular microscope at 30X and then using a compound microscope at 75X to examine the mosquitoes.

3.3.4 Epidemiological survey (microfilaria)

The 17 articles reviewed did not mention ethical clearance from the MoH, but only stated that permission for the surveys were obtained from the town chief or villages before the teams embarked on their research activities.

The investigators during the period under review identified microfilariae in humans in peripheral blood using microscopy to detect the filarial parasite. Blood preparations varied from thin to thick blood smears stained by the Giemsa method or the Knott method using both the day smear method and the night smear method.

Thick blood smear was made from a finger prick blood sample. The sample was air-dried and stained with Giemsa, washed and dried for 30 minutes, then examined under a microscope. This allows the distinction of the *W. bancrofti* from other filarial species (McMahon, Marshall, Vaughan, & Kolstrup, 1979).

For the Knott's concentration technique: approximately 1 mL of blood is placed in 10 mL of 1.0%–2.0% of formalin or citrate–saponin solution after which the mixture is centrifuged at 500 g for a minute. The sediment is examined under the microscope for *W. bancrofti* (Melrose, Turner, Pisters, & Turner, 2000).

The blood smears in most of the surveys were at times taken from the entire population or subset of the villages and towns. The sampled population age varied across the various studies ranging from babies to adults (from 9 months to >50 years old). Table 10 gives the distribution and prevalence of infection of *W. bancrofti* in human populations in Liberia using both the day and night smears. The blood was examined under microscope after staining the slides with Haematoxylin using the thick smear technique.

Table 3.2: Dissection of *A. melas* and *A. gambiae* in Marshall Territory, Liberia

A. melas	***A. gambiae***	***A. melas/gambiae*** +

	No. Dissected	No. Positive	%	No. Dissected	No. Positive	%	No. Dissected	No. Positive	%
Malaria*	427	6	1.4	369	21	5.7	1,142	27	2.4
Filariasis	306	83	27.	262	51	19.5	592	132	22.3
Total		**11**	1 **3.6**		**4**	**1.5**		**11**	**1.9**

Source: Gelfand (1955a, 1955b); * Salivary gland infections only.

3.4 Results

3.4.1 Entomology/mosquitoes survey

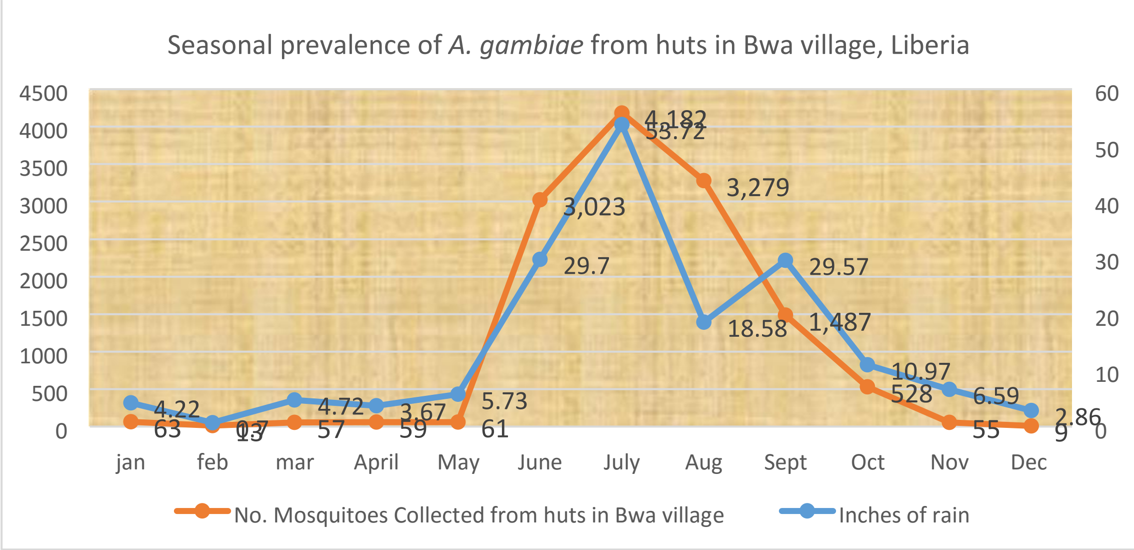
A total of 17 articles were reviewed and the data analysed. Six articles were selected based on entomological distribution of LF, while 11 articles were selected based on human distribution of LF. Eight of the articles conducted surveys using night blood smears and the remaining nine articles conducted surveys using day blood smears.

Participants were distributed according to regions and counties. Gender distribution could not be ascertained in some of the studies making it difficult to conduct a total aggregate of all the participants by gender.

Seasonal variations of the vectors were noted where the highest catches of mosquitoes were during the rainy season from April to October, and the lowest catches of mosquitoes were in the dry season from December to March.

The results of the systematic review also showed that the coastal region has the highest percentage of prevalence for *A. melas* and *A. gambiae* mosquitoes, this was demonstrated by Gelfand (1955a, 1955b) in the Marshall Territory (now known as Margibi County) in the coastal region of Liberia for both malaria and filariasis. The survey also showed that *A. melas* (27.0%) was a more effective vector in transmission than *A. gambiae* (20.0%) (see Table 3.3).

Figure 3.2: Seasonal prevalence of *A. gambiae*



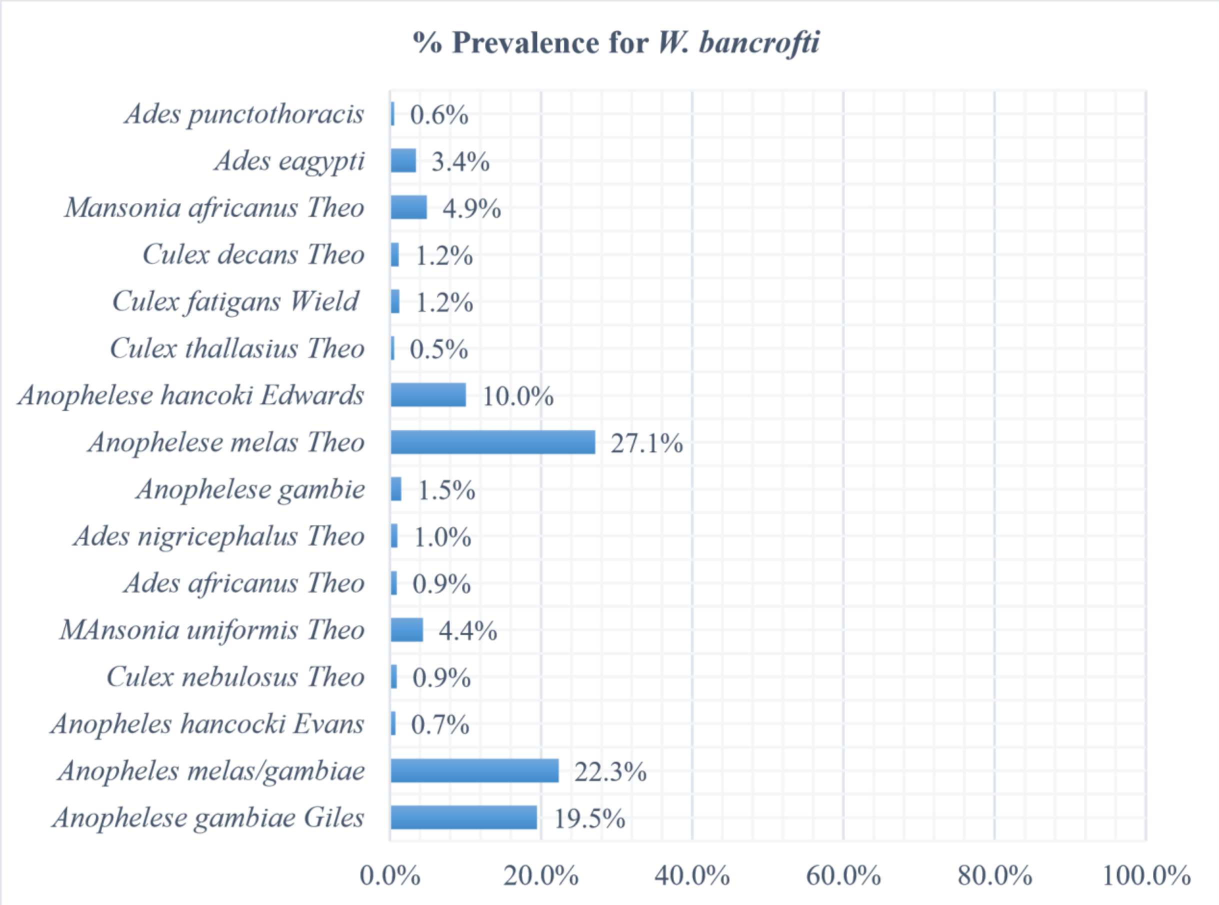
Source: Briscoe (1948).

Table 3.3: Summary results of various surveys showing distribution of *W. bancrofti* in mosquitoes in Liberia

Year	Region	Location	Proportion (%)	Mosquitoes species	Observer
1947	South Central	Robertsfield	1.6	*Anopheles gambiae*	Diller (1947)
1950	South Central	Robertsfield	0.8	*Anopheles gambiae*	Briscoe (1952)
1952–1955	South Central	Marshall Territory	19.5	*Anopheles gambiae*	Gelfand (1955a)
			27.1	*Anopheles melas*	
			22.3	*Anopheles melas/ gambiae*	
			10.0	*Anopheles hancocki*	
			0.0	*Anopheles hancocki*	
			0.6	*Culex thallasius*	
			0.0	*Culex nebulosus*	
			0.0	*Culex fatigans*	

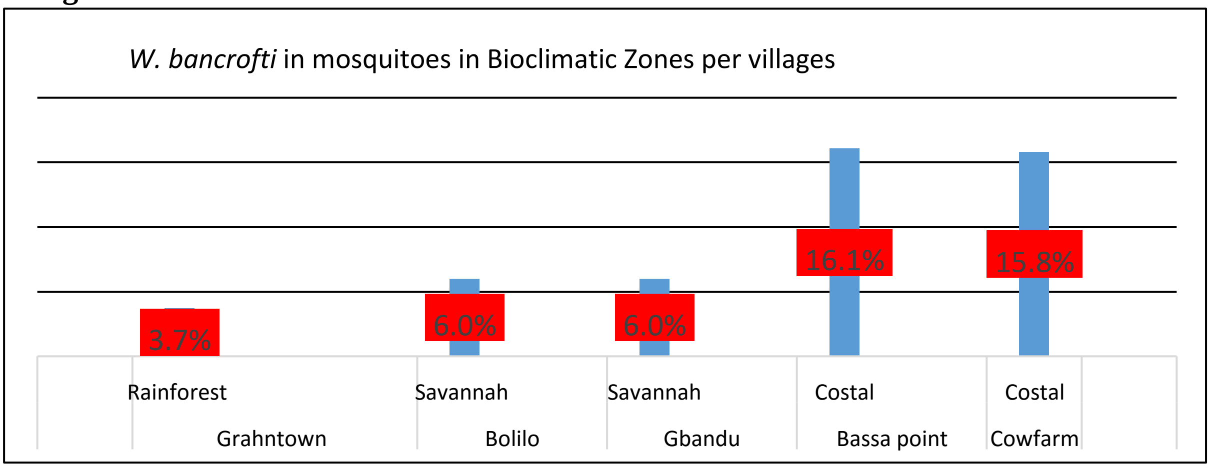
			0.0	*Culex nebulosus*	
			0.0	*Culex decens*	
			4.4	*Mansonia uniformis*	
			4.9	*Mansonia africanus*	
			0.0	*Ades africanus Theo*	
			3.4	*Ades aegypti*	
			0.0	*Ades nigricephalus*	
			0.0	*Ades punctothoracis*	
1957–1958	South Central	Marshall Territory	3.6	*Anopheles gambiae*	Fox (1957, 1958)
1976	North Central	Bolil	48.9	*Anopheles gambiae*	
			47.9	*Anopheles funestus*	
			2.86	*Anopheles nili*	
		Gbandu	8.7	*Anopheles gambiae*	
			3.1	*Anopheles funestus*	
			95.7	*Anopheles nili*	
		Grahntown	92.9	*Anopheles gambiae*	
			1.2	*Anopheles funestus*	
		Kaikatown	74.4	*Anopheles gambie*	
			23.3	*Anopheles funestus*	Kuhlow & Zielke (1978)

Figure 3.3: Proportion of wild catch and infected mosquitoes



Source: Gelfand (1955a).

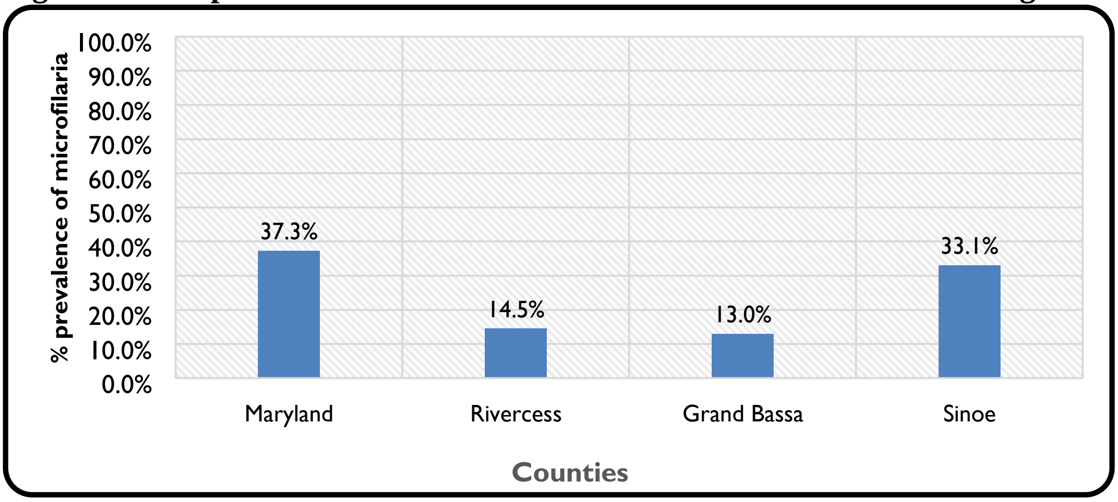
Figure 3.4: Proportion of *W. bancrofti* in mosquitoes, by Bioclimatic zones in five Liberian villages



Source: Gelfand (1955a).

In 1948, Briscoe conducted a study, which revealed that there are various species of mosquitoes found in the coastal and savanna zones of Liberia. *A. melas* and *A. gambiae* are the most abundant mosquitoes documented. Fairly abundant were also *A. funestus, Aedes aegypti, Culex nebulosus, C. mucheti* and *Mansonia Africana*.

Figure 3.5 The prevalence of microfilariae in four counties in the coastal region in Liberia



Source: Kuhlow & Zielke (1976).

3.4.2 Human survey of *W. bancrofti* in human populations in Liberia

In all the studies where gender was included, men in Liberia had higher prevalence of microfilaria 9.5%–24.0% as compared to their female counterparts 7.4%–19.0% (Zielke & Chlebowsky, 1979). A study carried out by Brinkmann (1972) also noted that men were twice as likely to have the infection compared to women. This increase in percentage was attributed to working in outdoor environments and that men tend to sleep late at night making them more prone to getting bitten by mosquitoes. The highest prevalence of parasites was observed amongst people between the ages of 40 and 49 years.

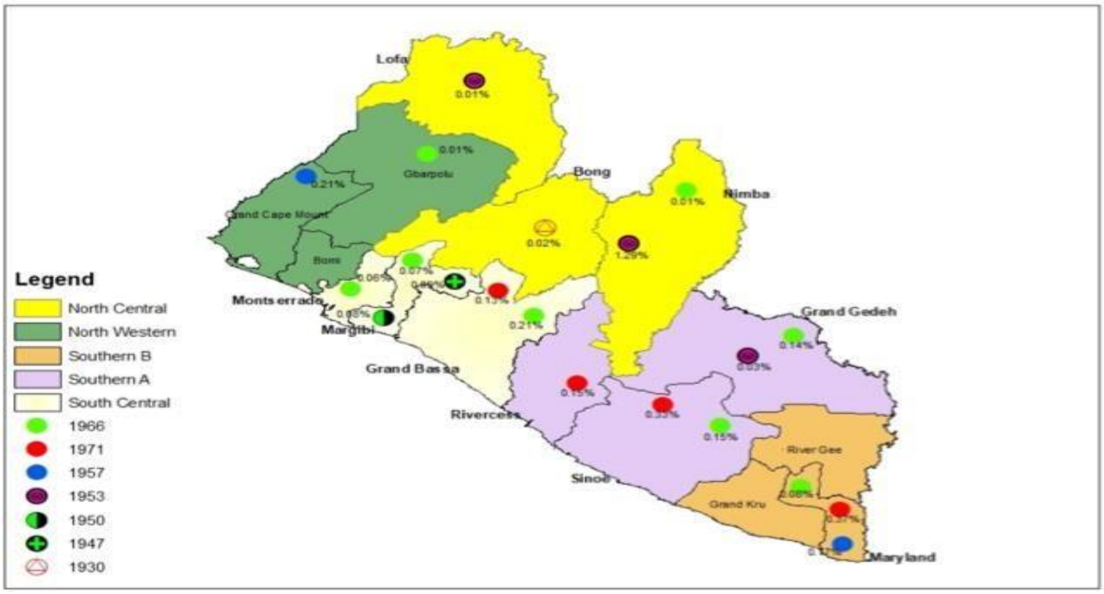
Table 3.4: Comparison of percentage prevalence of microfilariae in Liberia, by gender

Region	Total examined	Prevalence of microfilariae in females (%)	Prevalence of microfilariae in males (%)	Author, Year	Technique used
South-Eastern, Coastal	1,136	7.4%	9.5%	Diller (1947)	Thick blood film
South-Eastern, Coastal	180	19.0%	24%	Gratama (1966)	Knott method
Coastal	871	4.2%	8.4%	Brinkmann (1972)	Thick blood film
North Central /non-coastal	1,968	14%	19.0%	Zielke & Chlebowsky (1979)	Night blood smear

In the human population, the day blood smear revealed that there was active transmission of microfilariae in all four regions of Liberia. The highest percentage of prevalence for microfilariae was seen in the south-eastern region, coastal zone in Harper, Maryland County with a prevalence of 8.0% (Young, 1953), and the lowest percentage of prevalence of 0.3% was seen in the north-western region in the Gola Rainforest, Bomi County. These results correlate well with those by Kuhlow and Zielke (1976) who surveyed four counties in Liberia and found that Maryland County had the highest percentage prevalence of microfilaria (37.3%) compared to the other three counties: Bassa County (37.3%); Sinoe County (14.5%); and Rivercess County (14.0%).

The historical data correlates with the result of a nationwide mapping survey, which was conducted in Liberia by the MoH in collaboration with its partners, to determine the prevalence and epidemiology of LF in the country, the overall immunochromatographic test (ICT) prevalence was 24.0% with the highest percentage prevalence observed in the coastal regions as observed in the historical studies. In 2012, in order to conduct MDA after a period of 14 years of civil war, a total of 3,132 persons were examined between 22:00 p.m. and 02:00 a.m. This result also correlated with that of the historical data that reported the highest prevalence in the coastal regions.

Figure 3.6: Regional distribution of human population of *W. bancrofti* in Liberia per year of study



Source: Diller (1947); Briscoe (1952); Gelfand (1955a); Gratama (1966); Brinkmann (1972).

Table 3.5: Natural infection of *W. bancrofti* in humans in Liberia, by using day smear

Year	Regions	Counties	Prevalence rate of microfilariae (%)	Author, Year
1930	North Central	Bong	0.02	Strong & Shattuck (1930)
	South Central	Montserrado Roberts Field	0.3	

		/Margibi	0.8	
	South-Eastern			
		Grand Bassa	5.0	
		Sinoe – Greenville		Poindexter
1950		& Maryland – Webo		(1950)
		Tchien/Grand	5.0	
		Gedeh	3.0	
	North-	Gola		
	Western	Forest/Gabrpolu	0.3	
	North Central	Nimba	0.3	
	North Central	Nimba	1.0	
		Bong	1.5	
		Lofa	0.3	Young
1953	South-Eastern	Maryland	8.0	
		Grand Gedeh	0.0	(1953)
	South Central	Montserrado	2.0	
		Margibi		
		Margibi	3.5	

Table 3.6: Natural infection of *W. bancrofti* in humans in Liberia, by using night smear

Year	Regions	County	Prevalence of microfilariae (%)	Author, Year
1930	North Central	Bong	1.9%	Strong & Shattuck (1930)
1947	South Central	Margibi	8.8%	Diller (1947)
1950	South Central	Margibi	8.2%	Briscoe (1952)
	South-Eastern	Grand Gedeh	2.6%	Young (1953)
	North Central	Nimba	1.3%	
1953		Lofa	1.2%	
	Southern-Eastern B	Maryland	16.7%	Hawking (1957)
	North-Western	Grand Cape Mount	21.0%	Gratama (1966) Poindexter (1950)
1966				

		Gbarpolu	1.0%	
	South-Eastern B	Maryland	8.3%	
	South Central	Montserrado Margibi	5.9% 6.6%	
		Grand Bassa	20.0%	
	South-Eastern A	Grand Gedeh	14.0%	
		Sinoe	15.0%	
	North Central	Nimba	0.8%	
	South-Eastern A	Rivercess	14.5%	Kuhlow & Zielke
1976	South-Eastern A	Sinoe	33.1%	(1976)
	South-Eastern B	Maryland	37.3%	
	South Central	Bassa	13.0%	

Table 3.7: Continued and concluded natural infection of *W. bancrofti* in humans in Liberia, by using night smear

				Prevalence % of microfilarae	
			Wreboken	3.9% (153)	
	South-Eastern B	Grand Gedeh	Jiboken	0.0% (29)	Hawking, 1977
			Sureke	3.0% (200)	
			Gbalake	2.5% (120)	
1977			Dwekehn	1.2 (161)	
			Laryi	0.0% (58)	
			Chebioh	0.0% (80)	Hawking, 1977
			Tumbanville	1.8% (112)	
	South-Eastern A	Sinoe	Worteh	13.3% (75)	
		Maryland			

			Tuoh	1.2% (84)	
1979	South Central	Bassa	Blewen		Zielke & Chlebowsky 1979
			Kun		
			Balle Wreh	5.6% (143)	
				15.2% (46)	
				17.0% (47)	
			Quizah	4.8% (104)	
	North Central	Lofa	Upper Lofa	Men 19.0%; women 10.4%	

3.5 Discussion

3.5.1 Vector population

Sir Patrick Manson (1878) was the first who showed evidence that mosquitoes were the primary vectors of *W. bancrofti*. The principal mosquito species that convey the lymphatic filariae of humans are found in five genera: *Anopheles* (*W. bancrofti*, *B. malayi* and *B. timori)*; *Aedes (W. bancrofti* and *B. malayi)*; *Culex (W. bancrofti)*; *Mansonia (W. bancrofti* and *B. malayi)*; and *Ochlerotatus* (Chernin, 1983; Bockarie & Molyneux, 2009).

In sub-Saharan Africa, entomological investigations reported that *A. gambiae* complex are the principal vectors of *W. bancrofti* (Kiszewski, et al., 2004). In rural areas of East Africa bancroftia filariasis is mainly transmitted by *A. gambiae* and *A. funestus* and *Culex pipiens fatigans* is the main vector in urban areas. It has also been documented that effective vector control for malaria has been linked to the control of LF (Bockarie & Molyneux, 2009). In the study, national data from 17 countries on ITN ownership was analysed and the results reported there were some regions with >70.0% ITN ownership and suggested if this trend continued and is monitored, this may impact vector control of vector borne diseases (Kelly-Hope, et al., 2006).

This paper gives up-to-date information on the distribution of LF in the vector and human populations in Liberia. The main vectors for the transmission of *W. bancrofti* judging by dissections of wild-caught mosquitoes across the various surveys in Liberia are *A. melas* and *A. gambaie* (Gelfand, 1955a). It has also been reported in Mali that *A. gambiae* and *A. funestus* species are the predominant vectors of LF (Coulibaly, et al., 2006). In Gambia, the vectors responsible for the transmission of LF are *A. arabiensis*, *A. gambaie* and *A. funestus* (Knight, 1980); while in Freetown the LF vectors were identified as *A. costalis* and *A. funestus* (Gbakima & Sahr, 1996). In Ghana *A. gambiae* and *A. funestus* have been reported as LF vectors (Gyapong, et al., 2002).

The principal determining factors of the distribution and abundance of the mosquitoes are altitude, rainfall and humidity (Lardeux & Cheffort, 2001). Liberia, which is mostly flat land, has high humidity and heavy rainfall during the rainy season, which has the right environmental factors for mosquitoes to survive. Seasonal variations of the vectors were noted in this study. *A. gambiae* was seen essentially during the rainy season, while *A. melas* was found mainly during the early dry season in Liberia. *A. melas* was also found to be the predominant species in human dwellings (Peters, 1956).

The highest catch of the mosquitoes was noted during the rainy season from April to October, and the lowest catch was in the dry season from December to May (Briscoe, 1948). It has been observed that climate determines the spatial, seasonal distribution and inter-annual variability of many infectious diseases. Marshall Territory, now known as Margibi County, had the highest percentage prevalence of mosquitoes *A. gambiae* (19.5%) and A. *melas* (27.1%) (Gelfand, 1955a, 1955b). Ribbands (1944a, 1944b) reported that *A. gambaie* was observed to breed in seawater. Entomological studies along the coast of Ghana has also shown endemic foci of LF along the coast of the country (Dunyo, et al., 1996).

The study also observed that the breeding for *A. gambiae* and *A. melas* were mainly in small shaded streams, ditches and rocky pools that were in connection with running water and water containing dead vegetation, wells, swamps, grassy waterholes, slow flowing water temporary pools, borrow-pits, ditches, rock pools, small grounded pools found near houses, old cars and sandy small pools with muddy water fully exposed to sunlight (Peters, 1956). In Ghana, Gyapong (2000) observed that rainfall, humidity, temperature and surface area contributed to disease transmission.

