Aus der Medizinischen Universitätsklinik und Poliklinik Tübingen

Abteilung VII, Tropenmedizin

(Schwerpunkt: Institut für Tropenmedizin, Reisemedizin, Humanparasitologie)

Characterization of the epidemiology of major infectious diseases in the rural region of Tsamba-Magotsi in la Ngounie province in Gabon

Inaugural-Dissertation
zur Erlangung des Doktorgrades
der Medizin

der Medizinischen Fakultät
der Eberhard Karls Universität
zu Tübingen

vorgelegt von

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2017

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List of acronyms

AIDS	Acquired Immune Deficiency Syndrome
CERMEL	Centre de Recherches Médicales de Lambaréné
CRMN	Centre de Recherches Médicales de la Ngounié
CI	Confidence Interval
CIA	Central Intelligence Agency
DALY	Disability-Adjusted Life Years
EDTA	Ethylene Diamine Tetraacetic Acid
et al.	and others
g/dl	gram per deciliter
GDP	Gross Domestic Product
HBsAg	Hepatitis B surface Antigen
HIV	Human Immunodeficiency Virus
IgG	Immunoglobulin G
IPTp	Intermittent Preventive Treatment in pregnancy
Mp	*Mansonella perstans*
MiPPAD	Malaria in Pregnancy Preventive Alternative Drugs
P. spp.	Plasmodium species
SP	Sulfadoxin-Pyrimethamine
RAPLOA	Rapid Assessment Procedure for Loiasis
TPHA	Treponema pallidum hemagglutination assay
UNAIDS	Joint United Nations Programme on HIV/AIDS
WHO	World Health Organization
YLD	Years Lost due to Disability
YLL	Years of Life Lost

1 Introduction

This work aims to describe the basic epidemiology of major infectious diseases in the department of Tsamba Magotsi in the province of la Ngounie in central African Gabon. The department consists of Fougamou – a small town in this rural province – and its surrounding villages.

This manuscript describes for the first time the demographics and epidemiology of the most prevalent infectious diseases in this rural central African region. This analysis is needed as the epidemiology and impact of disease are varying importantly depending on geographical and economic characteristics.

1.1   Disease burden in Africa

While in Europe and America the burden of disease is mainly caused by non-communicable diseases, a completely different situation is found in the African region, where 65% of the disease burden is caused by communicable diseases, as shown in Figure 1. In no other region in the world infectious diseases account for such a high percentage of the disease burden. For example, infectious diseases account for 40% of total DALYs (Disability-Adjusted Life Years)[1] in the Eastern Mediterranean region and for 35% in South-East Asia. Wounds account for 9% of DALYs in Africa. Non-infectious diseases cause just 25% of the disease burden in the African region (Figure 1, WHO Regional Office for Africa 2016).

Non-infectious diseases are becoming more prevalent and therefore more important for public health systems in the region, while the disease burden caused by infectious diseases still remains at high levels (Kuate Defo 2014), "causing a double burden of communicable and non-communicable diseases"

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[1] "DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences" (WHO 2016a)