The methodology for vector collection varied across the different studies in Liberia. The mosquitoes were caught using three different methods: (i) some of the investigators set up nightly collection stations where mosquitoes were trapped; (ii) human baited traps; and (iii) early morning catching of mosquitoes from the huts of the local population. In Ghana, an entomological study was carried out in the Upper East region, to investigate the transmission dynamics and intensity of LF. Mosquitoes were collected by indoor spraying of houses in cluster communities. The dissection and processing of these mosquitoes were also approached in various ways. Wild mosquitoes caught were dissected for the presence of filarial larvae that resemble those of *W. bancrofti*, while laboratory-reared mosquitoes of various indigenous species were fed on human volunteers who demonstrated microfilaria of *W. bancrofti* in the peripheral blood film.

These mosquitoes were then dissected to verify the presence or absence of *W. bancrofti* larvae. Dissection methods used were not uniform but varied. In some studies, the head, thorax and abdomen of the mosquitoes were dissected separately, while in other studies the dissection of the thorax was not done and other investigators did not mention the parts of the mosquitoes dissected or infected with larvae of *W. bancrofti*. Dissection was performed over a period of time and the various species were not all present at any one time. In the Ghana study (Appawu, Dadzie, Baffoe-Wilmot, & Wilson, 2001) each mosquitoe was dissected and put on a slide separately, with head thorax and abdomen dissected separately for each mosquitoes. The polymerase chain reaction (PCR) method can also be used to examine *A. gambiae* complex members for specific species identification; this technique provides accurate information about the transmission of *W. bancrofti* (Goodman, Orelus, Roberts, Lammie, & Streit, 2003).

3.5.2 Human population

Before the 1980s, the only parasitological method used to confirm diagnosis of infection with *W. bancrofti* was through the identification of microfilariae in peripheral blood using the thick smear method or Knott's technique (Knott, 1935). Since then, several other tests have been made to confirm the diagnosis of infection with *W. bancrofti*. Examples of such tests are the ICT used to detect the filarial antigen, which are released by the adult *W. bancrofti* worms in humans. ICT has the advantage to be used both during the day and at night (Weil, Lammie, & Weiss, 1997). The urine Enzyme-Linked Immuno-Sorbent Assay (ELISA test) has been used in countries for the purpsoe of verification post-MDA to detect the antifilarial IgG4 antibodies in human urine post-MDA (Takagi, et al., 2019).

The method used to identify microfilariae in humans by the authors of the various studies under review were by peripheral blood; microscopy was used to detect the filarial parasite. Blood preparations vary from thin to thick blood stained by using the Giema or the Knott methods. Both the day smear method and the night smear methods were observed across studies. They also observed that all mirocfilaria found were that of *W. bancrofti* (Young, 1953).

The standard method or gold standard for diagnosing active infection of LF is the identification of microfilariae in blood smears by microscopic examination using the night blood film examination (blood taken between 21:00 p.m. and 01:00 a.m.) (WHO, 2005). In recent times, PCR assay based on the amplification of a highly repeated DNA sequence found in *W. bancrofti* was developed to address some of the limitations of the traditional diagnostic methods (Fischer, at al., 2007). *Wuchereria bancrofti* antigen Wb123 is highly specific and sensitive, which aided in the development of its lateral-flow strip immunoassay. Enzyme linked immunosorbent assay (ELISA) tests carried out on patients infected and uninfected with *W. bancrofti* infections revealed that there was high sensitivity 93% and 97% (ELISA) with specificities of 92% and 96% (strips), respectively. Separation of the patients uninfected with *W. bancrofti* to those infected with other helminths or filarial infections including strongyloidiasis and onchocerciasis together with those who were free from any parasite infection, the assay specificities ranged between 91% and 100%. Additionally, the geometrical means obtained by ELISA of *W. bancrofti*-infected patients was established to be elevated as compared to those uninfected with *W. bancrofti* ($P < 0.0001$). This implies that *W. bancrofti* Wb123 protein is highly sensitive and specific to the IgG4 proving that it has the potential as a post-mass drug administration monitoring tool.

The sample population age varied across the different studies ranging from babies to adults (9 months to >50 years old). The participants also varied across the studies ranging berween 105 to 10,128 persons per study. Brinkmann in 1977 conducted a survey that covered the four regions of the country. The results revealed a high infection rate of microfalariae in the coastal region. This corroborated with the other three investigators' findings that showed that infection with nocturnal bancrofti occured in the human population in various parts of the country and they were more common in the coastal zone compared to the forest zone (Poindexter, 1950; Young, 1953). However, Kuhlow and Zielke (1976) reported high prevalence amongst the Gissi Tribe in the Lofa County located in the north-western region of Liberia. In Ghana, a baseline LF study revealed high prevalence of microfalariae 1.8%–20.0% in the northern savanna and the southern coastal areas with low prevalence in the middle forest belt (Gyapong, Adjei, Gyapong, & Asamoah, 1996).

Kuhlow and Zielke (1976) conducted surveys in four counties located in the coastal region of Liberia; their results revealed that the prevalence of microfilariae was highest in Maryland (37.3%), Sinoe (33.1%), Rivercess (14.0%) and Grand Bassa (13.0%). This result compared *W. bancrofti* transmission in three different Bioclimatic zones namely, coastal, savanna and forest zones, and showed that only 5.0% of the 8,072 persons examined from 82 localities in various parts of these zones in the country were positive for *W. bancrofti*. All these analyses showed an uneven distribution of the prevalence of microfilariae in the coastal zone showing the highest prevalence rate of 9.0% in the forest zone (Kuhlow & Zielke, 1976). Previous authors (Poindexter, 1950; Young, 1953) also reported that infections with nocturnal *W. bancrofti* occurred in various parts of Liberia were much common along the coastal region compared to the forest and savanna regions with a high prevalence of *W. bancrofti* 14.2% amongst the Gissi Tribe in the upper Lofa County, a forest region. A national survey for filariasis was conducted in Ghana to determine the prevalence and distribution of *W. bancrofti* microfilariae, the results showed a high prevalence of the disease and microfalariae in the northern Guinea savanna and the southern coastal savanna, the middle forest belt was somewhat free (Gyanpong, et al., 1996).

Young (1953) examined blood film of 10,128 persons of all ages and found a prevalence of microfilariae of 4.3% by using the night blood smear and *W. bancrofti* was the only species identified. The heaviest foci were again found in the coastal area. The daytime examination was performed mainly on students. In this study, the prevalence of microfilariae in adults at night was 6.0%. This was 15 times higher than the daytime rate of 0.4%. Young also showed that the natural infection of *W. bancrofti* in humans in Liberia using the day smear was seen to be the highest in the south-eastern region in Harper, Maryland County, having the highest daytime prevalence of 8.0%, which indicates active transmission of *W. bancrofti* (Young, 1953). A similar finding was shown in a study conducted in the coastal area of India, West Bengal. Night blood samples of 4,016 participants revealed the microfilariae rate of 9.1% (Chandra, Chatterjee, Das, & Sarkar, 2007). The intensity of the infection could not be ascertained in all of the studies as various methods of identification of *W. bancrofti* were used ranging from the night blood film method to the Knott method.

Overall, the serological data shows that microfalariae prevalence rate is higher in the coastal regions of the country, this correlated with the entomological findings of studies that reported that LF vectors were also highest in the coastal regions.

3.6 Limitations

1. The total mosquitoes collected and dissected in the studies could not be verified.
2. Lack of standardisation of the methodologies used for blood smear collection.
3. The intensity of the infection could not be ascertained in all studies carried out.
4. Total aggregate of the gender and population of both humans and mosquitoes was not possible.
5. Dissection of mosquitoes to determine the location of infective larvae present in the mosquitoes was not standardised across the studies.

3.7 Study strength

The main strength of this systematic review is that it provides an up-to-date listing of the literature on the distribution of the vector and human populations of *W. bancrofti* in Liberia.

3.8 Conclusions

Historical documentation has clearly established the vectors and human distribution of *W. bancrofti* in Liberia. It is probably prevalent in other entomological host and human populations in the country, but these have not yet been recorded. Therefore, further studies on the vectors and human distribution of filariasis needs to be conducted in Liberia to provide recent data of the vectors and human infections caused by *W. bancrofti s*pecies. The serological data showed that the microfilariae prevalence rate is higher in the coastal region of Liberia, which correlated with various entomological studies in the country that also reported that the LF vectors were also highest in the coastal regions.

CHAPTER 4: BASELINE MAPPING FOR LF BY ICT CARDS AND BASELINE MICROFILARIA PRE-MDA IN LIBERIA

4.1 Abstract

4.1.1 Background

A nationwide mapping was undertaken in Liberia in 2010 to determine the prevalence and geographical distribution of LF. In 2012, a baseline microfilaria survey was conducted to determine the prevalence and intensity of the disease in order to perform longitudinal monitoring of the impact of MDA during the intervention phase.

4.1.2 General objective

To map the distribution of LF in Liberia prior to implementation of a mass drug distribution.

4.1.3 Specific objectives:

- To determine the geographical distribution and prevalence of LF.
- To identify the implementation units before the start of MDA and implementation.
- To determine the population at risk for LF in Liberia.

4.1.4 Methods

In 2010, a total of 1,560 persons aged >15 years were sampled in all 15 counties of Liberia using the ICT cards to determine the presence of the filarial antigen. In 2012, a total of 3,132 persons aged >5 years had blood samples taken between 01:00 a.m. and 02:00 a.m. to determine the intensity of the microfilaria in the 11 endemic counties in Liberia.

4.1.5 Results

The overall ICT prevalence was 24.0% with the highest prevalence rate observed in the coastal region in Maryland and Grand Bassa Counties where antigenaemia exceeded 45.0%. Impact of gender and age on the distribution and levels of rates were not analysed for ICT as both parameters were not properly recorded. A total of 3,132

persons were examined between 22:00 p.m. and 02:00 a.m. in 2012 for microfilaria. The overall prevalence rate of microfilaria was 6.2%, with men having a higher prevalence compared to women (8.0% for men and 4.2% for women). A total of 1,498 men were examined for LF morbidity. The survey found a prevalence of 12.8% for hydrocele and 6.3% for lymphoedema, Maryland (7.5%) and Grand Gedeh (3.6%) had the highest prevalence rates for hydrocele. Maryland (3.0%) and Rivercess (2.3%) were observed to have the highest percentage for lymphoedema cases.

4.1.6 Conclusions

The mapping using the ICT cards showed that LF was endemic in 13 out of the 15 counties in Liberia. The survey provided a nationwide epidemiological data on *W. bancrofti* infections in Liberia and serves as the bedrock for the establishment of the NTD programmes in Liberia.

4.2 Introduction

In 2000, WHO established the GPELF with two main objectives: (i) to interrupt the transmission of LF; and (ii) to manage the morbidity associated with it and to prevent disability. The World Health Assembly Resolution WHA50.29 called on Member States to work towards the elimination of LF as a public health problem by 2020 (WHO, 1997).

The swelling due to LF is called lymphoedema and can be found on the breasts, legs and genitals of men. The advanced form of lymphoedema is called elephantiasis.

The clinical manifestation of elephantiasisis is graded as follows. Elephantiasisis of the limb is graded from 0 to 3: 0 = Normal; 1 = Loss of contour or lymphoedema; 2 = Thick skin and loss of elasticity; and 3 = Evidence of elephantiasis. Hydrocoele is graded from

0 to 3: 0 = Normal; 1 = Swelling of spermatic chord; 2 = Swelling up to 10 cms in diameter; and 3 = Swelling greater than 10 cms. Scrotal elephantiasis is graded from 0 to 3: 0 = Normal; 1 = Lymphoedema; 2 = Thick skin and loss of elasticity; and 3 = Evidence of elephantiasis, (Gyapong, et al., 1994, cited in Melrose, 2004).

According to WHO (2017b), around 947 million people worldwide are at risk of LF, of which approximately 40 million are incapacitated and disfigured by the disease. Although not fatal, WHO has ranked LF as the world's leading cause of permanent and long-term disability. Cutting the transmission of *W. bancrofti* can be achieved through annual MDA to the entire population at risk for a period of 5 to 6 years with the goal of reaching 65.0%–80.0% coverage yearly and/or vector control, which could lead to the elimination of the disease (WHO, 2011b).

The recommended therapy for cutting the transmission of LF is treatment of the population at risk with Ivermectin and Albendazole in areas where Oncho is coendemic with LF, such as in Liberia, whereas DEC and Albendazole are administered in areas where Oncho is not co-endemic. The regimens for MDA is as follows: annual treatment of the entire population at risk with a single dose of Albendazole (400 mg) and Ivermectin (150–200 mg/Kg) or DEC (6 mg/Kg) for 4 to 6 years or DEC, Albendazole and Ivermectin used for a period of 1 to 2 years as recently recommended by WHO for countries or districts not endemic for Oncho. There was a trial of a triple regimen therapy for LF in Papua New Guinea, which included the use of Ivermectin 200 μg and DEC 6 mg/Kg and Albendazole 400 mg all together given once a year for a period of 3 years. The result showed that there was a greater clearance of microfilaria compared to the two doses of DEC 6 mg/Kg and Albendazole 400 mg (King, et al., 2018).

There are surveys as far back as the 1930s that determine the presence of LF from clinical cases reported in the Marshall Territory (Gelfand, 1955a). However, there has been no national survey to determine the prevalence of the disease before 2010. The first nationwide baseline mapping for LF by using the ICT in Liberia was conducted in 2010 by the MoH in collaboration with WHO before the establishment of the NTD programme in the country. A prevalence map was developed, which indicated that LF was endemic in 13 of the 15 counties in the country (MoHSW, 2017a). In 2010, all 15 counties in Liberia were mapped. The survey revealed that 13 out of the 15 counties were endemic for LF. Those counties with levels of antigenaemia <1.0% ICT considered non-endemic for LF. The 2010 map guided the implementation of MDA by the LSTM and NTD Programme at the MoH Liberia. This paper presents an evolution of the national programme and looked at potential factors that could influence the prevalence of LF in Liberia.

Liberia has a total population of around 4.5 million when applying the growth rate of 3.2% according to the nationwide census in 2008 (Government of the Republic of Liberia, 2008). This paper will be the first comprehensive description of the geographical distribution of LF throughout Liberia.

Table 4.1: Key events related to elimination of LF implementation in Liberia

Year	Event
1947	Microfilariae survey conducted in Margibi County using night blood on 297 participants, showed a mean microfilaria prevalence of 8.8% (Diller, 1947)
1949	Young and Johnson recorded the finding of *A. melas* larvae in Monrovia (Young & Johnson, 1949)
1952–1955	Greater than 11,000 *A. melas* and *A. gambiae* complex were collected in Margibi County of which 733 were dissected and 27.1% were positive for filariasis (Gelfand, 1955a)
2010	National mapping of LF survey based on the use of ICT

2012	First baseline sentinel site microfilaria survey carried out prior to MDA implementation
2012	First round implementation of MDA
2013	Second round implementation of MDA
2015	Third round implementation of MDA
2016	Mid-term sentinel site survey implementation after three rounds of MDA
2017	Fourth round implementation of MDA

4.3 Randomisation method

Survey design: Cross-sectional survey.

Inclusion criteria: Random community sampling of 15 years and above that lived in the district and consented to participate.

Exclusion criteria: <15 years and considered to be sick.

Study period: July to October 2010.

4.3.1 Planning for mapping at national level

The national level planning meeting was held in Monrovia at the MoH. A 1-day training was held for research assistants at the MoH. Pre- and post-test was administered during the training to help access the knowledge of the participants before and after the training exercise. At the end of the training, participants were divided into three groups of five based on their counties of assignment. Each team developed a detailed work plan to enable them to systematically complete the survey. The meeting included surveillance officers, laboratory technicians and community health volunteers from the 15 counties. Included in the training was a WHO representative. After the training, participants were knowledgeable about the LF mapping procedures and demonstrated some skills and knowledge in carrying out the survey. Surveillance officers were responsible to work with their respective counties and health teams to carry out sensitisation in the targeted communities.

4.3.2 Ethical issues

Ethical approval for the survey was obtained from the research unit of the MoH. Participants of the study gave consent before they were enrolled. Two years after the baseline study MDA was started in all endemic counties. The investigating teams in collaboration with the county health officers in the various counties, obtained verbal as well as written consent from the town chiefs and elders as well as the study participants before the survey commenced.

4.3.3 Field activities

Pre-sensitisation was carried out before the survey, community members were asked to assemble at a central point, preferably a palaver hut or clinic. The details and objectives of the survey were explained. Individuals who consented to be part of the study were invited to a designated place within selected communities.

4.3.4 Data collection

A total of 1,560 persons aged >15 years old was sampled for daytime antigenaemia, using the ICT provided by WHO in Liberia (Weil, et al., 1997). During the survey, 60 μL of fingerprick blood was collected from each participant and placed on the ICT cards. Results were regarded as negative if after 10 minutes the card indicated a negative result; positive results were usually seen within 5 minutes of beginning the test.

Based on WHO guidelines, in each of the sampled communities at least 100 people aged >15 years old were sampled. The survey was stopped if one of the first 50 adults were found to be positive since this gives sufficient precision (1/50 = 0.02%) for an implementation unit (IU) to be declared positive. If 100 ICTs were negative in a county this county was considered negative for LF. Assessing the prevalence of LF using ICT cards is easy to use when trained properly because it has been observed that in large surveys, crowd control as well as handling the cards by untrained staff members may read the cards wrongly, which could contribute to misinterpretation of the results and may lead to an inappropriate decision for a district (Ottesen, 2000).

4.3.5 Microfilaria prevalence and density data collection prior to MDA implementation

Survey design: Cross-sectional survey.

Inclusion criteria: Random sampling of people 15 years and above that lived in the district and consented to participate.

Exclusion criteria: <15 years and considered to be sick.

Study period: 2–20 August, 2012.

Microfilaria prevalence and density data was conducted to define LF sentinel sites in Liberia and to collect baseline data on LF microfilaraemia. Sampling was conducted in accordance with WHO guidelines; recommending to have one sentinel site by county and one to two spot check sites or IU was selected. In Liberia, a county is considered an IU (WHO, 2010a). According to WHO, when counties are not highly populated, several IUs could share one sentinel site considering that, at a minimum, there has to be at least one sentinel site and one spot check site per 1,000,000 people

(WHO, 2010a). In Liberia, the sizes of the IUs are small, therefore, some units were merged and one sentinel and spot check site represents the merged units. Sites were chosen from areas of known high and low LF transmission, low or high mosquito densities, and high or low antigenaemia prevalence.

Pre-sensitisation was carried out before the survey at each sentinel site. Individuals were asked to assemble at a central point, preferably a health centre, clinic or town hall. All those consenting were tested using ICT cards and those tested positive were further tested for microfilaraemia using night blood collection. However, some individuals who were tested positive with ICTs refused to be tested at night. To ensure the standardisation of activities and data, prior to the study commencing, all technicians were given a 2-day practical training.

According to a study by Weil et al. in 1997 on the comparison of tests for the detection of circulating filarial antigen, prevalence of microfilaraemia before the 1990s was assessed by parasitological methods, which used the microscope to determine filarial infection. The sensitivity of these methods depends on the time of the day the blood was collected, which in Africa, microfilariae circulates in the peripheral blood between midnight and 02:00 a.m. (Knott, 1935) This method is widely used in countries that are endemic for filariasis.

The data collected from the sentinel sites were used by the NTD programme to determine the impact MDA has had on LF.

4.4 Methodology

A total of 3,132 samples were collected and examined using the night blood method. The gender distribution for the participants were as follows. A total of 60 μL blood sample was taken from fingertips of each participant between midnight and 02:00 a.m.

Blood collected was smeared on the slide and allowed to air-dry at room temperature. The following day, the dried smears were dehaemoglobinised by flooding with distilled water for about 5 minutes, air-dried again, fixed with methanol for 30 to 60 seconds, and then stained with Giemsa for 10 minutes before being examined for microfilaria under a light microscope. Positive findings of microfilaria were recorded.

4.5 Results

Table 4.2 provides the summarised results of the distribution of LF in Liberia.

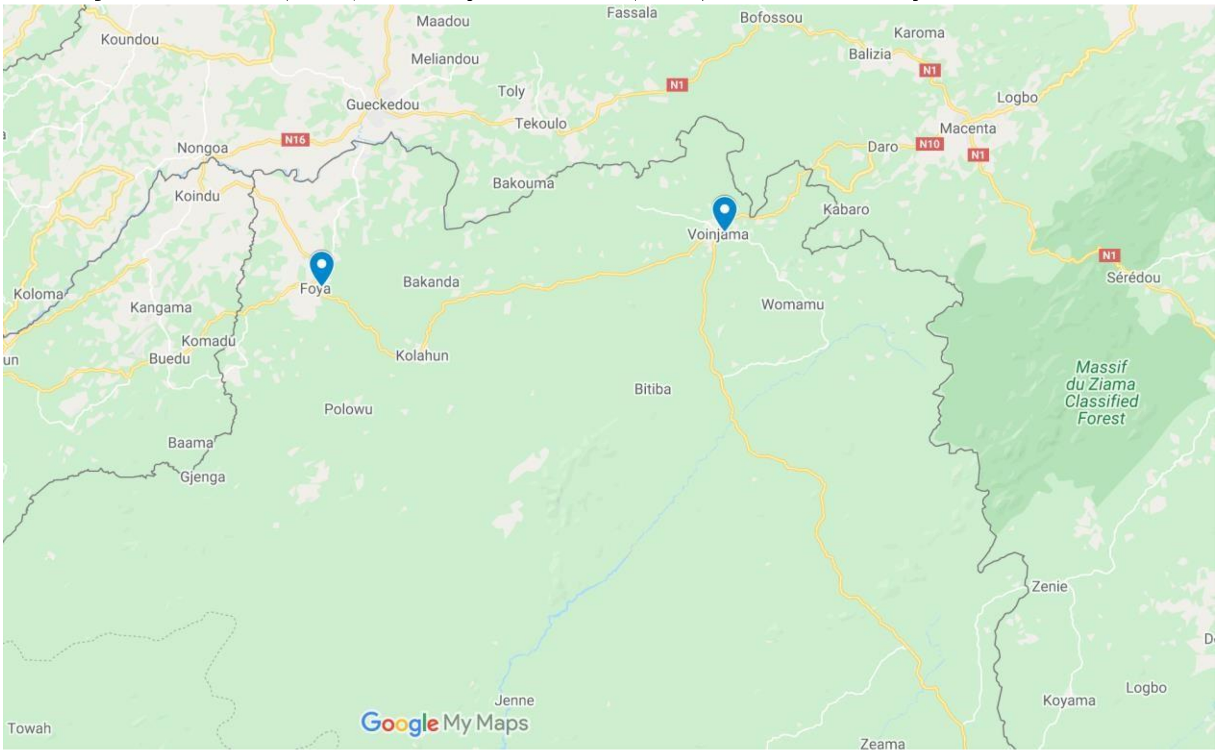
Table 4.2: Crude baseline LF prevalence with antigen detection and microfilaria test, by county and sex in Liberia

	Mapping		**Baseline microfilaria**		**Morbidity**	
positive	**No. of persons tested using ICT of**	**% prevalence antigen cards**	**No. persons examined microfilaria microfilaria**	**of % prevalence of for positives**	**% Hydrocele positive**	**% Lympho edema positive**
Total by counties	1,560	24.1%	3,132	6.2%	12.8%	6.3%
Montserrado	210	16.7%	300	0.3%	0.5%	0.0%
Bong	110	2.7%	300	3.0%	0.6%	0.0%
Sinoe	38	39.5%	294	20.0%	0.0%	0.0%
Rivercess	84	15.5%	300	5.0%	0.0%	2.3%
Maryland	52	46.1%	299	21.0%	7.5%	3.0%
Grand Bassa	28	46.4%	300	8.0%	0.0%	0.0%
Lofa	162	8.0%	300	4.7%	0.0%	0.7%
Grand Gedeh	128	6.3%	298	0.3%	3.6%	0.0%
Nimba	147	1.4%	300	0.0%	0.6%	0.0%
Grand Cape Mount	101	2.0%	290	1.7%	0.0%	0.3%
River Gee	119	5.0%	151	2.0%	0.0%	0.0%
Margabi	100	2.0%	–	–	–	–

Grand Kru	50	25.4%	–	–	–	–
Bomi	104	0.0%	–	–	–	–
Gbarpolu	126	0.0%	–	–	–	–
By sex						
Male	–	–	1,496	8.0%	All males	–
Female	–	_	1,636	4.2%	All males	_

Source: MoHSW (2017a).

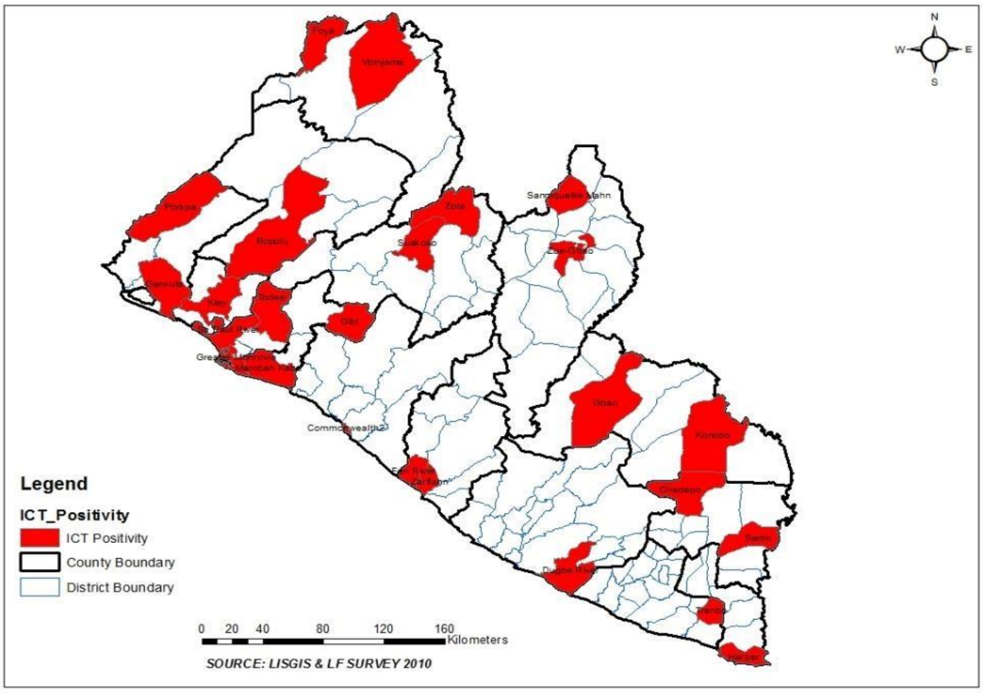
Figure 4.1: Google map showing ICT survey and the "baseline" survey carried out in Voinjama district (2010) and Foya disrtrict (2012) in Lofa County



4.5.1 ICT

All 15 counties in Liberia were surveyed using ICT cards. The results revealed that 13 of the 15 counties had a prevelance of ICT positive >1.0%. Figure 22 gives a graphic description of the communities. The overall ICT prevalence was 24.0% with the highest in the south-eastern coastal regions (Maryland and Grand Bassa Counties).

Figure 4.2: Map of baseline ICT card, results from survey in 2010 Liberia



Source: MoHSW (2017a).

4.5.*2 Microfilaraemia prevalence*

A total of 3,132 blood samples were examined between 22:00 p.m. and 02:00 a.m. of which 1,496 were males (47.8%) and 1,636 were females (52.2%). The results showed an overall prevalence rate of 6.3% with men having a higher prevalence compared to women.

Table 4.3: Crude data on the distributions of microfilaria prevalence and antigenaemia levels in Liberia from 1930–2022, by counties and year Baseline results 2012 before first MDA

Total by counties	**Historical data 1930–1990 (range)**	**Mapping 2010 by ICT**	**Baseline by ICT**	**% prevalence microfilaria**
Montserrado	7.6–21.0%	16.7%	0.0%	0.3%
Bong	1.9–3.6%	2.7%	3.3%	3.0%

Sinoe	15.0–33.0%	39.5%	19.3%	20.0%
Rivercess	–	15.5%	3.3%	5.0%
Maryland	15.3–37.0%	46.1%	21.3%	21.0%
Grand Bassa	13.0–20.0%	46.4%	7.3%	8.0%
Lofa	2.1–15.2%	8.0%	4.7%	4.7%
Grand Gedeh	33.0%	6.3%	33.6%	0.3%
Nimba	0.8–39.0%	1.4%	0.0%	0.0%
Grand Cape Mount	2.0–21.2%	2.0%	1.7%	1.7%
River Gee	–	5.0%	0.0%	2.0%
Margabi	3.8–14.0%	2.0%	–	–
Grand Kru	–	25.4%	–	–
Bomi	–	0.0%	–	–
Gbarpolu	–	0.0%	–	–

Source: MoHSW (2017a).

A total of 1,498 men were examined for LF morbidity the survey found an overall prevalence of 12.8% for hydrocele and 6.3% for lymphoedema. Maryland (7.5%) and Grand Gedeh (3.6%) Counties had the highest percentage prevalence for hydrocele. Maryland (3.0%) and Rivercess (2.3%) Counties had the highest percentage for lymphoedema.

Table 18 shows an uneven geographical distribution of *W. bancrofti* in Liberia. It also shows significant variations between regions and within regions. All the surveys were cross-sectional surveys.

4.5.4 Comparison of Liberia historical serological and entomological data to LF baseline data prior to MDA implementation in Liberia

The critical analysis of historical data on the distribution of *W. bancrofti* in vectors and human populations in Liberia reported that the south-eastern region in coastal areas had the highest prevalence of *W. bancrofti* vectors and microfilaria (see Chapter 3). This correlates with the nationwide survey performed in 2010 by the MoH, which also reported that indeed the south-eastern coastal region had the highest prevalence of microfilaria (MoHSW, 2017a).

In Liberia, for the purpose of determining the distribution of these diseases, various studies have been conducted. However, the first published report was by Diller in 1947, who reported that the disease was endemic in all Bioclimatic regions of the country and clinical manifestations was also found in the coastal region. Comparisons of results across the various surveys prior to MDA implementation in Liberia have demonstrated that LF is highly prevalent in the southern coastal regions of the country compared to the savanna and rainforest zones. There has also been evidence of repeated infected mosquito bites in the coastal region leading to the development of clinical filariasis in Liberia (Poindexter, 1950).

Various studies across West Africa showed the prevalence of *W. bancrofti* in the coastal regions. In Ghana, a study carried out by Gyapong et al. (2002) showed that the disease has a higher prevalence in the northern savanna areas with a microfilaria prevalence between 20.0%–40.0% and the coastal savanna areas (10.0%–20.0%). In Sierra Leone, a nationwide survey showed that LF was endemic in all 14 districts with *W. bancrofti* antigenaemia prevalence >1.0%, with a higher prevalence in the northeast regions (Bombali 52.0%; Koinadugu 46.0%; Tonkolili 37.0%; and Kono 30.0%) and lower in the south-west regions of the country (Koroma, et al., 2012). Also in the East

African country of Malawi a survey in 2002 showed that *W. bancrofti* infections were widespread in the country. The antigenaemia prevalence using the ICT cards was about 80.0% in some of the sampled villages (Ngwira, Tambala, Perez, Bowie, & Molyneux, 2007). In Kenya, similar studies were carried out by Wijers (2016) to get an insight on the prevalence of the disease in the coastal province. A cluster sample survey revealed 28.4% of the total of 5,004 males examined were found to be microfilaria positive.

4.5.5 Recent epidemiological studies in Liberia

Using the same platform used at the baseline in 2012, the NTD programme in Liberia in December 2016 carried out a survey after three rounds of interruption of MDA due to the Ebola virus. This survey confirms our baseline study carried out in 2012, which showed that microfilaria prevalence was highest in the south-eastern coastal region of the country. In order to determine the level of impact made through the MDA intervention for the control and elimination of LF, a couple of strategies have been instituted by the NTD programme in Liberia, including sentinel and spot check sites to evaluate the impact of the drugs. The sentinel sites are also used throughout the programme to determine the baseline parasitological indicators and to evaluate the changes in the indicators throughout the course of the programme.

MDA impact is ascertained when microfilaria surveys are performed using sentinel and spot checks. Since the implementation of MDA, there have been two rounds of sentinel and spot check sites in the country. The first sentinel and spot check site was conducted in 2012, while the second was conducted in 2016. According to WHO protocol, the first sentinel site survey should be conducted after two to three rounds of MDA (WHO, 2010b). The long period between first and second rounds of sentinel sites was due to the disruption of MDA activities caused by the Ebola outbreak in early 2014 to late 2015.

Sentinel sites require a minimum of 500 individuals, located in an area known to be highly endemic, where the population is stable and ideally with no previous history of Oncho and LF MDA. While spot check sites are used in association with sentinel sites and are selected based on the same criteria, they can change during each survey.

4.5.6 Key objectives of sentinel and spot check sites activities

- To determine the impact of the national LF elimination programme by detecting changes in LF prevalence and intensity using sentinel and spot check sites.
- To assess when the level of microfilaraemia is less than 1.0% in all sentinel sites suggesting that transmission has been interrupted and the country is ready to implement a Transmission Assessment Survey (TAS).

A survey to confirm LF transmission in big cities affected by conflict-related rural-urban migration in Sierra Leone and Liberia was conducted in 2014. The results revealed no evidence of active transmission of LF in cities, where internally-displaced persons from rural areas lived for many years during more than 10 years due to conflict (de Souza, et al., 2014).

Table 4.4: Microfilaria prevalence at spot check/sentinel sites, by county in 2012

Counties	Type of site	Participants tested per site	No. positive	Microfilaria prevalence
Grand Gedeh	Spot check	300	1	0.3%
Grand Bassa	Spot check	300	1	0.3%
Sinoe	Spot check	300	13	4.3%
Rivercess	Spot check	300	0	_
Maryland	Sentinel	300	33	11.0%

Grand Cape Mount	Sentinel	300	1	0.3%
Nimba	Sentinel	300	0	–
Bong	Sentinel	300	1	0.3%
Lofa	Sentinel	300	4	1.3%
Montserrado	Sentinel	300	0	–
Rivergee	Sentinel	300	4	1.3%
Total		**3,300**	**58**	**0.2%**

Source: NTDs unit MoH sentinel site survey

4.5.7 The role of vector control programmes on LF

The Roll Back Malaria Partnership programme established in 1998 by WHO and funded by its partners the United Nations Children's Fund (UNICEF), the United Nations Development Programme (UNDP) and the World Bank advocates for the use of integrated vector management and utilises the use of multi-programme synergies. However, global financial crisis affected the sustainability of the programme (Mutero, et al., 2015).

A study conducted by Njenga et al. (2011a) in coastal Kenya found that despite some of the villages had missed MDA during 2 years, the microfilariae were maintained in the absence of further MDA by the use of ITNs. The anitgenaemia levels declined form 34.6% in 2002 to 10.8% in 2009. These results were especially apparent when the major vector of *W. bancrofti* in these areas was Anopheles (Njenga, et al., 2011b).

Table 4.5: Distribution of bednets per county (Roll Back Malaria)

Counties Nimba	**2006**	**2007**	**2008**	**2009**	**2010**
	27.3%	32.1%	35.1%	36.3%	48.8%
Bong	34.6%	39.0%	41.7%	44.0%	57.2%
Bomi	27.6%	30.4%	32.5%	35.8%	50.1%
Rivercess	22.9%	26.4%	28.6%	30.1%	43.0%
Margibi	22.3%	25.4%	27.6%	29.8%	42.8%
Grand Gedeh	27.4%	31.6%	34.2%	35.0%	46.9%

Grand Kru	21.2%	24.0%	25.3%	25.7%	36.6%
Sinoe	21.2%	24.8%	27.0%	27.9%	40.2%
Maryland	23.6%	26.3%	27.5%	27.9%	38.7%
Montserrado	21.6%	24.3%	26.3%	29.0%	42.2%
Grand Cape Mount	32.5%	36.2%	38.4%	41.3%	55.9%
Grand Bassa	23.0%	26.3%	28.5%	30.2%	43.1%
Lofa	33.8%	40.0%	43.1%	44.2%	57.0%
Gbarpolu	32.3%	37.2%	40.0%	42.0%	55.8%

Source: President Malaria Initiave (2018).

In Liberia, according to the National Drug Service, there has been an upscale in bednets distribution by the MoH and its partners. The three Demographic and Health Surveys carried out in the country in 2007 (30.1%), 2009 (48.6%) and 2013 (59.6%), respectively showed an increase in household ownership of bednets in the country (see Table 20). ITNs could be a confounding variable in the decrease in both the microfilaria and antigenaemia levels in the country. The use of ITNs and improvement in environmental sanitation has proven to be effective in eliminating LF in the Solomon Islands (Webber, 1977). Preventive measures on the use of ITNs seems to be effective, but the cost-effectiveness still needs to be researched.

4.6 Discussion

Mansonella perstans

Mansonella perstans is a vector-borne human filarial nematode, which is transmitted through tiny insects known as biting midges or sucking flies. Geographically, it is widely spread across sub-Saharan Africa as well as parts of America (Central and South). The parasite can cause various morbidities and complications if not well managed. However, despite the prevalence of the parasite there is still lack of definite therapy for its complete elimination. Specifically, in Africa, there is a lack of adequate documented evidence on its transmission, symptoms, diagnosis and prevention. This thus poses a gap, which requires further investigation in order to improve the management of the filarial nematode and for recommending appropriate strategies on its treatment and control. Understanding this is vital in reducing any risks, complications, morbidity or mortality associated with *Mansonella perstans.* The donations of Ivermectin and Albendazole began since the establishment of GPELF and have been tested and found to be safe and effective in reducing the number of circulating microfilariae in the blood and preventing transmission of the infection (Horton, et al., 2000). Yearly MDA is carried out with at least 65.0% coverage of the total population in endemic areas (WHO, 2013b). The first campaign was in Egypt and Samoa and by the 2009 MDA had covered at least 496 million people at risk, and 37 countries were in the process of completing their fifth MDA. Since the establishment of GPELF in 2000, a total of 6.2 billion treatments have been delivered to greater than 820 million people at risk for at least once. By using the strategy of the GPELF the elimination of LF has occurred in some countries, for example, Korea, Japan, China, Thailand and the Solomon Islands. These countries followed the elimination strategy and have stopped the transmission of the infection permanently (Molyneux, 2003). Timor Leste and Senegal and have now achieved 100.0% geographical coverage bringing these countries on track to achieving elimination. Community sensitisation on the knowledge and perception of the disease must be carried out in order for successful elimination of LF (Cabral, 2017). Two pharmaceutical companies have given donations for the antifilarial drugs Albendazole by GlaxoSmithKline and Ivermectin by Merck and Co.

4.6.1 Baseline prevalence and intensity of infection for ICT

The baseline study on LF in the country has contributed immensely to the knowledge and epidemiology of LF in Liberia it has been the basis for which the NTD programme has been built. It provided the epidemiological information of the distribution, prevalence and intensity of LF, which could be used to build an elimination strategy of

LF in the country. The baseline data collected included demographic information, prevalence of the disease and its intensity. The NTD programme in the country used this baseline data for the longitudinal monitoring impact of MDA that has been carried out annually.

There have been different studies on Bancroftian filariasis in Africa that have showed how highly endemic the disease is. The baseline study of the epidemiology assessment of LF was the most comprehensive survey ever documented to have been carried out in Liberia prior to starting MDA implementation. The survey showed variation in and between regions. Due to the population size of the country and implementation of health-related activities 13 out of the 15 counties of Liberia have been declared endemic for LF. The transmission was confirmed to be in all regions and Bioclimatic zones of the country with the south-eastern coastal region (Grand Bassa and Maryland Counties) having the highest prevalence rate of 46.4% and 46.1% respectively). The prevalence ranged from 2.0%–46.4% with an overall prevalence of 24.0%. This confirms the findings of a previous study by Brinkmann (1977) who worked in the coastal zone of Liberia and reported *W. bancrofti* prevalence ranging from 2.0%–37.0% and had a median microfilariae density between 250 mf/mL and 1,200 mf/mL. All studies in Liberia have reported that the south-eastern coastal region has high transmission of *W. bancrofti*. In Sierra Leone, a nationwide LF mapping study was carried out to obtain baseline data on the prevalence of *W. bancrofti* infection using ICT for circulating filarial antigen, where the overall LF prevalence was 21.0% (Koroma, et al., 2012).

The baseline results also found high prevalence in the northern savanna regions of Lofa and Bong Counties. Lofa County had ICT prevalence of 8.0% and microfilaria prevalence of 4.7%, Bong County had ICT prevalence of 2.7% and microfilaria prevalence of 3.0%, but Nimba County had negative results for both the ICT and microfilaria prevalences. This shows how disproportionately the disease is distributed in the country. Unevenness in the geographic distribution of the disease in the country has also been reported by Diller (1947), when he conducted a survey in four counties.

The Ghana Health Services in 1999 conducted a nationwide prevalence survey to determine the prevalence and distribution of LF in which they reported that the disease had a higher prevalence in the northern savanna regions of the country and the coastal region and a lower prevalence in the forest region (Gyapong, 2000). These findings correlate to our results obtained during the baseline study, which showed that the coastal and savanna regions have a higher prevalence of LF as compared to the rainforest regions. This could be attributed to the presence of the vector in these regions as compared to the rainforest. A study on the distribution of LF in West Africa reported that the disease foci occurred in the savanna, coastal and some rainforest regions. The low altitude and tropical nature of Liberia could be a contributing factor to the prevalence of the disease. Cano et al., (2014) showed that LF transmission increased with mean maximum temperature and decreased with altitude.

4.6.2 The microfilaraemia

In Liberia in 1947, a microfilaria survey was done in Margibi County and night blood showed that 297 (8.8%) of the participants were positive for the larval worms. A breakdown by age and sex indicated that the infection can be acquired during the early years of life and continues into adulthood. The prevalence of microfilaraemia and antigenaemia increased with age. The circulating filarial antigen is an indicator of adult worm loads (Weil, et al., 1997). The age-related increase in the prevalence of antigenaemia indicates that the infection is age-related. A study of a cohort of children in Haiti established that filarial infections are acquired early in life (Hamlin, 2012).

The historical surveys noted that many males with scrotum enlargement, knee and ankle swelling and females with elephantiasis of the breasts were seen (Diller, 1947). The baseline microfilaraemia survey in 2012 in 11 counties showed an overall microfilaria prevalence of 6.2% with a range of 0.3%–21.0%. Maryland a coastal county had the highest prevalence of 21.0%. This is because Maryland the most populated costal county in the southeast of the country, and the communial life style of the people. They are more netted together. Males were twice as positive as females; this may be due to the fact that males sit outside with friends late at night making them exposed to mosquito bites. The prevalence of infection has been stated to be higher in males than females in many studies. It has been hypothesised that gender differences, sex hormones, immune effectors and females in reproductive age have markedly lower levels of infection. The microfilaraemia survey corroborated the results of the mapping survey in 2010.

During the survey in 2012, the presence of the clinical form of the disease was assessed and was found to be hydrocele 0.0%–8.0% and for lymphoedema was 0.0%–4.6%; this is much higher then that of Ghana were the baseline prevalence of the clinical forms were 0.4% for elephantiasis and 0.0%–35.0% for hydroceles (Gyapong, Webber, Morris, & Bennett, 1998). In Liberia, the overt forms of the disease have caused a significant social stigma. People presenting with the clinical signs tend to go further in the forest to live to avoid having contacts with others. Gelfand (1955b) stated in one of his communications that an entire community in Marshall Territory (now known as Margibi County) was deserted because some of the community members showed clinical signs of the disease.

The baseline study also gives an estimate of the population at risk for LF in Liberia. In 2010, the population of the country was 3.9 million, but with a 3.9% annual change, the population has increased to 4.7 million in 2017. Of the 15 counties surveyed and mapped using ICT, 13 had >1.0% circulating filarial antigen (CFA) positive. This is around 80.0% of the country's population at risk. The total population at risk of LF in Liberia is projected to be 4 million.

4.6.3 Impact of vector control on the reduction of microfilaria

Low microfilaria prevalence of *W. bancrofti* was found in Liberia during the baseline study despite 2 years of interrupted MDA due to the Ebola crisis in the country. Studies conducted between 1930 and 1990 have revealed a decline in the endemicity of LF pior to MDA. This could be attributed to vector control through distribution of bednets by the Roll Back Malaria programme through the MoH and the indoor residual spraying (see Figure 24). However, there is a need for studies to be conducted. WHO gave a Position Statement in 2011, which endorsed integrated vector management for the control of LF and malaria (WHO, 2011c).

4.7 Conclusions

In Liberia, 13 counties were endemic for LF although at different levels in terms of burden. Mapping and sentential sites survey conducted respectively in 2012 and 2016 clearly illustrated the foci of LF. The mapping results indicate that Maryland County, which is a coastal county, despite four rounds of MDA, still had the highest LF prevalence. This could be attributed to communites being missed during the MDA due to difficult road conditions. The research gives the baseline data for the country's NTD programme to design and implement MDA and serves as the bedrock for the monitoring and evaluation of LF in Liberia.

4.8 Recommendations

1. Additional research on LF to be conducted in Bomi and Gbarpolu Counties, which had less than 1.0% ICT prevalence and were considered non-endemic for LF because the protocol for mapping by WHO may have caused these two counties to have been missed.
2. The NTD programme should collaborate more with the malaria control programme to ensure that areas with high transmission rate of LF be given priority during distribution of ITN and residual spraying.
3. Those counties in the south-east are given priority during MDA in order not to have them missed, as was the case for Maryland County.

4.9 Study limitations

Some participants who had a CFA positive by the ICT were not willing to give blood or night blood smears owing to fears of undue experimentation.

CHAPTER 5: ASSESSMENT OF KNOWLEDGE AND COMPLIANCE TOWARDS MDA INTERVENTION FOR THE CONTROL OF LF IN BONG COUNTY, LIBERIA: A CROSS-SECTIONAL STUDY

5.1 Abstract

5.1.1 Background

In Liberia, there have been four MDA campaigns for LF interrupted due to the EVD. In the country, annual MDA is carried out using Ivermectin and Albendazole.

5.1.2 Objective

To access the efficiency of drug distribution by the community drug distributors (CDDs) and to assess associated compliance and knowledge of individuals in Bong County after four rounds of MDA.

5.1.3 Methods

A descriptive cross-sectional population KAP survey was conducted using structured questionnaires. The survey was conducted from January to February 2018 in Bong County.

5.1.4 Results

More than 60.0% of the participants were aware of the disease and more than 50.0% of the participants knew of the common symptoms of the disease. Around 63.0% of the participants were compliant to the MDA programme. Those that were non-compliant were afraid of the side effects. However, only 43.3% of the participants admitted to taking both medications, while 50.0% of the participants knew the mode of transmission of the disease.

5.1.5 Conclusions

The findings from this study have shown that there was some awareness regarding LF in the communities. Majority of the participants had knowledge of the MDA programme. However, there is a great need for pre-MDA campaigns and health education to improve compliance by the community.

5.2 Introduction

The GPELF was established in 2010 by WHO with the goal of eliminating LF by 2020. The GPELF launched a two-pronged strategy for the elimination of the disease. First, by MDA to people living in endemic communities in order to stop the spread of the infection (interrupting transmission). Since the beginning of MDA there are some counties that have been declared free of LF. The second strategy of GPELF is morbidity control to reduce the suffering of those already affected by the disease (WHO, 1997). Five rounds of medications are needed to interrupt transmission. In countries like Liberia where Oncho is also endemic it is recommended that annual MDA using Ivermectin (150– 200 μg/Kg) combined with Albendazole (400 mg) in communities where LF and Oncho are more prevalent be distributed to the entire population at risk, but with the exception of pregnant women, children <90 cms in height and very sick people. According to the 2017 WHO report on LF, about 28.0% of the countries that are endemic for LF are now having post-MDA surveillance to confirm that they have achieved elimination (WHO, 2017c). A randomised controlled study conducted in 2013 by Awadzi et al. (2013) to determine if the combination of Ivermectin with Albendazole was safe, reported that the drug was effective with no serious adverse effects observed. Compliance with Ivermectin and Albendazole medication is cardinal to achieving the elimination of LF as advocated by GPELF. A study conducted by

Yirga, Deribe, Woldemichael, Wondafrash and Kassahun (2010) in south-western Ethiopia, showed four positive predictors that can influence compliance to Ivermectin: (i) high risk perception; (ii) family support; (iii) perceiving that CDDs are doing their work well; and (iv) perceiving that measuring the height is the best way to determine a person's treatment dose. Health education before the MDA helps to improve compliance to the drugs (Nuwaha, Okware, & Ndyomugyenyi, 2005). Figure 25 gives a graphic description of vector control for the control of LF.

5.3 Assessment of coverage

Coverage is defined as the percentage of individuals in a given population that received drug or a drug combination in an intervention area (Albonico, Engels, & Savioli, 2004). WHO also defined coverage as the percentage of all residents of an endemic area who swallow the drugs should at least be ≥65.0%. If high drug coverage is not attained, untreated individuals could potentially act as reservoirs of transmission, hindering control and elimination efforts (WHO, 2011b). For the assessment of coverage, the LF coverage report 2016–2017 was obtained from the MoH NTDs unit, Liberia (.Due to the EVD outbreak in 2014, the NTD programme was suspended. However, there have been four rounds of MDA, which all reported high coverage. To verify the coverage reports, a cross-sectional survey was carried out from 23 March 2017 to 20 May 2017 by the MoH and its partners. This study was conducted in eight counties by the NTDs unit (one district each). Using population-proportionate sampling, the survey report showed that an overall coverage percentage of 84.0% had taken the medication. This is above the required 65.0% coverage recommended by WHO.

The Community-Directed Treatment with Ivermectin (CDTI) first adopted by the African Programme for Onchocerciasis Control (APOC) was found to be effective.

Community members selected by the community leaders were trained in the distribution of medication (Amazigo, 1999).

Table 5.1: Coverage of LF MDA, by district

County	**District**	**Communities (individuals) surveyed**	**Reported coverage* % (total population)**	**Verified coverage** % (total population)**	**Count of communities with <65% verified coverage (total population)**
Bong	Panta Kpaai	27 (809)	84.0	44.4	17
Grand Bassa	Buchanan	28 (929)	84.0	29.5	24
Grand Cape Mount	Garwular	30 (943)	82.0	71.4	11
Grand Gedeh	Konobo	29 (895)	81.0	57.9	12
Lofa	Voinjama	30 (913)	88.0	94.3	30
Maryland	Pleebo Sodoken	30 (895)	82.0	61.8	13
Rivercess	Jowen	24 (823)	83.0	92.5	0
Sinoe	Kyanyan	27 (939)	83.0	84.2	3
Total		**225 (7,146)**		**67.0**	**110**

Source: MoH NTDs unit 2016–2017 coverage report. *Reported coverage = Mass drug treatmnent reported by drug distributors during MDA; **Verified coverage = A coverage survey done to verify mass drug treatment by a programme.

5.4 Objectives

To access the efficiency of drug distribution by the CDDs and to assess associated compliance and knowledge of individuals in Bong County post-Ebola MDA. The researcher used structured questionnaires.

5.5 Methodology

5.5.1 Study area

Geographically, Bong County is located in the North Central region of Liberia. It is one of 15 counties. According to the 2008 census, Bong County has a population of 328,919 and measures approximately 3,387 square miles. The 2008 census puts Bong County as the third largest county of Liberia (Government of the Republic of Liberia, 2008). The Bong County has 12 political districts. However, the MoH has also divided Bong County into eight health districts. The Bong County is co-endemic for LF, STH and SCH. The survey was conducted in Zota (18,943 population) and Suakoko (28,277 population) districts.