(Maher et al. 2010). Africa is undergoing a considerable population growth, which is caused by decreasing mortality rates, while at the same time fertility rates are remaining at high levels (Kuate Defo 2014). The decline in mortality rates has been caused mostly by improvements made in maternal and childhood healthcare (Omran 1971).
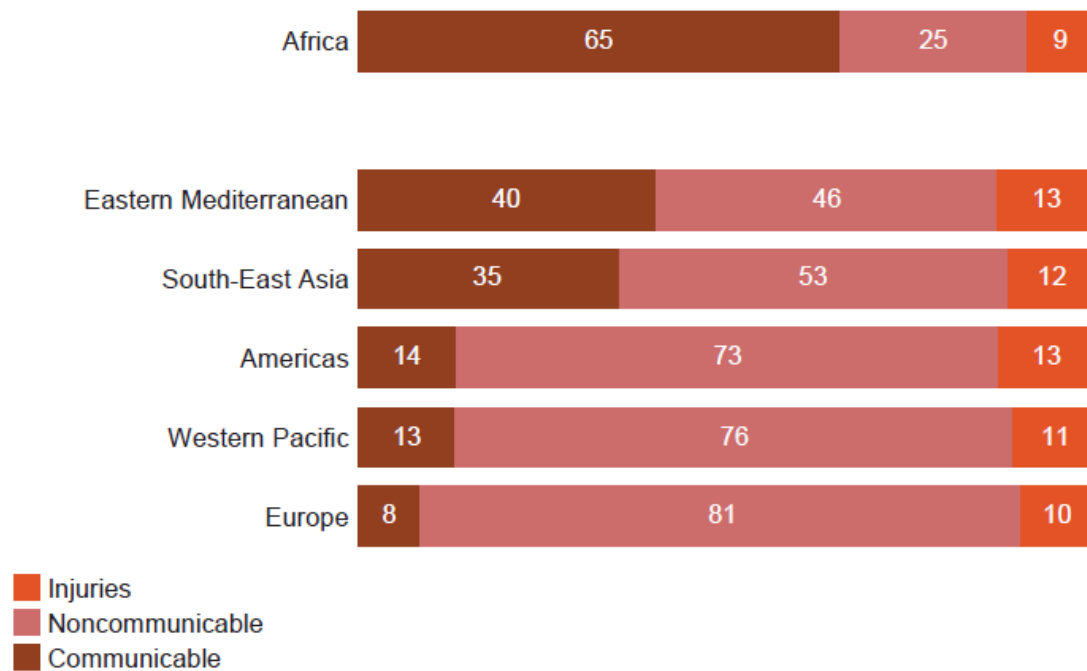
Figure 1: Distribution of DALYs by broader causes (%), by WHO Region, 2012 (WHO Regional Office for Africa 2016)

1.2 Gabon

Gabon is a small country located at the West coast of Central Africa (Figure 2), next to Cameroon, Equatorial-Guinea and the Republic of Congo. Gabon is a former French colony, and until today French is the main language. Apart from French, various African languages are spoken. The native population of Gabon are the Pygmies, but today they account for just 1% of the population. The majority of Gabonese inhabitants are descendents of Bantu tribes, of whom the

Fang and the Punu make up the largest groups. The climate is tropical, with the equator crossing the country. The population of Gabon was 1.6 million in 2013. Gabon's population is quite young, 38% is younger than 15 years old, just 7% is over 60 years of age. Life expectancy at birth increased from 59 years in 2000 to 63 years in 2012. In Gabon life expectancy is higher than the average of 58 years in the WHO African region (WHO 2015).

Worldwide, urbanization is a currently ongoing process. Unlike other African countries, this process is far advanced in Gabon. While in most other African countries the major part of the population lives in rural areas, in Gabon 87% of the population was living in urban areas in 2013 (WHO Regional Office for Africa 2016).

1.2.1 Gabon's history

The territory which forms Gabon nowadays has been home to humans for at least 400 000 years, and very old rock paintings have been discovered in the region. In the 16th to 18th century, the inhabitants of the territory of that time, called Pygmies, were displaced by Bantu tribes, mainly Fang, coming from the area which hosts Cameroon and Equatorial Guinea today.

In 1472, with the arrival of a Portuguese ship, the first Europeans arrived to that area. The coastal tribes established a strong cooperation with the Europeans while the inland population defended their land against European interests. British, French and Dutch ships arrived to trade slaves, ivory and wood. In 1849 the capital Libreville was founded for freed slaves. In 1885, at the Berlin Conference, the territory was recognized as French colony, being part of the so-called French Congo, later French Equatorial Africa. In 1960, independence of Gabon was declared, and Leon Mba became the first president. Only seven years later, Leon Mba died and his vice president Omar Bongo became president (Lonely Planet 2016). He ruled the country for 41 years and established a strong economical, political and personal relationship to France (Thorel 2013). Since the death of Omar Bongo in 2009, his son Ali Bongo is Gabon's president (Kölnische Rundschau 2009).

Figure 2: Location of Gabon (Wikipedia 2016)

1.2.2 Gabon`s economy

Gabon`s economy is mainly based on the exploitation of oil, manganese and wood. Oil exports are responsible for most of the gross domestic product (GDP) and exports (Wikipedia contributors 2016). The strong dependence on oil exports makes the Gabonese economy vulnerable to low oil prices, which has recently become a major topic for the country because of low oil prices in 2016, and Gabon`s government is therefore aiming to diversify the Gabonese economy (Puthod and Tsassa 2016, Schwikowski 2016). Agriculture, fishing and hunting is mostly practiced at a small scale for the local market or self-supply. Cocoa and coffee as well as palm oil and rubber are produced for export (CIA 2016). The construction of tarred roads is increasing, which

includes the road connecting the Tsamba Magotsi region with its neighboring towns of Lambaréné and Mouila. Exploitation of the natural resources and infrastructure projects are mostly run by European and Chinese companies. China is an important country for African export nations as Gabon, and the two countries have economical and political co-operations.

The oil richness has made Gabon one of the richest African countries. Gabon is known as the "African Swiss". The World Bank names Gabon an upper middle income country (WHO 2015). Material wealth is distributed very unequally throughout the country though. Therefore, people living in rural areas or poor districts of towns are often struggling economically. The percentage of children younger than five years of age suffering from malnutrition decreased from 10% in 1990 to 6% in 2012 (Puthod and Tsassa 2016).

Gabon is an inner-African immigration country, with immigrants mostly coming from countries as Cameroon, Mali, Nigeria, Republic of Congo, Central African Republic and Chad to work and live in Gabon.

1.2.3 Gabon`s health system

There are hospitals in the main towns and health stations which are run by nurses in most villages. Basic medical treatment is available in villages and province towns, while more specialized treatment is just to be found in the two bigger cities, namely Libreville and Port Gentil. Gabon suffers from a lack of physicians, while the number of nurses and midwifes is sufficient: in 2004, there were 0.24 physicians per 1000 inhabitants, and just 0.049 dentistry personnel, but 5 nurses and midwifes per 1000 inhabitants (WHO 2016b). This lack of physicians, especially in rural areas, is a problem not only concerning Gabon but Africa and the developing world in general, and migration of health professionals to more developed countries is a contributing factor to that situation (Crisp and Chen 2014). Cuba is sending physicians to Gabon, as to many other poor countries.

Since 2008, a national health insurance is being established, which covers everybody living in Gabon, which is unique in the central African region.

Burden of disease, 2012

Disability-adjusted life years (DALYs) are the sum of years of life lost due to premature mortality (YLL) and years of healthy life lost due to disability (YLD).

DALYs, YLL and YLD (thousands) by broad cause group

Cause group	
HIV, TB, malaria	
Maternal, neonatal, nutritional	
Other infectious diseases**	
Other NCDs*	
Neuro-psychiatric conditions	
Cardiovascular diseases and diabetes	
Unintentional injuries	
Acute respiratory infections	
Chronic respiratory diseases	
Cancers	
Musculoskeletal diseases	
Suicide, homicide and conflict	