5.5.2 Design (randomisation)

This survey was a population-based survey, using the EPI 30 x 7 method (WHO, 2008). Participants were selected from 30 clusters in each district where LF is endemic. For each cluster, seven houses were randomly selected. Those interviews were with the heads of the household, spouse and anyone above the age of 15 years. A standardised pre-tested questionnaire was used to collect data on compliance and knowledge of mass drug treatment using Ivermectin and Albendazole. The participants were asked on their KAP towards LF. The respondents were the head of each household their spouses and anyone above the age of 15 years who lived in the house and participated in the interview.

Figure 5.1: Interviewing a man with elephantiasis in Suakoko district, Bong County

Note: Written consent was obtained from this participant for his photo to be placed in this thesis (see Appendix D).

5.6 Results

5.6.1 Household survey

The survey was conducted in two districts, Zota and Suakoko. A total of 1,191 study participants were surveyed in 60 different communities within the Zota and Suakoko districts and 420 households were visited. There were 210 households visited in each district (see Table 22). Majority of the participants were in the age group 25–44 years (N =642) (see Table 23).

There were 617 (51.8%) females and 574 (48.2%) males that took part in the study. Liberia is predominantly a Christian nation and 86.6% of the participants were Christian. Around 58.3% of the participants were farmers and only 11.7% of the participants had a high school diploma (see Table 5).

Table 5.2: Surveyed population, by the two districts

District	No. of clusters surveyed	No. of households surveyed	Surveyed population
Suakoko	30	210	632
Zota	30	210	559
Total	**60**	**420**	**1,191**

Table 5.3: Surveyed population, by gender and age

	Age			
Sex	**15–24 years**	**25–44 years**	**45 years +**	**Total**
Female	123	329	166	**618**
Male	111	313	149	**573**
Total	**234**	**642**	**315**	**1,191**

Table 5.4: Sociodemographic characteristics

Sociodemographic characteristics		N = 1,191	%
Age	15–24 years	234	19.6
	25–44 years	642	53.9
	45 years and above	315	26.4
Gender	Male	574	48.2
	Female	617	51.8
Religion	Christian	1,031	86.6
	Muslim	158	13.3
	None	2	0.2
Educational level	Completed high school	139	11.7
	Elementary	301	25.3
	Have never had formal education	449	37.7
	Junior high	207	17.4
	Secondary high	95	7.9
Marital status	Cohabiting	161	13.5

	Divorced	47	3.9
	Married	587	49.3
	Single	314	26.4
	Widowed	82	6.9
Occupation	Business person	197	16.5
	Farmer	694	58.3
	Fisherman	44	3.7
	House wife	50	4.2
	Hunter	76	6.3
	Others	130	10.9

5.6.2 Assessment of drug compliance in relation to the two districts

Compliance (sometimes referred to as adherence) is a term used to denote a degree to which a client correctly follows advice. In this study it indicates how correctly the individuals followed instructions from drug distributors (Albonico, et al., 2004). For the community to be compliant to the MDA, the CDDs have to be accepted by the community, selected by the community, live within the community and be people of integrity (WHO, 1996). They could also be placed on payrolls to enable them to adequately carry out their duties.

Liberia is endemic for LF and a survey to determine the compliance of the medication is necessary to determine the impact of the NTD programme. Following the fourth round of drug distribution, a post-MDA survey was undertaken in Bong County from January to February 2018, this was done to assess possible factors influencing compliance/non-compliance and potential adverse effects. A total of 1,190 individuals were enrolled in this study.

In this study, 63.6% of the participants admitted to taking the medication during the MDA, 9.3% said they took Albendazole alone, and only 43.3% said they took both medications. The reasons for non-compliance varies, but majority (20.0%) said it was due to itching of skin after taking the medication, while 12.9% said it was due to weakness and dizziness (see Table 5.5). The side effects of MDA are specific to the drug that are given and and individual tolerance. This includes, vomiting, neausea, rashes, abdominal pains, dizziness and headheaches.

Table 5.5: Compliance and non-compliance

Compliance		**N**	**%**
Did you take the medication?	Yes	757	63.6
	No	434	36.4
Did you take Ivermectin alone?	Yes	110	9.2
	No	1,081	90.8
Did you take Albendazole alone?	Yes	111	9.3
	No	1,081	90.8
Took both of the medication together?	Yes	516	43.3
	No	675	56.7
Reasons for non-compliance		***N***	**%**
Weakness and dizziness		154	12.9
Impotency		1	0.1
Abdominal pain		80	6.7
Diarrhoea		42	3.5
Blood in faeces		5	0.4
Sweating		32	2.7
Nausea		13	1.1
Vomiting		100	8.4
Itching of skin		238	20.0
Fever and chills		58	4.9

5.6.3 KAP towards intervention of LF

A total of 1,191 participants participated in the survey. The study found that 69.3% had knowledge of the disease and 71.5% had known about MDA (see Table 5.6).

Table 5.6: KAP

		N	%
Knowledge of LF	Yes	825	69.3
	No	366	30.7
Total		1,191	
		N	**%**
Knowledge of how the disease is acquired	Through drinking dirty water	21	1.8
	Through traditional rituals	22	1.8
	Through mosquito bites	18	1.5
	Through farming	8	0.7
	Others	1	0.1
		N	**%**
Knowledge of clinical manifestation of the disease	Enlarged legs	623	52.3
	Enlarged scrotum	108	9.1
	Enlarged breast	75	6.3
	Fever and chills	38	3.2
	Mumps	131	11.0
		N	**%**
Knowledge of prevention	By taking medication	138	11.6
	By drinking clean water	38	3.2
	By using mosquito nets	11	0.9
	By spraying your house	14	1.2
	Others	4	0.3
MDA programme		**N**	**%**
Do you know about MDA?	Yes	851	71.5
	No	293	24.6
	Don’t Know	47	3.9
		N	**%**

How many times was the drug distributed in your community?	One	436	36.6
	Two	103	8.6
	Three	132	11.1
	Four	111	9.3
	Don't know	409	34.3

5.7 Discussion

There is overwhelming evidence that for chemotherapy-based control strategies such as that implemented for LF to be successful, adherence to treatment is cardinal for ensuring and sustaining good coverage. In this study, only 63.6% of participants admitted to taking the medication during MDA. Whereas 12.9% said that they did not take the medication because they experienced weakness or dizziness after taking the medication and 20.0% said that they experienced itching of the skin once they consumed the medication. Results from a similar study in Haiti showed that 74.0% of the respondents said they were given medication during MDA but only 71.0% swallowed the tablet (Eberhard, 1996). The results obtained from this study will be communicated to the MoH on the importance of pre-MDA educational campaigns in Liberia. If the community is aware of the risk factors associated with the disease, there will be a higher compliance rate and that in the upcoming MDA the NTD unit should have strategies, which will help to improve compliance and sustain the success of the programme.

For MDA to be successful there has to be pre-MDA sensitisation to help to alleviate the fears of community members who believe that the drugs cause adverse effects. There have been similar studies in India, which reported that reasons for noncompliance to the implementation ranges from fear of side effects to lack of perceived benefits (Babu & Mishra, 2008). In this study, 71.5% of participants had knowledge about the MDA before the distribution of the drugs, which indicates that the awareness of the implementation of MDA was adequate. However, a similar study carried out in Lofa County in Liberia reported 89.0% of respondents knew the purpose of the MDA (Bogus, et al., 2016). A KAP survey carried out in India on the predicators of compliance of MDA reported that in one community 97.1% of the respondents knew about MDA in advance, while in another community only 69.1% of the respondents knew about MDA (Cantey, Rout, Rao, Williamson, & Fox, 2010). For successful implementation of MDA it is very important that the community is aware of the purpose of the MDA as there are many health-related activities ongoing in the various communities, which makes it difficult for them to differentiate. Health education should be carried out and the risk and benefits of the drug be properly explained to the community (Talbot, et al., 2008). Of the total 1,191 respondents, 617 (51.8%) were females and 574 (48.2%) were males. This can be attributed to the fact that in Liberia women mostly stay at home or do farming compared to men who go on hunting expeditions. The result in this study correlates to a similar study carried out in Port-auPrince, Haiti, which reported that 70.0% of the respondents in their study were women and 88.0% of their respondents said information about MDA was disseminated to them before the process had started (Beau de Rochars, et al., 2004).

In our survey, the majority of participants indicated that LF is obtained from drinking dirty water and through traditional rituals and not transmitted by mosquitoes. This is in agreement with the findings of a study in West Bengal, India, which reported that only 13.9% of the respondents did not know the mode of transmission of LF and few had incorrect knowledge that direct contact, water and air are modes of transmission (Karmakar, et al., 2011). In this study 52.3% of participants knew that enlarged legs was a symptom of LF as well as enlarged scrotum, where some of the participants thought that mumps was a clinical manifestation of LF. This result corresponds to a study in Malaysia, which reported that majority of the participants responded that the common symptom of LF was leg swelling (Nazeh, et al., 2014).

5.8 Conclusions

The findings from this study have showed that there was some awareness regarding LF in the communities. Majority of the participants had knowledge about the MDA programme. However, the study also revealed that those particpants who did not take the medication did so because of the perceived side effects. This shows that the information of the disease has not been adequately conveyed to the community, making some of the people in the community to be non-compliant. Pre-MDA campaigns by the health promotion unit in collaboration with the NTD unit at the MoH will improve the rate of compliance and hence, programme success.

CHAPTER 6: AN EPIDEMIOLOGICAL SURVEY ON UROGENITAL AND INTESTINAL SCH AMONGST SCHOOL-AGE CHILDREN IN BONG COUNTY, LIBERIA, WITH OBSERVATIONS ON STH

6.1 Abstract

6.1.1 Background

Urogenital (*S. haematobium*) and intestinal (*S. mansoni*) SCH are serious public health problems in sub-Saharan Africa and school-age children are often at high risk for acquiring STH, i.e., *Ascaris*, *T. trichiura*, hookworms and STH. SCH infection is typically acquired by playing and bathing in cercarial infested water while STH is usually acquired ingesting eggs of *Ascaris* or *T. trichiura* or by walking barefoot on soil that is contaminated with hookworm larvae infections. Helminth infections are most obvious in school-age and pre-school-age children. An epidemiological followup study was performed to assess the prevalence and intensity of SCH and STH amongst school-age children in Liberia after MDA using Bong County as an exemplar.

6.1.2 Methods

A cross-sectional parasitological study was conducted from September to October 2017. A total of 1,003 school-aged children (5–15 years of age) were recruited from 10 randomly selected schools in Bong County. The school list was a representative of high and low infection prevalence in the Bong County. The listing of the schools was obtained from the Ministry of Education. Participants were registered on a prestructured and tested questionnaire and were given two labelled containers with their name and identification number (one for the stool sample and the other for the urine sample). Stool samples were collected and processed by the Kato-Katz method for STH and *S.*

mansoni. To determine the prevalence of *S. haematobium* urine specimens were collected and processed using the 10 mL urine filtration method.

6.1.3 Results

Of the total 1,003 school-aged children sampled, 504 (50.2%) were female and 499 (49.8%) were male. The results from the study showed that 123 (12.3%) schoolchildren were infected with *S. mansoni* and 112 (11.2%) schoolchildren were infected with *S. haematobium.* The results of the STH survey revealed a low prevalence for the disease with hookworm at 3.3% and *Ascaris* at 1.2%.

6.1.4 Conclusions

This study clearly showed that STH, *S. mansoni* and S. *haematobium* are endemic in Bong County and are a public health problem in Liberia. There is a need for implementation of MDA, continuous health education, and mobilisation and sensitisation activities, at both district and community levels. The low prevalence of STH in Bong County could be attributed to the annual national deworming programme in the country.

6.2 Introduction

STH, SCH, LF and Oncho are the most common NTDs in sub-Saharan Africa and are major public health problems (Molyneux, et al., 2005). SCH, or Bilharziasis, is a disease caused by parasitic trematode flatworms of the genus *Schistosoma*. There are more than 200 million people infected globally with the disease, with many more at risk of being infected, and 192 million cases of SCH occur in sub-Saharan Africa. The highest cases are found in Nigeria, Tanzania, Democratic Republic of Congo and Ghana

(Steinmann, et al., 2006). WHO has declared SCH as a public health disease, and an NTD targeted for elimination by 2020 (WHO, 2012b). However, there are some countries that still have ongoing transmission (Fenwick, 2017).

Studies on the epidemiology of SCH were carried out at the LIBR from the 1970s to 1989. Many water bodies (streams, ponds and rice paddies) in Lofa, Bong and Nimba Counties examined during the period were found to be harbouring molluscs (*Biomphalaria* and *Bulinus* species), which are the intermediate hosts of human schistosome. As a result of these findings, an SCH Surveillance Unit was established in each of the affected counties and was set up jointly by the World Bank and the Government of Liberia Development Projects. The SCH Surveillance Unit collected baseline data on the prevalence of SCH and other helminthic infections, amongst other activities, in these affected counties also known to be agriculture project areas, as it has been reported that SCH prevalence increases as a result of irrigation and agriculture projects (MoHSW, 2017a). Results from these studies showed that the prevalence of *S. mansoni* was significantly higher than *S. haematobium* (Mangal, Paterson, & Fenton, 2008).

People living close to water bodies, lakes, rivers, reservoirs and ponds that are infected with snails, which is the intermediate host, are at high risk of contracting the disease. These are some of the challenges, which in the future may cause the elimination of this disease to be unattainable by 2020 (Fenwick, 2006). After the civil war and to restart interest in disease control the Liberian MoH in collaboration with LSTM and APOC in 2010 conducted a study in all 15 counties consisting of a sample size of 3,144 schoolchildren who provided both stool and urine samples. The mean age of the schoolchidren examined was 10.7 years, with an age range between 7 and 14 years. The prevalence of *S. mansoni* and *S. haematobium* were 9.0% and 6.0% respectively

(MoHSW, 2017a).

There are five species of *Schistosoma* that can cause disease in humans of which there are three major species, which cause morbidity in humans namely, *S. haematobium* found in Africa and the Middle East, *S. mansoni* found in Africa and South America, and *S. japonicum* found in China and East Asia. The other two species are *S. mekongi* found in Laos and Cambodia and *Schistosoma intercalatum* found in West and Central Africa. Both *S. japonicum* and *S. mekongi* are mainly zoonotic species. In some countries, mixed infection has been observed with *S. mansoni* and *S. haematobium*. SCH may cause approximately 200 million deaths annually (Chitsulo, et al., 2000). Pre-school and school-age children are at high risk of infection, where infection is caused by bathing in freshwater, lakes, ponds and rivers that are contaminated with cercarial larvae. It has been observed amongst children living in endemic areas that the burden of the worms progressively increase and climax during adolescence (Gryseels, at al., 2006).

SCH can cause a wide range of symptoms and consequences depending on the species, the worm burden and the length of time infected. Individuals may have moderate to mild parasitic load and limited morbidity, while heavy infection with the disease occurs in fewer populations (Tukahebwa, et al., 2013). It has been reported in many studies that malaria and SCH are co-endemic in many regions and that developing hepatocellular carcinoma may be potentiated in people with co-infection (Yosry, 2006). Infection with *Schistosoma* is not evenly distributed within communities, which may be attributed to distribution of infected aquatic snails, acquired resistance, age-related and differences in exposure patterns. Each schistosome species requires a specific freshwater snail species *S. mansoni* (*Biomphalaria*), *S. haematobium* and *S. intercalatum* (*Bulinus*), *S. japonicum* (*Oncomelania*) and *S. mekongi* (*Tricula*) (Clements, et al., 2006). The current control strategy recommended by WHO for SCH and STH is by MDA with Praziquantel and Albendazole (Praziquantel 40 mg/Kg body weight + Albendazole 400 mg), targeting mainly school-age children and adults at high risk of infection. Pre-school-age children and infants are also being considered for inclusion in the target population (WHO, 2010d).

STH, commonly known as intestinal worm infection, is a public health problem in the tropics. They are the most common infections affecting the most deprived communities in sub-Saharan Africa (Hotez, et al., 2009). STH are transmitted due to exposure to contaminated soils containing larvae e.g., hookworm, or by ingestion by eating foods that are contaminated with eggs of *T. trichiura* and *Ascaris* (WHO, 2012b). The warm climate is essential for the STH eggs to thrive. Risk factors for developing STH are poor hygiene, poor sanitation and poverty (Vandemark, Jia, & Zhou, 2010).

Of the 7 billion population of the world it is estimated that between 807–1,121 million are affected with *Ascaris*, 604–795 million are infected with *T. trichiura* and 567–740 million are infected with hookworms. School-age children in particular are mainly affected with STH. It has been reported that approximately 89 million of the 181 million school-age children in sub-Saharan Africa are affected with one or more of the STH infections. About 135,000 deaths of STH occur annually (Brooker, Clements, & Bundy, 2006). The three main STH infections are: *Ascaris lumbricoides* (roundworms); *T. trichiura* (whipworms); and hookworm (*Ancylostoma duodenale* and *Necator americanus*). Common clinical conditions of STH can be anaemia, poor nutrition, stunted growth, diminished cognitive development and decreased physical fitness (Bethony, et al., 2006; Stothard, et al., 2009a).

Morbidity control of STH is primarily achieved through MDA administering a single tablet of Albendazole 400 mg or Mebendazole 500 mg. This control strategy has been used for decades and is still the forefront intervention for STH control alongside improvements in food, water, sanitation and hygiene. The addition of Mebendazole to vitamin A supplementation expanded the treatment to children aged 12–59 months with high coverage. The control of STH is also integrated into other programmes such as nutrition, school health and often parts of SCH control programmes or LF control programmes.

In Liberia, following the civil war and collapse of health infrastructures, there are not many studies conducted to assess STH prevalence and intensity. However anecdotal data from MoH clinics and hospitals indicate that *Ascaris, T. trichiura* and hookworm are the widely distributed STHs in Liberia (MoHSW, 2011a). However, in 2010 a study by the MoH and its partners reported that of the 3,144 schoolchildren from 59 schools around the county, the main STH species were *Ascaris* followed by hookworm, which also ranged from 0.0% to >50.0% per school. Liberia has now established a nationwide co-ordinated deworming programme due to the estimated high prevalence of the disease. UNICEF and the MoH in collaboration with the School Health Division of the Ministry of Education have targeted children aged 2 to 5 years in all 15 counties for deworming. It is believed that 65.0% of children under 5 years and pregnant women in rural areas in Liberia are anaemic due to *Ascaris*, *T. trichiura*, and hookworm (MoHSW, 2011a). Deworming also takes place when the LF drugs are distributed. To remedy this weakness, this chapter describes a survey that was conducted in Bong County to provide up-to-date information on SCH and STH infections.

6.3 Objectives

6.3.1 General objective

- To provide up-to-date information on the distribution, prevalence and intensity of SCH and STH in Bong County using an integrated surveillance approach with stool and urine sampling.

6.3.2 Specific objectives

- To determine demographic and clinical information from each of the schoolage children that was investigated on SCH and STH.
- To determine the prevalence and infection intensity of SCH (*S. haematobium* and *S. mansoni*) and STH (*Ascaris, T. trichiura* and hookworm) in Bong County.
- To create an integrated map for SCH and STH across sampled schools.

6.4 Methodology

6.4.1 Ethical considerations

The study protocol received ethical approval from the Univeristy of Liberia – Pacific Institute for Research and Evaluation Institutional Review Board at the MoH and the Ethics Committee of the LSTM. Approval was also received from the County Health Team and Ministry of Education in Liberia. The method and purpose of the study was explained to selected school authorities.

Prior to conducting demography and obtaining informed consent, the research team held repeated community meetings in all of the selected schools to communicate the purpose of the study and to answer questions at individual and community levels. The meetings highlighted: participant selection and participation; procedures and protocol; duration of the study side effects; risks and benefits of the study; confidentiality and sharing the results; the right to refuse or withdraw from the study;

and who to contact in case of any event. School heads were asked to sign written consent forms on behalf of schoolchildren targeted to participate in the study. The procedure was then explained to each schoolchild, who met the inclusion criteria, and asked to consent verbally to participating in the study. Amongst the schoolchildren that met the inclusion criteria, only those who provided consent were registered and requested to provide samples. Verbal consent was documented by recording the name of each schoolchild who provided consent. Paper forms were stored for the duration of the study plus 3 years per Institutional Review Board protocol for primary data storage. Demographic and morbidity forms included the following details: the participant's name; a unique study identification number (USIN); date of the sample collected; date of birth; sex; family relationships; and place of residence.

6.4.2 Team composition and training

The research team comprised of five members: a principal investigator; one microscopist; one datarecorder; one specimen collector; and one smearer. A 1-day orientation was held in Bong County for the research team. The principal investigator was Dr Louise Kpoto, the datarecorder was a school principal/teacher, and the microscopist, specimen collector and smearer were all county laboratory technicians.

The orientation was aimed at updating the team on the: research protocol; administration of informed consents; handling and transportation of samples to The C B Dumbar Laboratory for microscopy; parasitological examinations (Kato-Katz and the urine filtration methods); completion of data forms; and the manipulation of the GPS (Garmin eTrex 20) for collecting geographical co-ordinates. The GPS was truned on to determine our locations using satellites signals.

Pre-test was carried out after the team training and before the project began. The pre-test was aimed at standardising the specimen collection. The day was spent on evaluating the consistency of egg counting amongst the laboratory technicians. A simple method consists of preparing 10 slides and comparing the reading of each slide by each laboratory technician with that of the quality control officer. A discrepancy of 5.0%–10.0% for egg per slide count was considered normal, but a larger discrepancy led to the test not being considered valid, and reasons were identified and corrected. Accurate egg per slide count is particularly important for the Kato-Katz method for intensity assessment. Each school was investigated for 2 days and then the team moved on to the next school.

6.4.3 Selection of study population

The method used to select primary schools from the sampling frame was by stratified random sampling and involved:

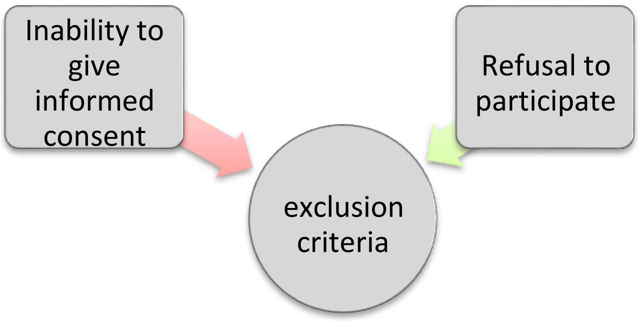
- The sampling frame consisted of a list, obtained from the MoH, on all primary schools in the Liberian districts classified as high or medium risk for *S. haematobium* and *S. mansoni*.
- Ten schools were randomly selected from a sample frame, which included schools co-endemic for *S. haematobium, S. mansoni* and STH.
- The sampling frame included: the name of each school; the district in which each school was located; the identification code of each school; the location of each school (geographical co-ordinates); the total number of students in each school; and whether the school was a high- or medium-risk area for *S. haematobium* and *S. mansoni*.

6.4.4 Inclusion and exclusion criteria

The inclusion criteria involved: the willingness of the school to participate and provide informed consent; the school being a resident in the Bong County, North Central region of Liberia; schoolchildren aged 5–15 years; and the school located in an area at high or medium risk of SCH and STH.

Schools who were unable to provide informed consent or refused to participate were excluded from the study (Figure 6.1).

Figure 6.1:Criteria for exclusion to participate



6.4.5 Sample size calculation

Based on the inclusion criteria of schoolchildren aged 5–15 years, the average number meeting this criterion was 100 schoolchildren. Using the Creative Research Systems sample size calculator for a confidence level of 95.0% with a confidence interval of 5, from the population of 134 schoolchildren meeting the criteria per school, the calculated sample size was 100 schoolchildren per school and 1,000 schoolchildren for the 10 schools.

6.4.6 Data collection for SCH and STH

Upon arrival to the selected schools, the schoolchildren that met the selection criteria were registered on the child personal form by the recorder and were each given two labelled containers, which contained their name, their USIN and their class. Each schoolchild was explained, which cup was for the stool sample and, which cup was for the urine sample. When the schoolchild returned the specimen cups, the recorder for quality control, checked that the labels on the cups were correct and the specimens properly collected.

6.5 Survey methods

To determine the prevalence and intensity of *S. mansoni* and STH infection, the KatoKatz method was used. To determine the presence and intensity of urinary SCH, the 10 mL urine filtration method was used. The detection of haematuria was also carried out on the schoolchildren by using the hemastix method.

6.5.1 The Kato-Katz method

In the Kato-Katz method for diagnosing *S. mansoni*, the general principle is that people infected with intestinal schistosomes pass the eggs of the worms with their faeces. By examining a stool specimen under a microscope, it is possible to count the number and the type of eggs that are present (see Figure 28).

Figure 6.2: Using the Kato-Katz method for the diagnosis of *S. mansoni*

6.5.1.1 Safety precautions

- The stool should be considered potentially infectious.
- Wear gloves and laboratory coats whenever handling stool samples.
- Benches, instruments and equipment should be routinely decontaminated with disinfectants after use.
- Materials contaminated with infectious waste should be disinfected before disposal.
- Drinking or eating during laboratory procedures is prohibited.
- Appropriate disinfectant(s) should be used for disposal of contaminated materials, wooden spatulas and specimen containers, and for cleaning of workbenches.
- Used specimen containers must be disinfected before washing. *6.5.1.2 Equipment for the Kato-Katz method*

Kato-Katz equipment involved:

- Stool sample in container (polythene squares tied with grass or plastic pot).
- Microscopic glass slides.
- Cellophane sheets (hydrophilic, 30–50 µm thick).
- Malachite green (or methylene blue).

- Glycerol.
- Metal sieve (Endecott Sieve) with 200–250 µm mesh size.
- Slide boxes.
- Newspapers.
- Wooden or plastic applicators.
- Forceps.
- Kato-Katz plastic template with a hole of 6 mm on a 1.5 mm thick template (delivering 41.7 mg of faeces).

Microscopic examination equipment involved:

- Microscope.
- Hand tally counter.
- Laboratory forms.

Disinfectants and waste disposal equipment involved:

- Disinfectant wipes.
- Medicated soap.
- Methylated spirit.
- Waste container (containing disinfectant).

6.5.1.3 Preparation steps of Kato-Katz reagents

Below are the five steps involved in the Kato-Katz reagents.

Step 1: Weigh out 3 g of Malachite green powder (or methylene blue).

Step 2: Dilute it in 100 mL of distilled water (this is the 'stock solution').

Step 3: Dilute 60 mL of glycerine in 40 mL of distilled water.
Step 4: Take 1 mL of Malachite green (or methylene blue) stock solution and add it to 100 mL of the 60.0% glycerol solution (this is the 'working solution').

Step 5: Cut cellophane into 25 mm x 30 mm pieces and soak them overnight in the working solution.

6.5.1.4 Before preparation

- Use clean containers for stool collection.
- Ensure the reusable sieves, templates and spatulas are well cleaned and dry.
- Clearly and correctly label the stool containers to match the participant USIN.

6.5.1.5 Kato-Katz steps

Step 1: Place two glass slides alongside each other and label both slides with the sample number and then place a plastic template on top of each.

Step 2: Place a small amount of the faecal specimen on a newspaper and press through the metal sieve. Using a spatula, scrape the sieved faecal material through the sieve so that only the debris remains on top.

Step 3: Scrape up some of the sieved faeces from the underside to fill the hole in the templates, avoiding air bubbles and levelling the faeces off to remove any excess. **Step 4:** Carefully lift off the templates and place it in a bucket of water mixed with concentrated detergent so that they can be reused.

Step 5: Place one piece of the cellophane, which has been soaked overnight in the Malachite green (or methylene blue) working solution, over the faecal specimen. **Step 6:** Place a clean slide over the top and press it evenly downwards to spread the faeces in a circle (this can be done by inverting the slide onto clean newspaper and pressing firmly). If done well, it should be possible to read the newspaper print through the stool smear.

Step 7: The ideal time for observing *S. mansoni* eggs is 24 hours after preparation, however, in bright sunlight the slides clear rapidly and a 24 hour delay is not necessary.

6.5.1.6 Microscopic examination for S. mansoni

Step 1: After 10 minutes place a little amount of eosin on the slide and place it under microscope using x 10 objective.

Step 2: Count ALL eggs present using a hand tally counter; start in one corner of the sample and systematically scan the whole sample in a 'zig zag' scheme.

Step 3: Record the number and the type of each egg on a recording form alongside the sample number. If no eggs are seen, record '0'.

Step 4: Each sample should be examined by two technicians, one technician reading slide A and the other technician reading slide B.

Step 5: 10.0% of slides A and B should be randomly selected and re-examined by a more experienced technician.

Discrepancy in egg count should not be greater than 10.0%. If discrepancy between readers is greater than 25.0% all slides should be re-read.

The participants were placed in three categories (light, moderate or heavy) based on the intensity of the infection.

For *S. mansoni:*

Light (1–100 eggs per gram).

Moderate (101–400 eggs per gram).

Heavy (>400 eggs per gram).

For *S. haematobium,* intensity of the egg per 10 mL of urine:

Light (1–50 eggs per 10 mL).

Moderate (51–499 eggs per 10 mL).

Heavy (>400 eggs per 10 mL).

Step 6: Once examination of the slides is completed, including quality control, remove the faeces and cellophane using a tissue into the waste container. Place all slides used when conducting the Kato-Katz method into the disinfectant. These slides should be cleaned and used again for the survey.

6.5.2 Hemastix method

In diagnosing *S. haematobium*, all manufactured kits come with instructions on how to use them. It is very important to follow the instructions to ensure the quality of the results.

6.5.2.1 Equipment for Hemastix test

- Case record form.
- Hemastix test strip and Hemastix pot with scale.
- Scissors.
- Gloves.
- Disinfectants and waste disposal.

6.4.2.2 Steps for reagent strips

Step 1: Collect a fresh urine specimen in a clean plastic container. Ensure that the urine is tested in the field within 2 hours of collection. If there is a delay, refrigerate the specimen if possible.

Step 2: Remove one strip from its bottle (you can cut the strip in two to save resources) and label the strips with the patient identification.

Step 3: Completely immerse the reagent areas of the strip into the urine specimen for a few seconds.

Step 4: When removing the strip, run its edge against the rim of the container to remove any excess urine.

Step 5: Put the strip horizontally on the table so that the chemicals do not mix together.

Step 6: Read the strip between 1 minute and 2 minutes after it has been dipped in the urine specimen.

Step 7: Match the colour of the strip with the colour chart on the bottle label and record the results on the monitoring form. Record '0' if the result is negative.

1 = trace non-haemolysed.

2 = trace haemolysed.

3 = +

4 = ++

5 = +++

6.5.3 Urine filtration Standard Operating Procedures

In diagnosing *S. haematobium*, all manufactured kits come with instructions on how to use them. It is very important to follow the instructions to ensure the quality of the results.

6.5.3.1 Safety precautions

- The urine should be considered potentially infectious.
- Wear gloves and laboratory coats whenever handling urine samples.
- Benches, instruments and equipment should be routinely decontaminated with disinfectants after use.
- Materials contaminated with infectious waste should be disinfected before disposal.
- Drinking or eating during laboratory procedures is prohibited.
- Appropriate disinfectant(s) should be used for disposal of contaminated specimen containers and for cleaning of workbenches.
- Used specimen containers must be disinfected before washing.

6.5.3.2 Equipment For general use:

- Gloves.
- Laboratory forms.

For urine filtration:

- Urine pots (20 mL).
- Swinnex Filter Holder.
- Tweezers/Forceps.
- Syringe, plastic, 10 mL.
- Nucleopore Membrane Filter, 13 mm diameter and pore size 12 µm.
- Microscope glass slides.
- Lugol’s Iodine (5.0% solution).

For microscopic examination:

- Microscope.
- Hand tally counter.

For disinfectants and waste disposal:

- Bucket (to discard urine).
- 1.0% hypochlorite solution (domestic bleach).
- Methylated spirit.
- Medicated soap.
- Rubber washing gloves.
- Disinfectant wipes.
- Waste container (containing disinfectant).

6.5.3.3 Sample collection

The number of eggs in the urine varies throughout the day, with the highest between 10:00 a.m. and 14:00 p.m. The specimen should be taken between these times and consist of a single urine sample. Since eggs are more often found at the end of a urine flow, at least 10 mL should be collected at the end of urination (the terminal urine). The easiest way to ensure a terminal urine sample is to ask individuals to ‘try to fill’ a large pot, e.g., 250 mL. Note that some children, particularly those who are heavily infected with SCH, may not be able to provide 10 mL of urine. Do not discard these smaller samples, but note the volume (mL) of urine provided. Specimens should be examined as soon as possible after collection as the eggs may hatch and then become invisible, or crystals may form, making a correct diagnosis more difficult.

6.5.3.4 Steps for urine filtration

Before preparation:

- Use clean containers for urine collection.
- Ensure the filter holders and syringes are well cleaned and dry.
- Clearly and correctly label the stool containers to match the participant USIN. **Step 1:** Unscrew the filter holder and insert a nucleopore filter between the two parts of the filter holder. Make sure it is correctly held in place before screwing the unit together again.

Step 2: Thoroughly shake and mix the urine specimen before drawing a 10 mL specimen into the syringe. Then attach the filter unit.

Step 3: Keeping the syringe and the unit in a vertical position, press the plunger down to push all the urine through the filter and out into a bucket.

Step 4: Carefully detach the syringe from the filter unit. Draw air into the syringe, reattach the syringe to the filter unit holder and expel the air again. This is important as it removes any excess urine and ensures that the eggs are firmly attached to the filter.

Step 5: Unscrew the filter holder and use a pair of tweezers to remove the filter and place it inverted onto the glass microscope slide labelled with a USIN. The top side of the filter, where the eggs were captured, should be face-up on the slide.

Step 6: Add one drop of Lugol’s iodine and wait 15 seconds for the stain to penetrate the eggs. This makes the eggs more easily visible.

Step 7: Immediately examine the whole filter under a microscope at a low power (x 40). Schistosome eggs can be seen clearly because they stain orange. Record the *total number of eggs on the filter.*

Step 8: At the end of the day, wash all reusable equipment (forceps, filter holders, syringes, urine containers and glass slides) in 1.0% hypocholorite solution (domestic bleach) for use next day, discard used filters and clean the workbench.

Step 9: Around 10.0% of slides should be randomly selected and re-examined by a more experienced technician. Discrepancy in egg count should not be greater than 10.0%. *If discrepancy between readers is greater than 25.0% all slides should be reread.*

6.5.3.5 Quality control measure

Quality control was implemented to verify the consistency of the microscopic readings and to ensure compliance with the following: wearing protective gloves and clothing at all times when handling the specimen. Make sure all specimens are properly labelled.

A quality control officer, highly trained personnel on microscopy of SCH and STH, cross-examined 10.0% of all positive and negative specimens to ensure the quality of the data. School and student personal data forms were properly filled and USIN on the form matched with the specimen.

6.5.3.6 Survey data and processing

Standardised pre-tested, paper base form was used for data collection. Participant information included: name of schoolchild; assigning a USIN; date sample was collected; date of birth; and sex.

Data was entered using SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) directly from labelled forms that were collected during the field survey, using chi square to determine the cross tabulation.

6.6 Results

6.6.1 Schools and districts

A total of 10 schools were randomly selected to participate in the study. The schools were selected from each of the eight health districts. Two districts had two schools selected from it due to the size of the districts (see Figure 6.3).

Figure 6.3: Bong County showing the location of schools surveyed

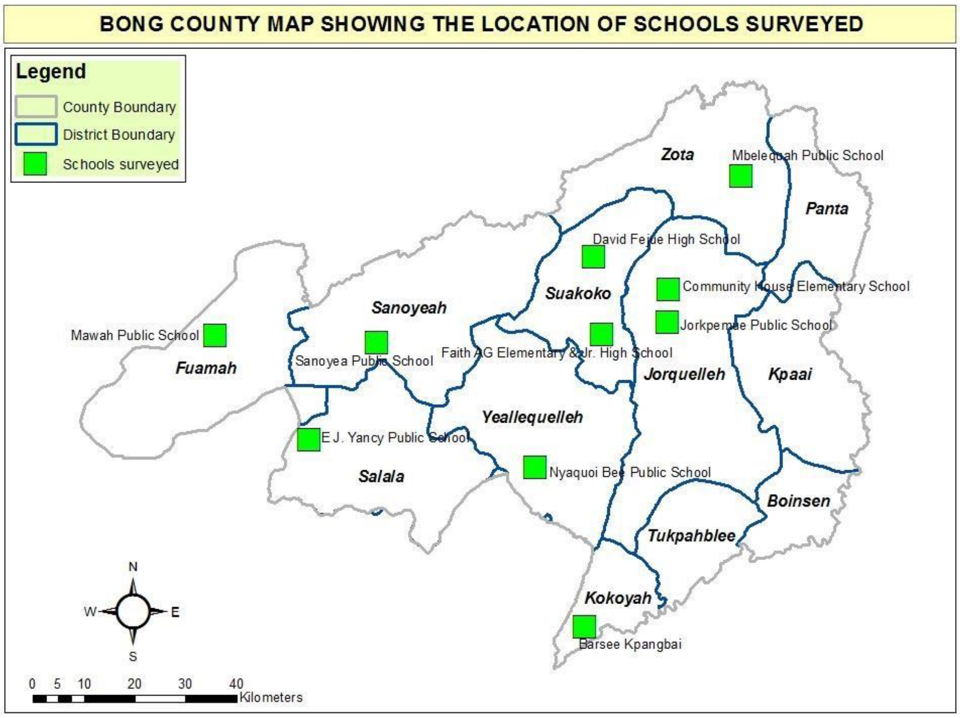


Table 6.1: Name of schools and number of participants per school

School Name	Frequency
Barsee Kpangbai	100
Community House Elementary School	100
David Fejue High School	101
E. J. Yancy Public School	100

Faith Community AG Elementary and Junior High School	100
Jorkpemue Public School	100
Mawah Public School	101
Mbelequah Public School	100
Nyaquoi Bee Public School	100
Sanoyea	101
Total	**1,003**

Table 6.2: Sociodemographic characteristics of participants Level of education by gender

Level of education	Female	Male	Total
Grade 3 to Grade 6	160 (31.7%)	125 (25.1%)	285 (28.4%)
Grade 7 and above	17 (3.4%)	16 (3.2%)	33 (3.3%)
K1–Grade 2	327 (64.9%)	358 (71.7%)	685 (68.3%)
Total	**504**	**499**	**1,003**

Of the total 1,003 school-age children that participated in the study 504 (50.2%) were males and 499 (49.8%) were females. The majority of schoolchildren at 685 (68.3%) were in K1–Grade 2 (see Table 28). The mean age was 10.9 years and medium was 11 years (see Table 6.3).

Table 6.3: Mean and median age of participants, by sex

Age	Female	Male	Overall
Mean (SD)	10.9 (2.1)	10.9 (2.0)	10.9 (2.0)
Median (IQR)	11 (9–12)	11 (9–13)	11 (9–12)

IQR = interquartile range; SD = standard deviation.

6.6.3 Prevalence of *S. mansoni*, *S. haematobium*, and STH

Of the total 1,003 school-age children that had their stools examined using the single Kato-Katz method, 123 (12.3%) schoolchildren were infected with *S. mansoni*. For STH, hookworm infection was found in 2 (0.2%) schoolchildren and *T. trichiura* and *Ascaris* infections were found in 12 (1.2%) schoolchildren. Amongst STH, hookworm had the highest prevalence at 3.3% followed by *Ascaris* at 1.2%. The results showed that females had the highest prevalence of *S. haematobium* (58.0%) whereas males had the highest percentage of *Ascaris* (66.7%).

The urine filtration on *S. haematobium* showed a prevalence of 112 (11.2%) schoolchildren infected with single infections, for *S. mansoni* a prevalence of 123 (12.3%) schoolchildren infected with single infections, and a prevalence of 27 (2.7%) schoolchildren infected with double infections. There was no statistical significance between single infections, double infections and age (See Table 6.4).

Table 6.4: Prevalence of *S. mansoni*, *S. haematobium* and STH

Age	Frequency	*S. mansoni* N (%)	Hookworm N (%)	*T. trichiura* N (%)	*Ascaris* N (%)	*S. haematobium* N (%)	double parasite
7–11 years	607 (60.5%)	59 (48.0%)	15 (45.5%)	2 (100%)	9 (75.0%)	61 (54.5%)	14 (51.9%)
12–14 years	352 (35.1%)	59 (48.0%)	15 (45.5%)	0 (0.0%)	3 (25.0%)	42 (37.5%)	12 (44.4%)
15 years	44 (4.4%)	5 (4.0%)	3 (9.1%)	0 (0.0%)	0 (0.0%)	9 (8.0%)	1 (3.7%)
Total	**1,003 (100%)**	**123 (12.3%)**	**33 (3.3%)**	**2 (0.2%)**	**12 (1.2%)**	**112 (11.2%)**	**27 (2.7%)**
Sex							
Female	504 (50.2%)	57 (46.3%)	13 (39.4%)	1 (50.0%)	4 (33.4)	65 (58.0%)	11 (40.7%)
Male	499 (49.8%)	66 (53.7%)	20 (60.6%)	1 (50.0%)	8 (66.7)	47 (42.0%)	16 (59.3%)
Total	**1,003 (100%)**	**123 (12.3%)**	**33 (3.3%)**	**2 (0.2%)**	**12(1.2%)**	**112 (11.2%)**	**27 (2.7%)**

Table 6.5: Bivariate and multivariate logistical regression analysis of STH in relation to selected variables amongst school-age children in Bong County, 2017

Variables	**Presence of Helminths, n (%)**		**COR (95% CI)**	**AOR(95% CI)**	**AOR(95% CI)****
	Positive (N=47)	Negative (N=956)			
Female	18 (38%)	486(51%)	1.00	1.00	1.00
Male	29 (62%)	470(49%)	1.85 (1.02–3.41)	1.85 (1.03–3.42)	1.84 (0.97–3.50)
Age (year)					

7 – 11	26 (55%)	581(61%)	1.00	1.00	1.00
12 – 14	18(39%)	334(35%)	1.22 (0.71–3.07)*	1.28 (0.69 – 3.46)*	1.09 (0.78–3.52)*
15	3(6%)	41(4%)	1.61 (0.79–3.25)*	1.78 (0.38–5.75)*	1.79 (0.56 – 5.84)*

COR crude odds ratio, AOR adjusted odds ratio, CI confidence interval, *statistically significant at P < 0.05 in multivariate logistic regression analysis**Adjusting for clustering within schools – schools included as a fixed effect

As shown by Table 2, the prevalence of STH infection was 4.68% whereby a total of 47 school age tested positive for the soil-transmitted helminthiasis. This prevalence is relatively low compared to a study done by Novianty, et al., (2018) who investigated the risk factors for soiltransmitted helminthiasis in preschool children in North Sumatera and found a prevalence of 40.5%. Whereas Wang et al., (2012) reported that there was STH infection prevalence of 21.2% in school children.

The prevalence of soil-transmitted helminthiasis was high among male pupils 62% (29) compared with females 38% (18) showing a difference between sex and the infection of schistosomiasis. Male pupils were established to have a significant correlation with the prevalence of soiltransmitted helminthiasis (OR=1.85, 95% CI: 1.02–3.41). This shows male pupils were 1.85 times more likely to have soil-transmitted helminthiasis as compared to the female pupils. Similarly, studies conducted have also confirmed the prevalence of STH to be higher among male children as compared to the female children (Novianty, et al, 2018; Pullan, & Brooker, 2012; Speybroeck, 2017).

With regards to age, children aged between 7 and 11 years were the most infected with an infection rate of 55%, followed by those between 12 and 14 years (39%) and those aged 15 years the least at 6%. Children between 12 and 14 years, and those at 15 years were further found a significant positive relationship with the number of soil-transmitted helminthiasis in relation infections (OR=1.22, 95% CI: 0.71–3.07 and OR=1.61, 95% CI: 0.79–3.25 respectively). This shows children between 12 and 14 years, and those at 15 years were 1.22 and 1.61 times respectively more likely to have soil-transmitted helminths as compared to the other age groups. In a similar manner, Alemu, et al, (2016) who investigated *Schistosoma mansoni* and soil-transmitted helminths among children in Chuahit, Dembia district, Ethiopia also established that prevalence intestinal helminthic infections showed significant association with age (p. value < 0.05).

Table 6.6: Bivariate and multivariate logistical regression analysis of *S. haematobium* and *S. mansoni* in relation to selected variables amongst school-age children in Bong County, 2017

Variables	Presence of Schistosomiasis		COR (95% CI)	AOR (95% CI)	AOR (95% CI)**
	Yes (N=235)	No (N=768)			
Female	122(52%)	382(49%)	1.00	1.00	1.00
Male	113(48%)	386(51%)	0.62 (0.22–1.84)	0.60 (0.20–1.82)	0.55 (0.19–1.78)
Age (years)					
7 – 11	120(51%)	487(63%)	1.00	1.00	1.00
12 – 14	101(43%)	251(33%)	1.59 (1.20–2.75)*	1.60 (1.21–2.78)*	1.81 (1.40–2.98)*
15	14(6%)	30(4%)	2.43(1.32–4.47)	1.89(0.99–3.64)	1.91(1.01–3.64)

COR crude odds ratio, AOR adjusted odds ratio, CI confidence interval, *statistically significant at P < 0.05 in multivariate logistic regression analysis**Adjusting for clustering within schools – schools included as a fixed effect

As shown by Table 1, the prevalence of Schistosomiasis infection was 23.43% whereby a total of 235 school age tested positive for

Schistosomiasis. This shows a relatively high prevalence as compared to a study done by Hajissa, et al., (2018) among school children in UmAsher Area, Sudan and found that the prevalence of S. *haematobium* was 12.9%, whereas that of S. *mansoni* was 2.95%.

The prevalence of schistosomiasis was high among female pupils 122(52%) compared with males 113(48%) showing a significance between sex and the infection of schistosomiasis. However, the male pupils were established by bivariate and multivariate logistic regression analysis to have a significant correlation with the prevalence of *S. haematobium* and *S. mansoni* infections (OR=0.62, 95% CI: 0.22–1.84). This shows male pupils were 0.62 times more likely to have schistosomiasis as compared to the female pupils. This is confirmed by Omer, et al., (2016) who investigated schistosomiasis prevalence among School Age Children at Shendi Locality and also established a statistical significance between sex and the infection of schistosomiasis (P value = 0.006). With regards to age, children aged between 7 and 11 years were the most infected with an infection rate of 51%, followed by those between 12 and 14 years (43%) and those aged 15 years the least at 6%. Empirical studies conducted also found out that infections of schistosomiasis was high among children aged 8 to 13 years (Bah, et al., 2019; Sokolow, et al., 2016). Accordingly, logistic regression analysis confirmed that schistosomiasis infections was statistically related to the age of the children between 12 and 14 years **(**OR=1.59, 95% CI: 1.20–2.75). This shows children between 12 and 14 years were 1.59 times more likely to have schistosomiasis as compared to the other age groups.

6.6.4 Prevalence of *S. mansoni, S. haematobium* and STH by school and district

Table 33 shows the intensity of infection with SCH and STH. Out of the 123 schoolaged children positive for *S. mansoni* based on the Kato-Katz method, results showed that 75 (61.0%) had a light infection intensity, 25 (20.3%) had moderate infection intensity, and 23 (18.7%) had a heavy infection intensity. Out of the 112 school-aged children positive for *S. haematobium* based on the urine filtration method, results showed that 69 (61.6%) had a light infection intensity and 43 (38.4%) had a heavy infection intensity. For STH, out of the 12 school-aged children positive for *Ascaris* 7 (58.3%) had a light infection intensity, 4 (33.3%) had a moderate infection intensity, and 1 (8.3%) had a heavy infection intensity. Out of 33 school-aged children positive for hookworm, 17 (51.5%) had a light infection intensity, 13 (39.4%) had a moderate infection intensity, and 3 (9.1%) had a heavy infection intensity. Out of the two schoolaged children positive for *T. trichiura* both showed a light infection intensity (100.0%)

(see Table 33).

Table 6.7: Intensity of infection with SCH and STH

Parasite	Intensity of infection by class			
	Light	**Moderate**	**Heavy**	**Total**
S. haematobium	69 (61.6%)	0 (0.0%)	43 (38.4%)	**112 (100%)**
S. mansoni	75 (61.0%)	25 (20.3%)	23 (18.7%)	**123 (100%)**
Ascaris	7 (58.3%)	4 (33.3%)	1 (8.3%)	**12 (100%)**
T. trichiura	2 (100.0%)	0 (0.0%)	0 (0.0%)	**2 (100%)**
Hookworm	17 (51.5%)	13 (39.4%)	3 (9.1%)	**33 (100%)**

Table 6.8: Intensity of infection, by gender

Intestinal parasite	*S. haematobium*		*S. mansoni*		*Ascaris*		*T. trichiura*		Hookworm	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Light	13 (27.7%)	28 (43.1%)	42 (63.6%)	33 (57.9%)	5 (62.5%)	2 (50.0%)	1 (100%)	1 (100%)	11 (55.0%)	6 (46.2%)
Moderate	13 (27.7%)	15 (23.1%)	14 (21.2%)	11 (19.3%)	2 (25.0%)	2 (50.0%)	0 (0.0%)	0 (0.0%)	7 (35.0%)	6 (46.2%)
Heavy	21 (44.7%)	22 (33.8%)	10 (15.2%)	13 (22.8%)	1 (12.5%)	0 (0.0%)	0(0.0%)	0(0.0%)	2 (10.0%)	1 (7.6%)
Total	**47 (100%)**	**65 (100%)**	**66 (100%)**	**57 (100%)**	**8 (100%)**	**4 (100%)**	**1 (100%)**	**1 (100%)**	**20 (100%)**	**13 (100%)**

Table 6.9: Prevalence of *S. mansoni, S. haematobium* and STH, by schools and districts

Schools	**Districts**	***S. mansoni*** **N (%)**	**Hookworm N (%)**	***Ascaris*** **N (%)**	***T. trichiura*** **N (%)**	***S. haematobium*** **N (%)**
Mawah Public School	Fumah	0 (0.0%)	2 (6.1%)	3 (25.0%)	0 (0.0%)	8 (7.1%)
Community House Elementary School	Jorquelleh	19 (15.4%)	1 (3.0%)	1 (8.3%)	0 (0.0%)	10 (8.9%)
Jorkpemue Public School	Jorquelleh	18 (14.6%)	0 (0.0%)	5 (41.7%)	1 (50.0%)	4 (3.6%)
Barsee Kpangbai	Kokoyah	3 (2.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	18 (16.1%)
Nyaquoi Bee Public School	Panta	11 (8.9%)	4 (12.1%)	3 (25.0%)	1 (50.0%)	6 (5.4%)
E. J. Yancy Public School	Salala	1 (0.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	5 (4.5%)
Sanoyea	Sanoyea	2 (1.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (0.9%)
David Fejue High School	Suakoko	0 (0.0%)	1 (3.0%)	0 (0.0%)	0 (0.0%)	27 (24.1%)
Faith Community AG Elementary and Junior High	Suakoko	25 (20.3%)	3 (9.1%)	0 (0.0%)	0 (0.0%)	18 (16.1%)
Mbelequah Public School	Zota	44 (35.8%)	22 (66.7%)	0 (0.0%)	0 (0.0%)	15 (13.4%)
Overall		**123 (12.3%)**	**33 (3.3%)**	**12 (1.2%)**	**2 (0.2%)**	**112 (11.2%)**

The intensity of SCH amongst the different age groups and gender showed that females had a higher prevalence of *S. haematobium* compared to males, but males had a higher prevalance of *S. mansoni*, *Ascaris* and hookworms. However, *T. trichiura* was prevalent in both males and females (see Table 34).