0   100   200
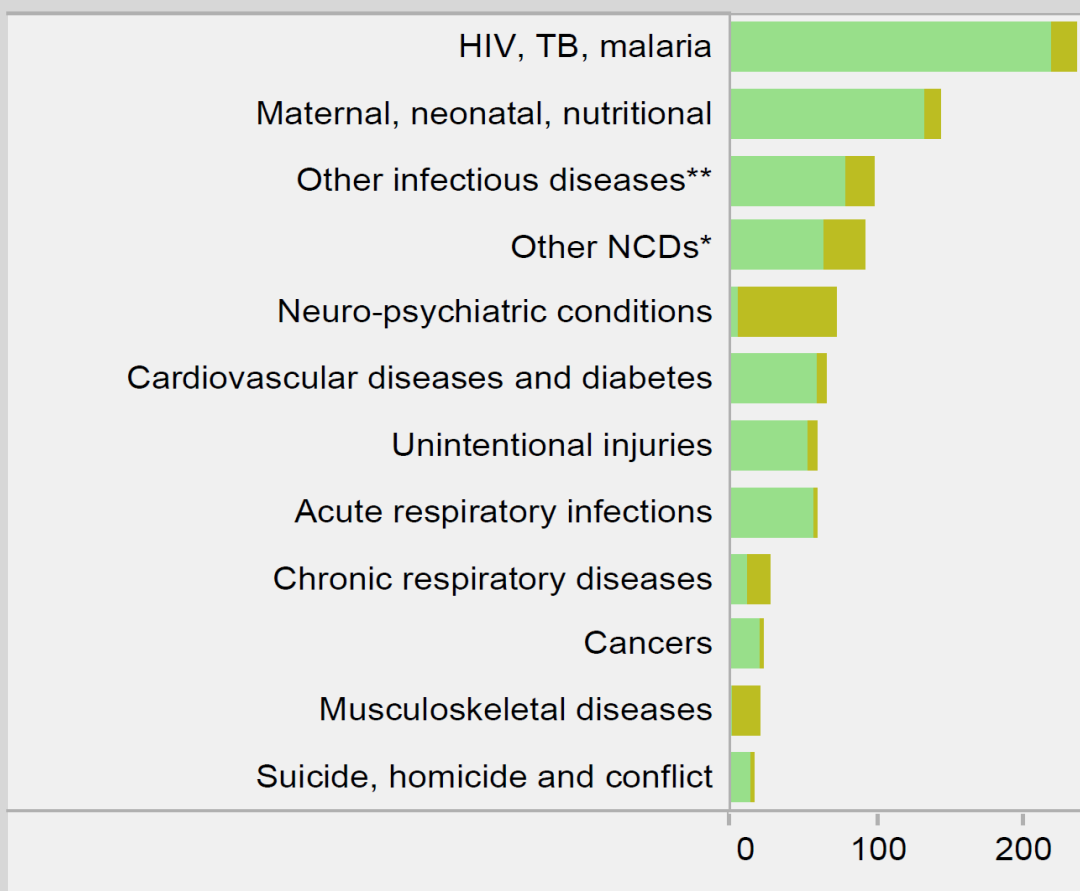
*Other noncommunicable diseases (NCDs) including non-malignant neoplasms; endocrine, blood and immune disorders; sense organ, digestive, genitourinary, and skin diseases; oral conditions; and congenital anomalies.
** Infectious diseases other than acute respiratory diseases, HIV, TB and malaria.

YLL   YLD

Figure 3: Most prevalent diseases in Gabon (WHO 2015)

Midwifery is covered by 100%, while most other medical services are covered by 80%, or 90% in case of chronic disease (Humphreys 2013).

Apart of the western oriented medical system described above, traditional medicine is practiced widely in Gabon. The Gabonese government is aiming to preserve traditional medicine and has therefore developed a national policy for traditional medicine (Kasilo et al. 2013). Cooperation of western medicine and traditional medicine is lacking but could have positive effects for patients and health professionals.

1.3 Disease burden in Gabon

According to WHO estimates, HIV/AIDS, malaria and tuberculosis are the most prevalent diseases in the region, causing the major part of the disease burden measured in disability-adjusted life years (DALYs), as seen in Figure 3. "HIV/AIDS was the leading cause of death, killing 2.3 thousand people in 2012" (WHO 2015). HIV/AIDS, malaria and tuberculosis are followed by maternal, neonatal and nutritional conditions, which affect mostly young children. Infectious diseases are clearly dominating, but non-infectious diseases, as neuropsychiatric conditions, cardiovascular diseases and diabetes are becoming more and more prevalent in Gabon (WHO 2015). For example, the rate of raised blood pressure was 36% among men and 30% among women in 2008 (WHO 2011).