Of the total 10 schools surveyed from the eight health districts during the study, for *S. mansoni*, Mbelequah Public School in Zota district had highest positive cases with 44 (35.8%) followed by Faith Community AG Elementary and Junior High in Suakoko district with 25 (20.3%) cases. For *S. haematobium*, David Fejue High School in Suakoko district had the highest positive cases 27 (24.1%) followed by Barsee Kpangbai in Kokoya district and Faith Community AG Elementary and Junior High in Suakoko district with 18 (16.1%) each. For the STH, Mbelequah Public School had the highest positive cases of hookworm with 22 (66.7%) followed by Jorkpemue Public School with 5 (41.7%) positive cases of *Ascaris.*

6.6.5 Prevalence of haematuria using the urine strips

There was no visible haematuria, however, reagent strips was dipped in the urine sample of each of the students for about 1 minute the strips were compared to the colorimetric scale on the cup of the strip. Of the 1,003 participants (111) 11.1% had positive haematuria. Amongst which 64 (57.7%) were female and 47 (42.3%) were male. The age range with the highest positivity was 7–11 years (see Table 36).

Table 6.10: Percentage of participants with haematuria, by age and sex using the dipstick

Age	Haematuria
7–11 years	60 (54.1%)
12–14 years	42 (37.8%)
15 years	9 (8.1%)
Total (N = 1,003)	**111 (11.1%)**

Sex	
Female	64 (57.7%)
Male	47 (42.3%)
Total	**111 (100.0%)**

6.7 Discussion

Studies on the epidemiology of SCH in Liberia indicates high prevalence of SCH in northern Liberia, Bong, Lofa and Nimba Counties, with no snail hosts of *Schistosoma* found in the coastal regions although records on earlier scientific research reports and other relevant unpublished documents were lost during the war (Strickland, 2006). STH is the most prevalent parasitic disease in the world. These infections are most prevalent in tropical and subtropical regions of the developing world where adequate water and sanitation are lacking. These contribute to malnutrition and impaired physical and cognitive development in early childhood, poor school performance, reduced working capacity, and complication of pregnancy and birth outcome. According to a recent study, it has been noticed that even low infection intensities of multiple helminth infections enhance the risk of anaemia (Hotez, 2011).

The prevalence of *S. mansoni* infection amongst the 1,003 school-age children in Bong County, northern Liberia that participated in this study was 123 (12.3%). This is similar to a study on pre-schoolchildren in Sierra Leone that showed a prevalence rate of 11.2% (Hodges, et al., 2012) and another study on STH and SCH amongst preschool-age children in Ethopia also showed a prevalence of 11.2% (Alemu, Tegegne, Damte, & Melku, 2016). These results were higher than the nationwide study carried out in Liberia by the MoH and its partners in 2010, where the prevalence of *S. mansoni*

was 9.0% and *S. haematobium* was 6.0% (MoHSW, 2011b). A study on the epidemiology of SCH in Bong County by Dennis et al. (1983) showed that there was a higher prevelance of *S. mansoni* (24.8%) compared to *S. haematobium* (22.0%). Their study also showed that the snail population in Bong County were *Bulinus globosus* and *Biomphalaria pfeifferi*, but the most prevalent snail population of the two was *Bulinus globosus* (Dennis, et al., 1983). The 1983 study by Dennis et al., collaborated with this study and showed that there is a higher prevalence of *S. mansoni* (12.3%) compared to *S. haematobium* (11.2%) in Bong County, Liberia. A further study conducted in Malawi on SCH in pre-school-age children observed that *S. mansoni* was 17.0% and *S. haematobium* was 45.1% (Poole, et al., 2014). These results are higher than that of this study. The prevalence of *S. mansoni* and *S. haematobium* observed in this study was lower than that of the overall prevalence of STH, where *Ascaris* had a prevalence at 1.2%, hookworm at 3.3% and *T. trichiura* at 0.2%. These results were similar to that of a study in Sierra Leone where there was a low prevalence of *Ascaris* (0.2%–17.2%), hookworm (8.4%–22.8%) and *T. trichiura* (0.9%–2.6%) infections (Hodges, et al., 2012). The low prevalence of STH can be attributed to the nationwide annual deworming programme by the Ministry of Education, MoH and their partners targeting all school-age children in the country.

Of the 10 schools that enrolled in the study, the Mbelequah Public School located in Zota district, had the highest positive cases of *S. mansoni* with 44 (35.8%) followed by Faith Community AG Elementary and Junior High in Suakoko district with 25 (20.3%). For *S. haematobium*, David Fejue High School in Suakoko district had the highest positive cases with 27 (24.1%) followed by Barsee Kpangbai in Kokoya district and Faith Community AG Elementary and Junior High in Suakoko district with 18 (16.1%) each. For STH, Mbelequah Public School had the highest positive cases of hookworm with 22 (66.7%) followed by Jorkpemue Public School with 5 (41.7%)

positive cases of *Ascaris* (see Table 35). Of the eight health districts, 10 schools located in 10 different communities were surveyed. This study revealed that the highest STH prevalence was in Zota district (35.8%) followed by Suakoko district (20.3%) and Jorquelleh (15.4%). A similar study by the MoH in Bong County, Liberia reported *Ascaris* at 21.0%, hookworm at 14.0%, and *T. trichiura* at 1.0% (MoHSW, 2011b). This study showed a decrease in the prevalence of STH, which could be attributed to the nationwide deworming programme that has been ongoing in schools around the country.

6.7.1 Intensity of SCH and STH

The intensity for *S. mansoni* based on the Kato-Katz method, results showed that 61.0% had a light infection intensity, 20.3% had moderate infection intensity, and 18.7% had a heavy infection intensity. The intensity for *S. haematobium* based on the urine filtration method showed a 61.6% had a light infection intensity and 38.4% had a heavy infection intensity. For STH, *Ascaris* had a light infection intensity of 58.3%, a moderate infection intensity of 33.3%, and a heavy infection intensity of 8.3%. Hookworm had a light infection intensity of 51.5%, a moderate infection intensity of 39.4%, and a heavy infection intensity of 9.1%. *T. trichiura* had 100.0% light infection intensity.

The intensity of SCH amongst the different age groups and gender showed that females had a higher prevalence of *S. haematobium* compared to males, but males had a higher prevalance of *S. mansoni*, *Ascaris* and hookworms. However, both males and females showed equal prevalence to *T. trichiura*.

6.8 Limitations

The study was limited to only one county as opposed to the entire country. However, the results obtained were valid and accurate, but is not a representation of the entire country. Also the intensity and prevalence of STH and SCH were obtained from a single stool specimen, which may have an influence on the accuracy of the egg count.

6.9 Conclusions

The study confirms urogenital and intestinal SCH are endemic in Bong County and that *S. haematobium* and *S. mansoni* were the two species of *Schistosoma* identified in the study. The study has shown that the prevalence of the parasitic disease varies across schools in the same county. The study also revealed that there is a low prevalence of STH across all participating schools and confirms that *T. trichiura* infection is generally low in the country. The decrease in the burden of STH could be attributed to the annual deworming programme in the country.

CHAPTER 7: KNOWLEDGE, ATTITUDES AND PRACTICES TOWARDS SCH, LF AND STH AMONGST SCHOOL-AGE CHILDREN IN BONG COUNTY, LIBERIA

7.1 Abstract

7.1.1 Background

There is considerable overlap in the geographical distribution and endemicity of LF, Oncho, SCH and STH in Liberia. Co-endemicity of the four NTDs occurs in 13 counties: Bong; Grand Gedeh; Grand Cape Mount; Grand Bassa; Grand Kru; Montserrado; Maryland; Margibi; Nimba; Lofa; Sinoe; Rivercess; and River Gee. Coendemicity of three NTDs excluding Oncho occurs in 14 counties (excluding Rivercess

County); while co-endemicity of three NTDs excluding LF occurs in 13 counties (excluding Gbarpolu and Bomi Counties); co-endemicity of two NTDs excluding LF and Oncho occurs in three counties: Bong; Nimba; and Lofa. However, there has never been a survey to determine the KAP in the population at risk to NTDs in the country.

7.1.2 Objective

To assess KAP of SCH, LF and STH amongst school-age children in Bong County, northern Liberia in order to prepare a health promotional material on the prevention and control of NTDs.

7.1.3 Methods

A cross-sectional survey was conducted in 10 primary schools from September to December 2018, using a structured and pre-tested questionnaire, to evaluate KAP amongst 1,003 school-aged children who met the inclusion criteria age of 5–14 years.

The survey was carried out on the second day following collection of samples from the schoolchildren to determine the prevalence of STH and SCH. Descriptive analysis was used for the data analysis.

7.1.4 Results

Of the 1,003 school-aged children, 90.0% had not heard about SCH, 86.0% had not heard of STH, and 92.0% had not heard of LF. For the water contact pattern only 9.0% had access to pipe water. Around 28.0% of schoolchildren had received medication during the MDA by the MoH, 21.4% slept under mosquito nets, and 72.0% used the bushes as latrines.

7.1.5 Conclusions

The study highlights the need for health education amongst schoolchildren in Bong County in order to raise awareness on the prevention and control of SCH, LF and STH and its related health risks. The study also highlights the need for improving sanitation and the use of mosquito nets.

7.2 Introduction

KAP in relation to NTDs are crucial in establishing effective disease control measures. In Liberia, data on the KAP of populations in endemic areas in Liberia with regards to NTDs are not available. Awareness of the community and their involvement are considered as one of the fundamental tools for the success and sustainability of any disease control programme (Kihara, et al., 2007). To remedy this weakness, this study assessed the KAP of school-age children on SCH, LF and STH in Bong County. It is anticipated that the findings may add new understandings about the prevention and control of NTDs in Liberia. There is considerable overlap in the geographical distribution and endemicity of LF, SCH and STH in Liberia. Co-endemicity of the four

NTDs occurs in 13 out of 15 counties: Bong; Grand Gedeh; Grand Cape Mount; Grand Bassa; Grand Kru; Montserrado; Maryland; Margibi; Nimba; Lofa; Sinoe; Rivercess; and River Gee. Co-endemicity of three NTDs excluding Oncho occurs in 14 counties (excluding Rivercess County); while co-endemicity of three NTDs excluding LF occurs in 13 counties (excluding Gbarpolu and Bomi Counties); co-endemicity of two NTDs excluding LF and Oncho occurs in three counties: Bong; Nimba; and Lofa (MoHSW, 2017a). Bong County was selected for this survey due to the co-endemicity of the three NTDs under review; it has a high prevalence for SCH as compared to other counties and to be used as an exemplar to update the data on SCH for the NTD programme at the MoH after two rounds of MDA.

Universally, approximately 2 billion people are affected by schistosomes and STH, of which over 300 million suffer severe morbidity or permanent impairment. These worm infections affect the underprivileged, particularly children (Hotez, et al., 2006). At the fifty-fourth Word Health Assembly in 2001 a resolution was adopted for Member States to annually administer anthelmintic drugs to at-risk populations and to 75.0%–100.0% of school-age children that are at risk of morbidity due to STH and SCH (WHO, 2001). There is a need for integrating the control of STH with that of other NTDs (Stothard, et al., 2009b). In 2002, SCH control was launched with a grant from Bill and Melinda Gates. Since then millions of children in sub-Saharan Africa have received medication for the control for SCH and STH (Givewell, 2014).

Liberia has a population of 4.7 million. The NTDs MDA coverage index has reached 62/100. In 2016, data showed that there was 74.0% treatment coverage for LF, 31.0% treatment coverage for SCH, and 90.0% treatment coverage for STH (Uniting to Combat Neglected Tropical Diseases, 2016).

7.3 Objectives

- To assess the KAP on SCH, LF and STH amongst school-age children in Bong County, northern Liberia.
- To prepare a health promotional material on the prevention and control of NTDs.

7.4 Methodology

7.4.1 Ethical considerations

Before being interviewed, information about the questionnaire and objectives of the study were explained to the schoolchildren. They were also informed about their rights to withdraw from the study at anytime without any penalty. Written informed consent was obtained for each participant. During the entire period in each school, the principal and a teacher were present. Ethics was obtained from the MoH ethical committee, and the LSTM research and ethics committee. Recommendation for health education on the prevention and control of NTDs was made to the NTDs unit at the MoH.

7.4.2 Study design and study area

Liberia is located on the West Coast of Africa along the Atlantic Ocean. The country is divided into 15 political sub-divisions called counties. According to the World Bank development index 50.0% of the population of 4 million people are said to be under the national poverty line (World Bank, 2010). A cross-sectional survey was conducted in 10 primary schools from September to December 2018, using a structured, pre-tested and validated questionnaire, to evaluate KAP amongst 1,003 school-aged children who met the inclusion criteria (5–14 years old). The survey was carried out on the second day following collection of samples from the schoolchildren to determine the prevalence of STH and SCH. The researcher under the supervision of a teacher and the school principle interviewed the students.

7.4.3 Study population

A total of 1,003 schoolchildren were recruited from 10 schools in Bong County. These schoolchildren had also participated in the studies on SCH and STH.

7.4.4 Questionnaire survey

A structured questionnaire for data collection was used to collect data. The questionnaire was pre-tested in a school, which was not part of those enrolled in the study. The questions were designed based on the research objectives of the larger study.

7.5 Results

7.5.1 Sociodemographic characteristics of participants

Using an integrated approach, the participants were also enrolled in the follow-up survey carried out to determine the intensity and prevalence of STH and SCH. A total of 1,003 school-aged children participated in the study where 504 (50.2%) were females and 499 (49.8%) were males. The mean age was 10.9 years and the medium age was 11 years. The majority of the schoolchildren 685 (68.3%) were in K1–Grade 2. The demographics are the same as in previous chapters as the participants were from the same study (see chapter 6).

Association of knowledge of SCH, STH and LF as it relates to gender and age are shown in Table 7.1.

Table 7.1: Association of knowledge of STH, SCH and LF, by age and gender

AGE				
Do you know what LF is?	**7–11 years**	**12–14 years**	**15 years**	**Total**
Yes	40 (6.77%)	24 (6.79%)	10 (16.7%)	74 (7.4%)
No	550 (93.2%)	329 (93.2%)	50 (83.3%)	929 (92.6%)
Total	**590**	**353**	**60**	**1,003**
Do you know what SCH is?	**7–11 years**	**12–14 years**	**15 years**	**Total**
Yes	55 (9.3%)	37 (10.5%)	8 (13.3%)	100 (10.0%)
No	535 (90.7%)	316 (89.5%)	52 (86.7%)	903 (90.0%)
Total	**590**	**353**	**60**	**1,003**
Do you know what STH is?	7–11 years	12–14 years	15 years	Total
Yes	71 (12.0%)	53 (15.0%)	11 (18.3%)	135 (13.5%)
No	519 (88.0%)	300 (85.0%)	49 (81.7%)	868 (86.5%)
Total	**590**	**353**	**60**	**1,003**

GENDER			
Do you know what STH is?	**Female**	**Male**	**Total**
Yes	68 (13.5%)	67 (13.4%)	135 (13.5%)
No	436 (86.5%)	432 (86.6%)	868 (86.5%)
Total	**504**	**499**	**1,003**
Do you know what LF is?	**Female**	**Male**	**Total**
Yes	37 (7.3%)	37 (7.4%)	74 (7.4%)
No	467 92.7%)	462 (92.6%)	929 (92.6%)
Total	**504**	**499**	**1,003**
Do you know what SCH is?	**Female**	**Male**	**Total**
Yes	54 (10.7%)	46 (9.2%)	100 (10.0%)
No	450 (89.3%)	453 (90.8%)	903 (90.0%)
Total	**504**	**499**	**1,003**

This study showed that majority of participants had not heard about SCH (90.0%), STH (86.5%) and LF (92.6%). However, 13.5% of participants had heard of STH compared to SCH (10.0%) and LF (7.4%).

The results on the knowledge of school-age children on the signs and symptoms of SCH, LF and STH are shown in Tables 40, 41 and 42. The results showed a low level of knowledge (>90.0%) on the signs and symptoms of LF, STH and SCH.

Table 7.2: Knowledge on the signs and symptoms of STH (N = 1,003)

Variables	Yes	No
Swollen abdomen	27 (2.7%)	976 (97.4%)
Passing worms	47 (4.5%)	956 (95.3%)
Passing blood in stool	54 (5.4%)	949 (94.6%)
Lose of appetite	48 (4.8%)	955 (95.2%)
Loosing weight	42 (4.2%)	961 (95.8%)

Table 7.3: Knowledge on the signs and symptoms of LF (N = 1,003)

Variables	Yes	No
Enlarged legs	44 (4.4%)	959 (95.6%)
Enlarged breasts	3 (0.3%)	1,000(99.7%)
Enlarged scrotum	3 (0.3%)	1,000 (99.7%)
Fever and chills	35 (3.5%)	968 (96.5%)

Table 7.4: Knowledge on the signs and symptoms of SCH (N = 1,003)

Variables	Yes	No
Abdominal pain	43 (4.3%)	960 (95.7%)
Vomitting	44 (4.4%)	959 (95.6%)
Blood in stool	49 (4.9%)	954 (95.1%)
Blood in urination	14 (1.4%)	989 (98.6%)
Painful urination	29 (2.9%)	974 (97.1%)
More frequent urination/urgency	18 (1.8%)	985 (98.2%)
Fever/headaches/chills	44 (4.4%)	992 (98.9%)

Table 7.5: Water contact and sand mining behaviour

Variables	Yes	No
Collect water from piped water	9 (0.9%)	994 (99.1%)
Collect water from wells	412 (41.1%)	591 (58.9%)
Collect water from creeks	207 (20.6%)	796 (79.4%)
Rivers	29 (2.9 %)	974 (97.1%)
Collect water from hand pumps	491 (49.0%)	512 (51.0%)
Others	1 (0.1%)	1,002 (99.9%)
Play in creeks	492 (49.1%)	511 (51.0%)
Pick up snails	38 (3.8%)	965 (96.2%)
Sand mining using pans (to be sold)	86 (8.6%)	917 (91.4%)
Wash hands before eating	466 (46.5%)	537 (53.5%)
Fishing	264 (26.3%)	739 (73.7%)

Table 7.8, shows the results on the attitude and practices of the participants. Of which, 3.8% collect snails, 8.6% were involved in sand mining, 49.1% play in creeks, and 46.5% wash their hands before eating.

On receiving drugs during MDA, of the 1,003 participants only 28.8% said they received medication for SCH, 96.9% said they received medication for deworming, but surprisingly none of the participants had received medication for LF.

Table 7.8: Knowledge on MDA

SCH		
Knowledge of drug distribution	**Yes**	**No**
Have your received medication for SCH?	289 (28.8%)	714 (71.2%)

	1 time	2 times	3 times	None
If yes how many times?	264 (24.5%)	45 (4.5%)	13 (1.3%)	699 (69.7%)
STH				
	Yes	**No**		
Have you taken worm tablets in the last 12 months?	972 (96.9%)	31 (3.1%)		
	School	**Health facility**	**Home**	
Where did you get the deworming treatment?	16 (51.6%)	6 (19.4%)	9 (29.0%)	
Have you taken tablets for LF?	0 (0%)	1,003 (100.0%)		

In this study only 1.7% of participants had access to indoor toilets (see Table 45).

Table 7.9: Participants knowledge on sanitation

Where do you go to Latrine	Yes	No	% Yes
Bush	725	278	72.3
Pit latrine	157	846	15.7
Behind the house	104	899	10.4
Indoor toilet	17	986	1.7

Table 7.10: Results from questions on malaria medication and test and sleeping under mosquito nets

Variables	N	Percentage
Have you taken malaria medication in the past 12 months?		
Yes	418	41.7%
No	585	58.3%
Have you had malaria test done in the last month?		
No	751	74.9%
Yes	252	25.1%
Did you sleep under a bednet last night?		
Yes	217	21.6%
No	786	78.4%

Malaria is endemic in Liberia. Curative consultations across Liberia in 2014 were 2,347,631 visits and malaria accounts for 41.0% of all curative consultations. Inpatient admissions were 81,938, where malaria accounts for 32.0% of the total admissions. Therefore, participants were also surveyed for malaria. Of the 1,003 participants, 41.7% reported that they were treated for malaria in the past 12 months, while 74.9% reported that they were tested for malaria in the last month, and 21.6% slept under mosquito nets (see Table 46).

7.6 Discussion

This study carried out information on KAP of school-age children on SCH, LF and STH in Liberia. A parasitology follow-up survey was performed on the same 1,003 participants the day before.

The study was carried out in Bong County, which according to data from the MoH is co-endemic for STH, LF and SCH and is currently undergoing prevention and control measures by the NTD unit at the MoH. NTDs are a serious public health problem in Liberia that led the MoH to move from vertical programming to form a unit called the NTD unit. The NTD unit at the MoH has the following programmes: Oncho, which is prevalent in all 15 counties in Liberia; LF, which is prevalent in 13 counties in Liberia excluding (Gbarpolu and Bomi Counties); and STH has been recorded in all 15 counties in Liberia; Buruli ulcer and leprosy has also been recorded in all 15 counties in Liberia.

The NTD programme in the country has conducted three rounds of MDA for SCH and LF with a therapeutic coverage of 81.0%. However, results showed that more than 90.0% of the schoolchildren interviewed did not have any knowledge of LF and SCH, while 89.0% of the schoolchildren did not have knowledge of STH. In a KAP study conducted in rural Yemen it was found that 82.4% of the participants had heard of SCH, but their knowledge about the transmission and prevention of the disease was low (Sady, et al., 2015). In this present study, 90.0% of the participants had no knowledge of how the disease was transmitted and prevented, which shows that there is a great need for health education in Liberia. This is a surprise as there is active surveillance and treatment that is ongoing for LF, STH and SCH in Bong County. It was observed that many of the participants could not distinguish the name STH and SCH; therefore, this had to be explained in the local language by the research assistants. A study in Zambia reported that 53.0% of school-age children did not know how one was infected with the disease (Nyati-Jokomo & Chimbari, 2017). In this study, 90.0% of the participants did not know how one could be infected with SCH and LF. A study in sub-Saharan Africa also reported that the knowledge amongst community members about SCH was low (Sacolo, Chimbari, & Kalinda, 2018).

Majority of females did not know or had not heard about the disease, while only a few females confirmed to have knowledge of the disease. Similar findings were obtained in Tanzania where it was reported that male participants had more knowledge than female participants (Knopp, at al., 2013). For sourcing water at home only 9.0% of the schoolchildren had access to piped water, those who fetched water from wells were 41.0% and from creeks 20.6%. Up to 49.0% of the schoolchildren collected water from handpumps. This study found that the pattern of water contact in the schoolchildren could be a contributing factor for the transmission of SCH and the pattern in sand mining could be a contributing factor for being infected with STH. During this study, most of the schools were close to water bodies or sand mining, and picking up and selling snails could have attributed to the high burden of SCH in Bong

County. A study in Mali in West Africa reported that schoolchildren who were close to breeding sites of snails were at risk of contracting SCH (Dabo, et al., 2015). Around 49.0% of the schoolchildren in this study admitted that they played in the creek (i.e., swimming). A study in three schools in Sudan reported that frequency of swimming was related to urogenital SCH (Ismail, et al., 2014).

When the schoolchildren were asked about MDA, 71.2% of them had no knowledge about MDA, 69.7% did not receive medication for SCH, and of those who admitted to receiving medication only 13.0% had received the three rounds of Praziquantel from the MoH during the MDA implementation. Of the 1,003 participants only 3.1% had received medication for Ivermectin and 97.0% had received anthelminthic drugs. Around 51.1% of participants admitted to taking the medication at school; this information correlated with the report from the MoH and the Ministry of Education that there is an annual deworming programme in all schools in the country. A similar study undertaken in Kenya reported that out of the 239 participants, 89.1% had heard of SCH and 87.4% had heard of STH (Gitaka, et al., 2019).

Malaria is endemic in Liberia and there have been various preventive measures put into place by the MoH, the Roll Back Malaria initiative and other partners ranging from indoor residual spraying and distribution of mosquitoes nets. In this study, 21.6% of the schoolchildren said that they slept under mosquito nets, about 99.0% heard of malaria and 25.0% had been tested for malaria within a month’s time and 41.0% had taking antimalarial medication within the past 12 months. A study in northern Nigeria reported that majority of their respondents had good knowledge about malaria (Singh, Musa, Singh, & Ebere, 2014). A KAP study in Swaziland reported that a high number of the research participants had knowledge of malaria and 90.0% said they would seek treatment within 24 hours of the onset of malaria symptoms (HIongwana, Mabaso, Kunene, Govender, & Maharaj, 2006).

LF is endemic in Bong County, but 92.6% of the participants had not heard about LF, a substantial amount of them did not have knowledge of the signs and symptoms of LF, and only 3.1% of participants had taken treatment for LF. In a similar KAP study carried out in Indonesia, 89.0% of the respondents had heard of LF and while 21.0% had taken LF medication before MDA, 88.0% reported to have taken the medication after MDA (Krentel, et al., 2006).

7.7 Conclusions

This study reveals that the knowledge, symptoms and prevention of SCH, LF and STH was very low and this could be a major challenge to the achievement of the goals of the NTD programme in Liberia of: eliminating LF by 2020; achieving 100.0% treatment coverage of STH; and 75.0% therapeutic coverage for schoolchildren for SCH. This study revealed a great need for well-co-ordinated health education on NTDs amongst schoolchildren and community involvement, as well as prevention and control of these diseases. If a community is well informed about a disease the prevention measures will be practised by communities, which will lead to a decrease in prevalence of the disease.

7.8 Limitations

The parents of the schoolchildren in this study were not interviewed. It is possible that the parents may have knowledge of the diseases, but these may not be discussed with their children due to cultural practices. Also, the accuracy in recall by the participants could be low as children are unable to give accurate dates of events.

7.9 Recommendations

The MoH should strengthen the NTD programme. Health education is urgently needed in order to accelerate the elimination of NTDs. Annual social mobilisation and community sensitisation on the prevention and control of NTDs in Liberia is essential. The NTD programme in Liberia should work in collaboration with the health promotion unit and the community health unit in order to achieve their objectives.

CHAPTER 8: ASSESSMENT OF SCH-RELATED MORBIDITY AMONGST SCHOOL-AGE CHILDREN IN BONG COUNTY, LIBERIA BY THE USE OF ULTRASOUND: A CROSS-SECTIONAL STUDY

8.1 Abstract

8.1.1 Background

S. mansoni and *S. haematobium* are endemic in three counties in Liberia, despite the intermittent MDA by the MoH and its partners the disease is still prevalent. Ultrasound is a very important tool for assessing morbidty related to SCH, we can observe hepatomegaly, splenomegaly and urinary tract abnormalities. Ultrasound is accessible, mobile, cheap, and can be used on the field.

8.1.2 Objectives

To assess pathological changes of the bladder caused by *S. haematobium.*

To assess pathological changes of the liver caused by *S. mansoni*.

To access pathology changes of the spleen caused by *S. mansoni*.

8.1.3 Methods

A Mindray diagnostic system ultrasound Model MS MR–17003578, which has a 3.5 megahertz convex transducer was used to access the abdomen and urinary tract of 272 school-aged children from 10 different communities for SCH-related morbidity. A single sonographer scanned the participants to avoid intra-observer variability. The Niamey protocol was used as the guide for this study.

8.1.4 Results

Of the 272 school-aged children examined, only one (0.4%) had periportal fibrosis, one (0.4%) had hepatomegaly, three (1.1%) had splenomegaly, and 37 (13.6%) had starry

sky liver pattern. The urinary bladder pathology examination revealed that 53 (19.5%) had distorted bladder shape, 49 (18.0%) had focal bladder thickening where the multifocal was 19 (7.0%). Irregular bladder was found in 69 (25.4%) schoolchildren, the multifocal was found in 7 (2.6%) schoolchildren, and 2 (0.7%) of the schoolchildren had single pseudopolyp. There was no bladder mass noted.

8.1.5 Conclusions

The study revealed that *S. mansoni*- and *S. haematobium*-related morbidities such as hepatomegaly, splenomegaly and urinary tract abnormalities are prevalent amongst school-age children in Bong County, Liberia. The use of ultrasound should be encouraged in endemic areas as it helps to detect *Schistosoma*-related morbidities.

8.2 Introduction

Although SCH is controlled in some countries, it still remains a major public health problem in Liberia, especially in the Central region; this maybe due to farminig in swamps practised in this region. In Liberia, the intermediate hosts for a snail are *Bulinus globosus* and *Biomphalaria pfeifferi* (Dennis, et al., 1983).

There are more than 230 million people worldwide that are infected with SCH. Of which, 120 million are symptomatic, 20 million have severe disease and around 600 million are at risk of infection. It has been estimated that approximately 192 million (93.0% of the world total) are from sub-Saharan Africa (Kramer, Zhang, Sinclair, & Olliaro, 2014). The three species of schistosome that affect humans are *S. haematobium, S. mansoni* and *S. japonicum* (McKerrow & Salter, 2002).

The female and male adult worms live in the mesenteric veins of their host at different locations, where they mate and produce eggs. The female is about 7 mm to 20 mm long and the male is slightly smaller about 6 mm to 11 mm long. The eggs produced as a result of mating are released either through the urine or faeces in fresh waters. The eggs then are hatched under ideal conditions and release larvae, and then environmental transmission can ensue. However, eggs die after a period of 1 to 2 weeks after they leave the worm. Upon successful hatching, the miracidium enters the compatibile snail, which is the intermediate host. Thousands of cercariae are later produced when the mother and daughter sporocytes undergo replications and their produce are released into the fresh water. The infected cercariae may penetrate the skin of any person who enters the water especially those who do swamp rice farming, swimming, snail picking or sand mining (Lawson & Wilson, 1980).

After entering the human host, the parasite lives for about 3–20 years in its host and in rare cases about 40 years (van Oordt, van den Heuvel, Tielens, & van den Bergh, 1985). In regions where SCH is endemic, research has showed that approximately 20.0%–40.0% of school-age children remain actively infected (Stothard, et al., 2011).

8.2.1 Pathogenesis and morbidity

The intensity of the infection depends on continuing exposure, the age of first exposure, and whether or not the person develops immunity against the infection (Gryseels, et al., 2006). It has been noted that the intensity of the infection is mostly seen in the first two decades of life, but declines in adults. This could be attributed to acquisition of antibodies or antigen from the disease due to continuous exposure (Buttterworth, 1998).

Not all infected individuals develop signs and symptoms of SCH. If symptoms do appear, it usually takes 4 to 6 weeks from the time of infection. The first symptom of the disease may be a general ill feeling. Within 12 hours of infection, an individual may complain of a tingling sensation or light rash, commonly referred to as 'swimmer's itch', where this is due to irritation at the point of entrance (Charnock, 1980). The rash that may develop can mimic scabies and other types of rashes. Other symptoms can occur 2 to 10 weeks later and can include fever, aching, cough, diarrhoea or gland enlargement. These symptoms can also be related to avian SCH, which does not cause any further symptoms in humans. The manifestations of schistosomal infection vary over time as the cercariae, and later adult worms and their eggs migrate through the body (Cheng, 2014).

Signs and symptoms may include abdominal pain, diarrhoea, bloody stool or blood in the urine. Those who have been infected for a long time may experience liver damage, kidney failure, infertility or bladder cancer (squamous cell carcinoma). In children, it may cause poor growth and learning difficulties (Cheng, 2014).

The first potential reaction is an itchy, popular rash that results from cercariae penetrating the skin, often when a person is first infected. The round bumps are usually 1 cm to 3 cms in size. As people living in affected areas have often been repeatedly exposed, acute reactions are more common in tourists and migrants. The rash can occur between the first few hours and a week after exposure and lasts for several days. A similar, more severe reaction called 'swimmer's itch' can also be caused by cercariae from animal trematodes that often infect birds (Rutherford, 2000).

8.2.2 Intestinal SCH

In intestinal SCH, eggs become lodged in the intestinal wall and cause an immune system reaction called a granulomatous reaction. This immune response can lead to obstruction of the colon and blood loss. The infected individual may have what appears to be a swollen or pot-belly (Charnock, 1980). Eggs can also become lodged in the liver, leading to high blood pressure through the liver, enlarged spleen, the buildup of fluid in the abdomen, and potentially life-threatening dilations or swollen areas in the oesophagus or gastrointestinal tract can rupture and bleed profusely (oesophageal varices). In rare instances, the central nervous system is affected (Grimes, et al., 2014).

8.2.3 Genitourinary disease

The worms of *S. haematobium* migrate to the veins around the bladder and ureters. This can lead to blood in the urine 10 to 12 weeks after infection. Over time, fibrosis can lead to obstruction of the urinary tract, hydronephrosis and kidney failure. Bladder cancer diagnosis and mortality are generally elevated in affected areas. In Egypt efforts to control SCH have led to decreases in the bladder cancer rate. The risk of bladder cancer appears to be especially high in male smokers, perhaps due to chronic irritation of the bladder lining allowing it to be exposed to carcinogens from smoking. In women, genitourinary disease can also include genital lesions that may lead to increased rates of HIV transmission (Cheng, 2014).

8.2.4 Central nervous system disease

Central nervous system lesions occur occasionally. Cerebral granulomatous disease may be caused by *Schistosoma* eggs in the brain. Communities in China affected by *S. japonicum* have been found to have rates of seizures eight times higher than the baseline. Similarly, granulomatous lesions from *S. mansoni* and *S. haematobium* eggs in the spinal cord can lead to transverse myelitis with flaccid paraplegia. Eggs are thought to travel to the central nervous system via embolisation (Oliveira, Rodrigues, Romanha, & Bahia, 2004).

8.3 Objectives

- To assess pathological changes of the kidney due to *S. haematobium.*
- To assess pathological changes of the liver due to S. *mansoni*.

- To access pathology changes of the spleen due to *S. mansoni*.

8.4 Justification of the study

Liberia is a post-conflict country, which following a number of studies have produced evidence of the presence of multiple NTDs where three NTDs are widespread, amenable to MDA and could be controlled on the same platform. However, there is no study in the country for the assessment of SCH-related morbidity amongst children.

8.5 Methodology

8.5.1 Ethical considerations

Ethics clearance was obtained from the MoH ethical committee, and the ethics committee of LSTM. The objectives of the ultrasound study was explained to the students and their parents with verbal and written consent obtained from them. They were also informed about their rights to withdraw from the study at anytime without any penalties. Informed consent was obtained for each participant. During the ultrasound examination most of the parents were present.

8.5.2 Study design and study area

Liberia is situated on the West Coast of Africa between Sierra Leone on the West, Côte d'Ivoire on the East, and Guinea on the North. The study was conducted in Bong County, one of the 15 counties in Liberia and located in the northern region. Bong County was selected due its co-endemicity with STH, SCH and LF. According to the World Bank development index 50.0% of the population of 4 million people are said to be under the national poverty line (World Bank, 2010).

8.5.3 Study design and population

The study assessed the mobidity of *S. haematobium* and *S. mansoni* by using a portable ultrasound. The bladder, liver and spleen were examined. Physical examination of the schoolchildren was performed in addition to the examination of the abdomen and urinary tract by the use of ultrasound. About 28.8% of the children admitted to having taken Praziquantel treatment. The baseline study to determine the prevalence of *S. haematobium* and *S. mansoni* was conducted 2 days before the scanning of the abdominal and urinary bladder.

The schoolchildren were aged from 5–15 years. A total of 123 schoolchildren examined by the Kato-Katz method, were found to be positive for S. *mansoni*, while 112 schoolchildren examined by urine filtration were found to be infect. 37 students not positive for *S. haematobium* and *S. mansoni* were recruited for the study.

8.5.4 Study procedures

The schoolchildren that were positive for *S. mansoni* and *S. haematobium*, their parents were informed that an ultrasound was going to be performed to determine SCH morbidity. Upon arrival at the school on the morning of the survey a room was given to the research team to be used for the ultrasound procedure.

A list was given to the school principal of those schoolchildren who were positive for SCH and who needed to be scanned. The schoolchildren were called to a room where approximately 500 mL of water was given to each schoolchild to drink 30 minutes to 1 hour before the examination. They were then scanned only if they felt the urge to urinate. Once the student entered the ultrasound room accompanied by their parents the procedure was explained to them. The schoolchild was than placed on the bed and gel placed on the abdomen to enable better resolution. A convex ultrasound probe was used to check the liver and kidney, looking for morbidities related to *S. haematobium* and *S. mansoni*. A makeshift bed was placed in the room and a portable ultrasound placed on a table. A portable generator was used to provide electricity to the machine. The ultrasound used was a Mindray diagnostic system ultrasound Model MS MR–17003578, which has a 3.5 megahertz convex transducer for the abdominal scan.

8.5.5 Kidney ultrasound

The ultrasound was performed using the Niamey protocol (Richter, Campagne, Berquist, & Jenkins, 2000). Each schoolchild was placed in a supine position, and an ultrasound gel and a linear ultrasound probe was placed on the abdomen to assess the kidneys and bladder. This procedure was carried out in each school. Bladder wall irregularity is considered when thickeness of the wall is about 5 mm. Two or more lesions are recorded as multiple lesions. Bladder wall thickness was recorded and measured in the proximity of the trigone. Normal thickness of the bladder wall is $\leq$5 mm. When there is a localised thickening of the bladder wall protruding in the lumen a score of 2 is given for the mass. The intermediate score for urinary bladder is indicated if the participant has SCH or not (Richter, et al., 2000). Scores are as follows: 0–1 = SCH unlikely; 2 = SCH likely; and >3 = SCH very likely.

8.5.6 Hepatic ultrasound

The ultrasound was performed using the Niamey protocol (Richter, et al., 2000). Each schoolchild was placed in a supine position and an ultrasound gel was placed on the abdomen. A linear convex ultrasound probe was placed on the abdomen showing the liver to check for any abnormalities as a result of SCH. This procedure was carried out in each school. The procedure was performed early in the morning. The standard view as described in the protocol was used, but at times different views were also used. The image pattern of liver parenchyma + IP score. If the liver appears normal (pattern A) score = 0 then no further investigation is needed. If there is any echogenic periportal thickening then the score ranges from 1–8 depending on severity.

8.5.7 Spleen

The spleen was measured in the left oblique view. Each schoolchild was placed in a supine position, tilting a little towards the sonographer and ultrasound gel was placed at the anatomical level of the spleen. A linear convex ultrasound probe was used to check for abnormality (splenomegaly) as a result of SCH. This procedure was carried out in each school.

The maximium length of the spleen was measured through the splenic hilus: 0 = splenomegaly absent (mean + 2 SD) ; 1 = moderate splenomegaly (size >2 to 4 SD above mean); and 2 = marked splenomegaly (>4 SD above mean).

The following are the normal lengths of the spleen, taking into consideration that in malaria endemic areas like Liberia, the spleen may also be enlarged in the absence of SCH: 9.0 cms at 4 years; 9.5 cms at 6 years; 10.0 cms at 8 years; 11.0 cms at 10 years; 11.5 cms at 12 years; 12.0 cms at 15 years or older for girls; and 13.0 cms at 15 years or older for boys (Rosenberg, et al., 1991).

8.6 Results

Of the 272 school-age children examined by ultrasound for periportal fibrosis, only one female had periportal fibrosis (see Table 47).

Table 8.1: Prevalence of organomegaly and periportal fibrosis of participants, by age and sex (N = 272)

Age	No. examined		Total % with periportal fibrosis
	Male	**Female**	
7–11 years	85 (59.9%)	79 (60.8%)	0 (0.0%)
12–14 years	52 (36.6%)	43 (33.1%)	1 (0.4%)
15 years	5 (3.5%)	8 (6.2%)	0 (0.0%)
Total	**142**	**130**	**1 (0.4%)**

Of the 272 school-age children examined by ultrasound and clinical examination for hepatomegaly and splenomegaly, only one male (0.4%) was found to have hepatomegaly and three schoolchildren (1.1%) were found to have splenomegaly, one male (33.3%) and two females (66.7%) (see Table 48).

Table 8.2: Prevalence of organomegaly and periportal fibrosis of participants, by age and sex (N = 272)

Sex	**No. examined**	**Liver enlargement**		**Starry sky liver**	**Splenomegaly**
		Right lobe	**Left lobe**		
Male	142	0 (0.0%)	1 (0.4%)	20 (54.1%)	1 (33.3%)
Female	130	0 (0.0%)	0 (0.0%)	17 (46.0%)	2 (66.7%)
Total	**272**	**0 (0.0%)**	**1 (0.4%)**	**37 (13.6%)**	**3 (1.1%)**

Figure 8.1: Participant being scanned during examination

Of the total 272 school-age children examined by ultrasound and clinical examination for urinary bladder pathology, 53 (19.5%) had distorted bladder shape, 49 (18.01%) had bladder thickening that was focal, and multifocal was 19 (7.0%). Those with irregular bladder, 69 (25.4%) were focal and 7 (2.6%) were multifocal. There was no mass noted during the process, but two schoolchildren (0.73%) were noted to have single pseudopolyp (see Table 49 and Figures 31 and 32).

Table 8.3: Classification of urinary track diseases of participants

Urinary bladder pathology		**Classification**	**N (272)**	**Frequency**
Bladder shape	Normal (rectangular)	0	219	80.5%
	distorted (round)	1	53	19.5%
Thickening	Normal	0	204	75.0%
	Focal	1	49	18.0%
	Multifocal	2	19	7.0%
Irregularity	Normal	0	196	72.1%
	Focal	1	69	25.4%
	Multifocal	2	7	2.6%

Mass	None	0	272	100.0%
	Single	2	0	0.0%
	Multiple	n+2	0	0.0%
Pseudopolyp	None	0	270	99.3%
	Single	2	2	0.7%
	Multiple	n+2	0	0.0%

Figure 8.2: A scan showing an irregular shaped bladder in a participant

8.7 Discussion

The patology due to *Schistosoma* may heal after the PQZ treatment, provided treatment is started early before organic complications such as, bladder cancer and hepatic scaring. There are many methods for the examination of *Schistosoma* induced pathology of the liver, kidney and spleen. The changes are usually due to the result of the *Schistosoma* eggs lodging in different tissues causing inflammation, which leads to fibrosis as a result of the host response. One of such methods is ultrasound, which is now widely used to follow-up patients. Ultrasonography of the liver, spleen and kidney for the diagnosis of pathology due to SCH usually correlate with the clinical status of the person with the disease (Abdel-Wahab & Strickland, 1993).

Ultrasound is non-invasive, has low radiation, is portable and can be used in the field. Ultrasound has been used for over 50 years as a key method for monitoring SCH morbidity and has been reported to be accepted in communities (Hatz, 1992). The main limitations have been reported as operator skill and inter-observer differences (King, et al., 2003). In the 10 communities, there were objections by the community for the use of ultrasound on their children; this was due to the recent end of the Ebola crisis that terrified the nation making them lose confidence in health workers. They asked if adults could be scanned instead of the children. After series of meetings with the communities and the built confidence of the team, the research was agreed to continue.

Other imaging methods that can be used to detect *Schistosoma* pathology in humans and experimental animals are intravital microscopy, fluorescence molecular tomography and positron emission tomography (Skelly, 2013).

Globally, ultrasound is now frequently used to assess the morbidity of *S. haematobium* and *S. mansoni.* In some endemic areas morbidity has been observed in children from 7–14 years of age, and pathological changes identified by the use of ultrasound usually directly correlates with the intensity of the *Schistosoma* infection (Mostafa, Sheweita, & O'Connor, 1999). It has been reported that there is a relationship between *S. mansoni* and carcinoma of the colorectal and between *S. haematobium* and squamous cell carcinoma of the urinary bladder (Khurana, et al., 1992). In contrast, another study reported that there was no cause effect relation with the parasite in relation to tumour of the urinary bladder (Dimmette, Sproat, & Sayegh, 1956).

In this study, no histopathology was performed to determine if there was carcinoma due to SCH. Histopathology can detect if there is inflammatory granulomata due to eggs and in such cases would require barium enema or colposcopy.

The measurement of periportal fibrosis can be conducted in two ways: (i) by using the qualitative method by using image classification; and (ii) the quantitative method by measuring the diameter of the secondary portal branches (DoehringSchwerdtfeger, et al., 1989). In this study, both qualative and quantitative methods were used to assess periportal fibrosis.

In this study, both abdominal and urinary track ultrasounds were performed on the 272 school-age children from 10 schools in Bong County.

The results from this study showed that of the 272 participants only one schoolchild (0.4%) was noted to have periportal fibrosis, which may have been due to infection with *S. mansoni*. Periportal fibrosis lesion is usually seen after years of infection with the disease, but this was present in a schoolchild in this study. The eggs that are produced by the female worms go into the bowel, bladder and the environment. In the human body some of the *Schistosoma* eggs go into the portal veins from the mesenteric venules where some get entrapped and cause inflammation, granulomas of the liver and then fibrosis. The fibrosis of the liver could lead to obstruction of the portal veins, portal hypertension and futher leads to oesophageal varices (Cheever & Andrade, 1967).

A study in Tanzania amongst 1,840 children and adults reported that only 458 participants were invited to have extended examination. The study used the Mangagil protocol for classification of their results and reported that 65.0% of the participants were classified with periportal fibrosis. The study concluded that the ultrasound scan usually does not correlate very well with the staging of SCH and was not found to be of significance in classifying periportal fibrosis and therefore, not useful in follow-up studies on *S. mansoni* as it relates to periportal fibrosis (Asztely, Ericksson, Gabone, & Nilsson, 2016). In this study, as mentioned earlier, there was only one (0.4%) male schoolchild with periportal fibrosis compared to 36.0% in the Tanzanian study.

Furthermore, of the 458 participants invited for extended examination, 1.0% of participants had right lobe of the liver enlargement compared to 17.0% with left lobe enlargement in the Tanzanian study.

Hepatomegaly and splenomegaly in this study were defined using the Niamey protocol. For normal size left liver lobe less than or equal to 2 SD, and the right liver lobe greater than or equal to 2 SD, but less than or equal to 4 SD were classified as hepatomegaly, and splenomegaly was defined as the length of the spleen greater then 2 SD above the normal reference.

In a similar cross-sectional study, in north-western Tanzania amongst 412 participants aged 18–89 years, 29.6% had left hepatomegaly and 58.5% had right hepatomegaly (Mazigo, et al., 2017). A similar study in China, by Wiest, et al. (1992), to assess morbidity induced by *S. japonicum* in 825 participants, found hepatomegaly (75.0%) using ultrasound and physical examination. In these participants 20.0% were found to have Symmer's clay fibrosis as compared to this study where 37 schoolchildren (13.6%) were noted to have starry sky liver (Wiest, et al., 1992).

The use of ultrasound to assess pathology of the kidney associated with infection due to *S. haematobium*, has also become widely used. Studies have shown that there is a strong association between *S. haematobium* and squamous cell carcinoma of the urinary bladder. Therefore, it is important to use ultrasound to record bladder wall thickening in endemic areas for the purpose of follow-up. If a person was found to have bladder lesions and treated, this should lead to regression. If there is no change after taking medications for STH, then malignancy of the bladder should be ruled out (Abdoulaye, et al., 2015).

In this study, we found that of the 272 school-age children 53 (19.5%) had distorted bladder shape, 49 (18.0%) had focal bladder thickening, 69 (25.4%) had bladder wall irregularity, and 2 (0.7%) had pseudopolyp. This compares favourably with a similar study in Mali using the WHO protocol to assess *S. haematobium* pathology from 29 randomly selected schools (Abdoulaye, et al., 2015). This result was higher compared to another study in Nigeria where a total of 2,822 schoolchildren were examined by ultrasound. The results revealed that 6.0% of the schoolchildren had bladder wall thickening and irregularities, masses and pseudopolyps with an estimated upper urinary tract pathology of 3.7% (Koukounari, et al., 2006). A similar study also carried out in Nigeria amongst 138 participants (both adult and children) showed that on ultrasound 55.8% had bladder wall thickness, 69.8% was abnormal and 4.7% had pseudopolyps (Nmorsi, Ukwandu, Ogoinja, & Blackie, 2007). A cross-sectional study in Kenya amongst 1,014 participants of all ages living in *S. mansoni* endemic areas, on urine cytology examination found that amongst those without therapy for *S. haematobium* the prevalence of cellular inflammation, hyperkeratosis and squamous cell metaplasia was greater than 30.0% as compared to those treated for *S. haematobium* (Hodder, et al., 2000).

A randomised controlled trial was conducted amongst 162 pre-school-age children and 141 school-age children in Côte d'Ivoire, West Africa, to assess morbidity due to *S. haematobium,* using ultrasound examination. The participants were positive with *S. haematobium* who were compared with a placebo group. The result revealed that 67.0% of the school-age children had bladder morbidities that were mainly moderate, 4.0% had pseudopolyps, and 6.0% were found to have dilatation of the renal pelvis. Of the pre-school-age children examined, 43.0% were found to have urinary tract pathology, of which 7.0% were found to have hydronephrosis. The study reported that those in the placebo group had worse pathology compared with those treated with Praziquantel (Barda, Coulibaly, Hatz, & Keiser, 2017).

Some reasons communities reject to the study will include if there were no pror senstitition , if they think the study may have harmful effect on them and if they think there is no financial benfit.

8.8 Conclusions

This study revealed that *S. mansoni* and *S. haematobium* and their associated morbidities such as hepatomegaly, splenomegaly and urinary tract abnormalities are endemic amongst school-age children in Bong County, but not common. According to the MoH report there have been two rounds of MDA of Praziquental in Liberia, in 2013 and 2015 (MoHSW, 2017b). However, results from our study indicate that, despite the intermittent treatment, morbidity due to *S. mansoni* and *S. haematobium* are still a public health problem in Liberia. Ultrasound is very much important in assessing morbidities due to SCH as it is accessible, mobile, cheap and can be used on the field with reliable results. Its use should therefore be encouraged to access SCH-related morbidities.

8.9 Recommendations

1. Follow-up ultrasound study to be performed after MDA to assess progression of pathology of the disease in the participating school-age children.
2. Ultrasonography study to be undertaken by the MoH in all endemic counties.
3. MDA for SCH should be distributed to both adults and children in endemic counties.
4. Continuous and vigilant health education to enhance compliance and to note any challenges from participants.
5. Revison of pathology after Praziquantel treatment.

8.10 Limitations

This study did not take into consideration adult participants as the focus was on schoolage children.

CHAPTER 9: GENERAL DISCUSSIONS, RECOMMENDATIONS AND CONCLUSIONS

9.1. General discussions

Neglected Tropical Diseases (NTDs) continue to form a huge health burden in majority of low income countries. According to Mitjà, et al. 2017 every low income country is affected by at least one NTD while others by up to five. Due to the increasing morbidity and mortality associated with unmanaged NTDs, there is a need for urgent and effective control of NTDs, to prevent hindering of the attainment of the sustainable development goals for eliminating NTDs by 2030. As many of the NTDs have the same aetiology, epidemiology and treatments, integrated efforts in the management have the potential to control NTDs in an accountable, efficient and economical manner (Standley et al.2018). Efforts should be geared towards enhancing the detection and surveillance as recommended by the World Health Organization (WHO, 2013).

An integrated approach therefore provides an avenue for tracking the progress, promoting accountability and easy verification of the success of the management of the disease by improving the efficacy and quality of service delivery in managing NTDs. It also reduces disparities in the control programmes (WHO, 2017). Therefore, the World Health Assembly emphasises the need to intensify and integrate the programs aimed at controlling NTDs and improving the health of those affected by these diseases. Efforts have been made by several countries that have high burden of NTDs, including Liberia, to integrate the management programs of several of the diseases into a single program.

In Africa, NTDs integration has been embraced and implemented in several countries. For example, in West Africa, Sierra Leone a post conflict and post Ebola country like its neighbouring country Liberia, has an integrated some of its NTDs program vertical programs examples, LF, SCH, Oncho, and STH since 2007,but have is still having challenges like ,budget constraints to fully implement the integration and relay on health partners for support.(NTDs Masterplan Sierra Leone (2016-2020) has and Nigeria has an integrated plan for the management of tuberculosis and leprosy (Walsh et al.2015). Togo and Benin have integrated programmes for the control of yaws, leprosy and Buruli ulcers. Cameroon has integrated strategic plans for the management of yaws, Buruli ulcers and leishmaniasis (WHO, 2010). Sudan has integrated strategies for controlling vector-borne diseases that are arthropod associated (Ministry of Health report Sudan, 2015). In post-conflict Côte d'Ivoire integration was focused on the elimination of dracunculiasis instead of all of the NTDs.(Standley, et al., 2018). In Liberia, strategic plans have been designed and put into place to transfer most of NTDs programmes from vertical to integrated for the control of Schistosomiasis (SCH), Soil transmitted Helminths (STH), Onchocerchiasis (ONCHO), Buruli ulcer and Lymphatic Filariasis (LF).

In Liberia, NTDs related prolong morbidities and in extension concomitant socioeconomic burden posed on the population with an already poor health infrastructures, and lack of logistics and funding have necessitated the embracing of the integrated program for the control of these diseases. Recent data obtained through a survey by the Ministry of Health from the mapping of NTDs in the regions in this study revealed high prevalence and overlapping of the following NTDs: onchocerciasis; lymphatic filariasis; schistosomiasis; soil-transmitted helminthiasis; Buruli ulcer; and leprosy (Ministry of Health, Liberia, 2016). Notably, more than a million people are at risk of contracting these specific NTDs. Among these at-risk group is a great proportion of school-age children that are affected by soil-transmitted helminths namely, *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms, This class of NTDs are prevalent in all of the 15 counties. Therefore, WHO in collaboration with the Ministry of Health has set up the integrated program for the management of these NTDs in the through preventive chemotherapy by Mass Drug Administration (MDA) and management of attendant morbidities.

Accordingly, a 5-year master plan was introduced in 2011 through the NTDs programme. This formed the basis for the implementation of the integrated form of management of these diseases. The goal of the programme is to reduce the burden of targeted NTDs, to a level that it no longer poses a public health problem, whilst simultaneously contributing to the socioeconomic development of the country.

In Liberia, the advantage of the program lies in its efficiency, time saving, cost effectiveness through its optimisation and greater control of limited resources, and labour saving. Its socioeconomic benefits are through decrease morbidity, improve health and increase productivity and therefore the alleviation poverty. However, the program implementation started regionally and is yet to cover the entire country. Even at that there are challenges experienced in these selected regions that hinder the full realization of the potential benefits of the Integrated program. Some of these challenges are either institutional, technical, resource limitation and lack of roads and trained manpower capacity. Others include Natural disasters, civil unrest, interregional migration mismanagement and lack of political will. These have to be addressed in order for the country to realize the full benefits of integration.

These challenges prevent sustained regular MDA and monitoring and evaluation and therefore leads to resurgence of the diseases, depletion of megar resources and donor fatigue. In order to succeed the integrated approach to the control of NTDs must be multidepartment, to include example, the department of education, and agriculture. Multi-partnership with Tropical medical institutions example, Liverpool School of Tropical Medicine, and NGOs like Sight-Savers.

The challenges enumerated including the Ebola crisis were very interruptive to the health sector of the country as well as to the integrated control of NTDs. This study however has shown for the first recorded time in Liberia the use of ultrasound to diagnose bladder and liver pathologies due to Schistosomiasis.

The study also showed demographic distribution of the respective NTDs under study in Liberia based on the vector habitat and geographic landscape, social practices as well as age groups. The absence of substantive resource local records, literatures and data base to compare were specific challenges.

The present study was conducted looking at the integrated approach to the control of three NTDs: LF; SCH; and STH. Liberia a post-conflict country is endemic for these NTDs.

The objectives of the NTD programme in the country are as follows:

1. To strengthen the government's ownership, advocacy, co-ordination and partnership.
2. To establish and sustain partnerships for the control, elimination and eradication of targeted NTDs at central, county, district and community levels.
3. To enhance high level reviews of NTD programme performance and the use of lessons learned to enhance advocacy, awareness and effective implementation.
4. To strengthen advocacy, visibility and profile of NTD control, elimination and eradication interventions at all levels.

5. To strengthen service delivery systems for the prevention, control and management of NTDs.
6. To build the capacity of service providers on NTD prevention, control and management.

To get a clearer understanding of the epidemiology and distribution of *W. bancrofti* in human and vector populations in Liberia, a literature review of historical documents was undertaken and results from the study showed that *A. gambiae* and *A. melas* were the prevalent vectors in the country and were found mainly in the coastal regions. This result also collaborates with the only nationwide mapping survey for LF conducted in 2010 by the MoH and its partners, the results which have been referenced in WHO publications, indicates that 13 out of the 15 counties in Liberia are endemic for LF. The MoH and its partners conducted a pre-MDA baseline survey for microfilaria in 2012. The result showed an overall 6.3% prevalence rate with males having higher prevalence compared to females.

After the establishment of the NTD programme, a nationwide survey was conducted amongst 1,489 males, they were examined to determine the morbidity of the LF. Results from the survey indicated that 12.8% of those examined had hydrocele and 6.3% had lymphoedema. Not much has been done on the morbidity control of the disease. To date, only 10 cases of hydrocelectomy has been recorded by the national health management information system unit of the MoH. The programme has since conducted three rounds of MDA for LF in 2013, 2015 and 2017 in all affected counties with therapeutic coverage of 83.0%.

There is currently an MDA plan and budget for the implementation activities in the counties including coverage and a sentinel or spot check sites survey.

Based on the NTDs master plan 2016–2020, an annual implementation plan for the programme has been developed. The programme has also developed a 1-year operational plan, which is a subset of the master plan. It describes short-term ways of achieving milestones and explains how, or what portion of the master plan will be put into operation during a given operational period (MoHSW, 2016).

9.1.1 SCH

SCH is endemic in Liberia. Unfortunately, in all 15 counties in the country that have not been mapped for the disease, records on earlier scientific research, reports and other relevant documents were lost during the civil war. In 2010, there was an estimated nationwide prevalence of 24.0% for SCH (Jones, 2015). In some unpublished studies it was reported that SCH was found in mainly Bong, Nimba and Lofa Counties. However, a study by Dennis and colleagues (1983) on the epidemiology of SCH in Liberia indicated high prevalence of the disease in Central Liberia (Bong, Lofa and Nimba Counties) where the snail host responsible for the transmission was *Bulinus globosus* (for urinary SCH) and *Biompjalaria pfeifferi* (for intestinal SCH). There were no snail hosts of the disease in coastal regions (Dennis, et al., 1983).

In 2012, the MoH in collaboration with its partners conducted an integrated mapping survey for STH and SCH using the Kato-Katz method. The results indicated that in Bong County the prevalence rate for *S. mansoni* was 63.0% and for *S. haematobium* was 56.0%, in Nimba County the prevalence rate was 38.0% for *S. mansoni* and 20.0% for *S. haematobium*, and in Lofa County, the prevalence rate was 32.0% for *S. mansoni* and 10.0% for *S. haematobium*. Analysis of these results indicates that Margibi County showed a prevalence of 9.0% and 7.0% for *S. mansoni* and *S. haematobium*, respectively. The remaining counties had SCH prevalence rates ranging from 0.0% to 3.0%. The distribution of SCH was 11.6% and 11.2% for *S. haematobium* and *S. mansoni* respectively in schoolchildren aged 5–8 years. The age group of 9–12 years had the highest prevalence rate of 58.0% for *S. haematobium* and 57.0% for *S. mansoni*; age group 13–15 years followed with prevalence of 28.2% and 30.6% for *S. haematobium* and *S. mansoni* respectively; while age group >15 years had a low prevalence rate of 2.2% for *S. haematobium* and 1.2% for *S. mansoni*. These results showed that Bong County has the highest prevalence rate of SCH in Liberia, schoolchildren aged 9–12 years are the most vulnerable, and schoolchildren above 15 years are the least affected (MoHSW, 2013).

The MoH in 2013 conducted the study again at 38 sentinel schools in the three endemic counties. Results from the 2013 study showed a marked reduction in SCH prevalence compared to the 2011 study. Since the establishment of the NTD programme in the country, the MoH has conducted two rounds of MDA for STH in the three endemic counties and had a therapeutic coverage of 81.0% (MoHSW, 2017b).

This integrated study on SCH and STH was conducted in Bong County amongst school-age children in 10 schools representing the eight health districts of Bong County. The study selected Bong County as an exemplar to provide up-to-date information for the national control programme after two rounds of MDA because of its high prevalence of STH. The study was a cross-sectional parasitological study conducted amongst 1,003 schoolchildren aged 5–15 years. The results indicated that 12.3% of the schoolchildren were infected with S. *mansoni* while 11.2% were infected with S. *haematobium*. The result in this follow-up study conducted after two rounds has shown that there is approximately a 50.0% decrease in the prevalence of the disease in Bong County as compared to the 1980s and 2011 survey results. This is attributed to:

(i) the two MDA rounds conducted in that county; and (ii) vast migration of citizens from rural areas to urban areas – evident by the overpopulation in the capital in

Monrovia and the scarcity of the population in rural areas.

9.1.2 STH

STH are widely distributed in Liberia and are prevalent in all 15 counties. A nationwide mapping survey was conducted for STH conducted in 2011 by the MoH and its partners on 59 sampled schools totalling 3,144 schoolchildren. The results indicated the prevalence rates of the disease as: *Ascaris* at 20.0%; hookworm at 9.0%; and *T. trichiura* at 3.0%. This study found generally a low prevalence of STH in Bong County and observed that hookworm had the highest prevalence at 3.3%. The current decrease in the prevalence of STH can be attributed to the annual deworming programme by the combined efforts of the Ministries of Education and Health as well as the inclusion of the deworming programme in the MoH polio campaigns.

9.1.3 KAP towards SCH, LF and STH

The present study observed the KAP towards SCH, LF and STH amongst school-age children in Bong County, northern Liberia. The results highlighted the need for health education and improved sanitation for the control of NTDs. Additional significant information gathered from this study on 1,003 school-age children was that 92.0% had not heard of LF, 86.0% had never heard of STH, and 90.0% had never heard of SCH. Furthermore, this study observed that only 9.0% of participants that came from the communities had access to pipe water; this is a major reason why these school-age children go to vector snails infested streams for their domestic water needs in addition to swamp farming.

9.1.4 SCH-related morbidity using ultrasound

This study assessed SCH-related morbidity amongst school-age children in Liberia by use of ultrasound. This study was necessary to access the pathological changes of the kidney, liver and spleen after MDA. Results from this study showed that of the 272 school-age children examined, the following pathologies were observed: hepatomegaly at 0.4%, splenomegaly at 1.1% and periportal fibrosis at 0.4%. There was no urinary bladder mass noted.

9.2 A brief analysis of the county health system and the Ebola outbreak

9.2.1 Health system situational analysis

Liberia is a low-income country with an estimated GDP per capita of US$454 in 2013. Although the real GDP growth in 2014 had been projected at 5.8%, it was estimated to have declined to 2.5% or less by the end of 2014 due to the EVD crisis.

During the 14-year period (1989 to 2003), the health system was dysfunctional as a result of the destruction of the infrastructure and the mass exodus of the workforce. Since 2005, the country has made great strides in rebuilding the health system through reform, an introduction of the 'Basic Package of Health Services (BPHS)' under the 'National Health Policy, National Health Plan 2007–2011' (MoHSW, 2007); and later the 'Essential Package of Health Services (EPHS)' under the 'National Health Policy and Plan 2011–2012', all of which defined the type of services to be delivered at every level of care, in the face of the minimum levels of resources required to provide the package namely, infrastructure, equipment, essential medicines and human resources (MoHSW, 2016).

The main health policy document, which is the ‘National Health and Social Welfare Policy’ (MoHSW, 2011c), is the blue print of the strategy that identifies the priority areas including decentralisation, access to basic services, increasing health workforce and expanding the package of health services. The strategy enables transformation from a highly centralised to a decentralised client-centred health care delivery system, focusing on the essential package of health. The service delivery system is pluralistic with a variety of direct service providers (government, faith-based organisations, local and international non-governmental organisations and the private sector). The government abolished user fees in 2006 towards more equitable access to health care. However, communities frequently reported informal payments as a common practice.

There are challenges relating to facility functionality. From the 2014–2015 health facility assessment, 13.0% of all facilities did not have access to safe drinking water, 43.0% had no functional incinerators, while 45.0% did not have a primary power source for emergency lighting. This significantly limits the readiness of facilities to provide the health services required in the EPHS (MoHSW, 2016).

9.2.2 The Ebola outbreak (NTD)

The outbreak of the EVD is a zoonotic tropical disease, of which should be classified as an NTD. Ebola is usually found in countries with low economic status and in a poorly prepared health sector as that of the NTDs.

In Liberia, the outbreak was first detected in a person from Lofa County bordering on 22 March 2014, confirmed on 30 March 2014, and officially declared an EVD case by WHO on 31 March 2014. By April 2014, documented cases of EVD had spread from Lofa County to Margibi and Montserrado Counties. Because of the the risk involved both to the study participants and the researcher during the Ebola outbreak my research was suspended.

Liberia was declared EVD transmission free for the second time and certificated by WHO on 3 September 2015

9.3 Conclusions

The multiple burdens of different NTDs in Liberia are impediments to socioeconomic development of an already resource limited impoverished society with a poor health sector. This study showed the nationwide mapping of LF and has therefore, provided accurate knowledge on the distribution and epidemiology of LF and the associated morbidities in Liberia. This study has further quantifiably, for the first time, revealed the socioeconomic benefits derived from integrated MDA by significantly reducing the financial, logistics, manpower and time consuming burdens previously involved in the individual control methods used for these NTDs. This is graphically demonstrated in the pre- and post-MDA surveys by a significant decrease in SCH and STH after MDA.

9.4 Recommendations

- The integrated NTD programme at the MoH should endeavour to collaborate with other health service-related programmes at the MoH, the Ministry of Education, the Liberia water and sewer company, the National Drug Service and other relevant stakeholders in order to maximise programme impact.
- The establishment of a Centre of Excellence for Case Management and Disability Prevention of NTDs.
- Mapping for NTD-related morbidities, such as hydrocele and lymphoedema.

- Annual community-based health education programmes on NTDs to be carried out amongst all counties in the country.

9.5 Future study

If further funding was available, in the future I would wish to carry out future studies related to NTDs in Liberia. The study of priority would be: ‘Using colposcopy to diagnose Female Genital Schistosomiasis (FGS) in Liberia: a cross-sectional study’.

In Liberia, doctors as well as health workers are unaware of FGS, which has gone undiagnosed or misdiagnosed for decades. This may also be due to the similarity of FGS to sexually transmitted diseases (STDs). FGS is caused by *S. haematobium*, where the patient will present with vague signs, which are similar to that of any of the STDs such as: vaginal discharge; bloody discharge; bleeding after intercourse; spotting, itching or burning sensations; pelvic pain; and pain during or after intercourse.

In my future study, I will enrol females aged 15 years and older who live in the three endemic counties (Bong, Lofa and Nimba) for SCH. Using the 28 images that are in the pocket atlas for clinical health care workers, I will use the colposcopy and carry out visual inspections of the cervix of the participants to help diagnose FGS.

The results from this study will be used to sensitise the medical community in Liberia on FGS, to raise awareness that it is a public health concern, and to highlight that FGS is one of the causes of infertility amongst women who live in endemic areas, especially in a country where infertility is a rising problem. According to observations by doctors in the gynaecological outpatient clinic, a great percentage of the clinic attendees come with complaints of primary or secondary infertility.

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APPENDICES

Appendix A: Questionnaire for the Knowledge, Attitudes and Practices towards SCH amongst school-age children in Bong County, Liberia

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Name of School ---

Community --

District ---

Initials of person doing the survey ……………………………………………….

GPS co-ordinate: Longitude …………………Latitude …………………………

Demographic characteristics

Date--

ID number ------------------------------------

Name of the respondent

Gender Male { } Female { }

Age----------
Level of education:

a) K1–Grade 2
b) Grade 3 to Grade 6
c) Grade 7 and above

1. Knowledge of Schistosomiasis
Yes -------------if yes, what is your source of information?
School
Health workers
Clinic/hospital
Relatives
Parents
Town chiefs
I don’t have knowledge of schistosomiasis
Others specify
2. Knowledge of sign and symptoms of Schistosomiasis
Bloody urine (blood in your pee pee)
Bloody stool (blood in your pop poo)

Abdominal pain
Diarrhoea
Headache
Fever
Chills
Itching skin/rash

3. What germ causes schistosomiasis?

Worm
Fresh water
Snail
Other specify -------------------------
Don’t know

4. Water contact pattern

Where do you get your water from a well/creek/river/hand pump?
Do you play in fresh water ponds or streams?
Where do you wash your cloths in the river/creek?
Do you pick up snails from the swamp?
Have you helped your parents with their rice farm?
Do you wash your cloths in the fresh water?
Where do you get your drinking water from?

5. Presence of latrine Toilet in the house?
Go to the nearby toilet house?
Go to the bush to toilet?
Go to the waterside to toilet?

6. Do you know how to prevent Schistosomiasis?

Avoiding unsafe drinking water
Washing hands before having a meal
Washing hands when leaving the bathroom Not playing and swimming in unsafe water
Don’t eat uncooked snail
Wash fruits and vegetables before eating
Taking the medications for schistosomiasis during MDA

7. Mass Drug Administration

Do you know of any drug distribution in this community where people’s height were taken?
How many drugs did you receive?
Have you received the medication for schistosomiasis?
How many times have you received the schistosomiasis medication? Who gave you the medication?

Appendix B: Assessment of Knowledge Awareness and Attitude to MDA intervention for the control of LF, northern Liberia (Bong, Lofa, and Nimba Counties): A post-Ebola survey

Name: Dr Louise Mapleh Kpoto, Tel: 0777702609, Health worker Name: Tel:
ID number:

GIS co-ordinates:
Latitude:
Longitude:

A) Sociodemographic characteristics

1. Age

2. Sex Male Female

3. Marital status

   a) Married

   b) Single

   c) Divorced

   d) Widowed

   e) Cohabiting

4. Occupation

   a) Farmer

   b) Fisherman

   c) Hunter

   d) House wife

   e) Business person
   f) Others

5. Religion

   a) Christian

   b) Muslim

6. Level of education

   a) Have never had formal education

   b) Elementary

   c) Junior high

d) High school

e) Completed high school

B) Knowledge of the disease (you can tick more than one)

1. Have you heard of the disease LF a) Yes b) No

2. If yes, how does it present?

   a) Enlarged leg

   b) Enlarged scrotum

   c) Enlarged breast

   d) Fever and chills

   e) Mumps

3. How does one get the disease?

   a) Through traditional rituals

   b) Through drinking dirty water

   c) Through farming

   d) Through mosquito bites

   e) Don't know

   d) Others

C) Prevention

1. Do you know how the disease is prevented? Yes NO

a) By taking medication

b) By drinking clean water

c) By using mosquito nets

d) By spraying your house

e) Others

D) Drug distribution/compliance

a) Has there been drug distribution in your community for LF? Yes or NO

b) Did you take some of the medications? Yes or No

c) How many times was the drug distributed? a) one b) two c) three d) four

d) Did everyone in your house take the medications? Yes or No

e) If no, why did they refuse the medication?

f) How many tablets were given per person? a) one b) two c) three

1. What are the side effects of the drug?

    a) Nausea

    b) Vomiting

    c) Fever and chills

    d) Itching of skin

    e) Impotency

    f) Weakness/dizziness

    g) Abdominal pains

    h) Diarrhoea

    i) Sweating

    j) Blood in faeces

2. If these drugs were distributed would you take it again? Yes or No

Question on the Ebola

1. Were you or your family affected by the Ebola? Yes or No
2. If yes, were you in the Ebola Treatment Unit? Yes or No
3. Did you have a family member in the Ebola Treatment Unit? Yes or No
4. Did you have a friend in the Eboal Treatment Unit? Yes or No
5. Did you lose a friend to the Ebola? Yes or No
6. Did you lose a family member to the Ebola? Yes or No
7. During the Ebola did you have assess to health care? Yes or No
8. Do you know how Ebola is prevented? Yes or No
9. Select any answer

    a) By washing hand

    b) By avoiding others

    c) By praying

d) Don’t know

e) Others

10 Do you know how Ebola is acquired?

a) Through food

b) Through witchcraft

c) Through hand shake

d) By bodily fluids

e) Don’t know

f) By touching others

Appendix C: A practical guide to the standardised use of ultrasonography for the assessment of SCH-related morbidity

See: www.who.int/schistosomiasis/resources/tdr_str_sch_00.1/en/

Appendix D: Informed Consent Form for lymphatic filariasis, schistosomiasis prevalence study

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Study participants ID#

Informed Consent

This Informed Consent Form is for men and women living in the targeted study villages who we are inviting to participate in research on the effectiveness of integrated mass drug administration in an environment that has not previously received treatment through community health workers. The title of our research project is: 'Integrated Approach to the Control of Lymphatic Filariasis, Schistosomiasis and Soil-Transmitted Helminthiasis in Liberia, West Africa'.

Principal investigators: Louise Kpoto

Liverpool School of Tropical Medicine, Liverpool, UK

This Informed Consent Form has two parts:

- Information Sheet (to share information about the research with you)
- Certificate of Consent (for signatures if you agree to take part)

You will be given a copy of the full Informed Consent Form

PART I: Information Sheet Introduction

Hello, my name is ______________________and I am in from the Ministry of Health and Social Welfare. We are conducting a study about a disease called lymphatic filariasis (Guah), which are very common in this county. I am going to give you some information about the study and invite you to be part of this research. We would very much appreciate your participation; however, your participation is completely voluntary. Before you decide, you can talk to anyone you feel comfortable with about the research.

There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them of me or any of the other members of the research team.

Purpose of the research

Lymphatic filariasis is a common disease in this region, spread by mosquitoes. The infection is usually acquired in childhood; however, the painful and disfiguring visible manifestations are normally visible later on in life. Men suffering from the disease are commonly found with hydrocoeles, while both men and women will suffer with enlarged and inflamed limbs. The treatments for this disease are two tablets that will be provided by your community health volunteer once a year for everyone in the village, including children. For effective treatment it is important to take the tablets every year.

We want to determine if you are affected with this disease. Results from the research will then be used by the Ministry of Health in providing treatment for children in this district.

Participant selection
We are inviting healthy adults living in your village to participate in this study.

Voluntary participation
Your participation in this research is entirely voluntary. It is your choice whether to participate or not. You may change your mind later and stop participating even if you agreed earlier.

Procedures and protocol
If you agree to participate, we will first ask you some basic questions about yourself and the people living in your household, such as your age, the location of your home, how long you have lived in this community, and the type of methods you use in your household to control mosquitoes.

Lymphatic filariaisis
We will take blood from your finger using a lancet. The blood will be tested to determine if you have been exposed to lymphatic filariasis and if you have active disease.

We will first clean the finger to be pricked with an alcohol swab and allow the finger to dry. We will then prick the finger with a sterile lancet and a small amount of your blood will be placed on a test card (show a test card). We will share the results with you.

We will also be conducting an additional test for detecting lymphatic filariasis; where a very small volume of blood will be collected from another finger approximately 2 mL taken at night between 22:00 hours and 02:00 hours will be mixed with approximately 10 times its volume of distilled water in a simple slide counting chamber and examine the slide immediately. We will also share these results with you.

The blood obtained during this research procedure will be used only for this research. At the end of the research, in 2 years, any leftover blood sample will be destroyed.

Duration
Our research study will take about 2 years to complete. During this time, we will return to your community to repeat the blood testing on a random sample of the community about once per year. When we return, you may or may not be included again in the study. Your participation at this time will take place over the next 2 days. During this time, we will ask you some simple questions about your household using a

questionnaire. This should take approximately 10 minutes. We will then conduct the blood test.

Side effects

Potential side effects are limited. You may experience some mild discomfort at the site of the blood drawn from your finger.

Benefits

There will not be any monetary benefit for you but your participation is likely to help us find the answer to the research question and if people in this county are found with the disease they will receive treatment through Mass Drug Administration.

Confidentiality

With this research, something out of the ordinary is being done in your community. It is possible that if others in the community are aware that you are participating, they may ask you questions. We will not be sharing the identity of those participating in the research.

The information that we collect from this research project will be kept confidential. Information about you that will be collected during the research will be put away and no-one but the researchers will be able to see it. Any information about you will have a number on it instead of your name. Only the researchers will know what your number is and we will lock that information up with a lock and key. It will not be shared with or given to anyone except the senior members of our research team.

Sharing the results

The knowledge that we get from doing this research will be shared with you through community meetings before it is made widely available to the public. Confidential information will not be shared. There will be small meetings in the community and these will be announced. After these meetings, we will publish the results in order that other interested people may learn from our research.

Right to refuse or withdraw

You do not have to take part in this research if you do not wish to do so. You may also stop participating in the research at any time you choose. It is your choice and all of your rights will be respected.

Who to contact

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact any of the following: Dr Louise Kpoto MoH&SW, Tel: 06514469; Mr Jerry Diaboi Tel: 06543567.

This proposal has been reviewed and approved by the University of Liberia, which is a committee whose task it is to make sure that research participants are protected from harm. If you wish to find about more about the University of Liberia Institutional Review Board, contact: Mr Jamee, University of Liberia Tel: 06583774.

PART II: Certificate of consent

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this research.

Print Name of Participant__________________

Signature of Participant ___________________

Date ___________________________

Day/Month/Year

If illiterate

I have witnessed the accurate reading of the consent form to the potential participant, and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

Print name of witness_____________________ AND Thumb print of participant

Signature of witness ______________________

Date ________________________

Day/Month/Year

Statement by the researcher/person taking consent

I have accurately read out the information sheet to the potential participant, and to the best of my ability made sure that the participant understands the study procedures.

I confirm that the participant was given an opportunity to ask questions about the study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

A copy of this Informed Consent Form has been provided to the participant.

Print Name of researcher/person taking the consent________________________

Signature of researcher /person taking the consent__________________________

Date ___________________________

Day/Month/Year