The burden of malaria is unequally distributed throughout the country. Rural areas suffer more from malaria than urban areas (Mawili-Mboumba et al. 2013). While in urban areas the morbidity of malaria has decreased in the last decade, in rural areas it has been at a steady state or even increased (Assele et al. 2015, Moukandja et al 2016).

After the introduction of intermittent preventive treatment in pregnancy (IPTp) in Gabon (Ministère de Santé, 2005), the prevalence of malaria at delivery dropped from 10.5% in 2004 to 1.7% in 2006 in Libreville and Lambaréné (Ramharter et al. 2007).

1.4 Albert Schweitzer Hospital

The German doctor Albert Schweitzer founded a hospital near the small town of Lambaréné in 1913 (Association Internationale Schweitzer Lambaréné 2016). Schweitzer, also called "le grand docteur", gained a lot of international reputation later in his life, for his ethics of reverence for life and the practical manifestation of those ethics in his work in Lambaréné. He won the Nobel Peace Prize in 1952 (Association Internationale Schweitzer Lambaréné 2016) for his ethics and his practical work in Lambaréné.

Figure 4: The Albert Schweitzer hospital[2]

The hospital has be renewed various times, and the buildings that were used during Schweitzer`s time are now a museum, new buildings have been build near the historic hospital to host the modernized hospital.

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[2] Photo made by Yann-Arthus Bertrand and used with permission of Yann-Arthus Bertrand

Figure 4 shows the area of the historic Albert Schweitzer hospital next to the Ogooue river, and the new buildings including the renewed hospital and the medical research unit (chapter 1.5) behind of it.

The hospital nowadays consists of an internal medicine ward, chirurgic ward, pediatrics, maternity, ambulance, policlinic, dentistry and pharmacy.

The hospital is able to provide basic chirurgic operations and caesarian sections. It is equipped with an X-ray and an ultrasound device.

Physicians from various African nations work permanently at the hospital, midwifes and nurses are mostly Gabonese. European physicians and nurses as well as medical and public health students from Europe and the United States of America regularly travel to Gabon to work at the hospital for limited periods

Figure 5 The Medical Research Unit in Lambaréné[3]

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[3] Photo used with the kind permission of Florian Thol

of time. The Albert Schweitzer hospital has got a good reputation in the local population due to its long history of providing affordable medical care to the people of Lambaréné and its surrounding villages.

1.5 The Medical Research Unit

In 1981, a research institution was founded next to the hospital, focusing mainly on malaria and other infectious tropical diseases (Ramharter et al. 2007). It was called "Medical Research Unit" and was recently named "Centre de Recherches Médicales de Lambaréné" (CERMEL). It works in cooperation with the tropical institute of the University of Tübingen (Germany) and various other international institutions, for instance the medical departments of the Leiden University and Amsterdam University (Netherlands), University of Vienna (Austria) and the Vietnamese-German Center for Medical Research (CERMEL 2016).
The CERMEL is mainly based in Lambaréné but founded a satellite institution located in Fougamou which is the main town of Tsamba Magotsi, the department that is subject to this work.

1.6 Study Objectives

Very little epidemiological data has been published focusing on the rural region of central Gabon. This cross-sectional study provides basic information on the epidemiology of the Fougamou region by analyzing and presenting data from various sources, as hospital records, laboratory books, and screening logs of research projects conducted in the region. It aims to be a helpful tool for health workers searching for epidemiological data and a baseline study for further research projects in the region.

2 Methods

2.1 Study site and population

The Tsamba Magotsi department is located in the center of Gabon in the Ngounié province. It includes the small town of Fougamou and surrounding rural villages, as indicated in Figure 6. The department is crossed by the Ngounie river, which later on unites with the Ogooue river, the biggest river in Gabon. The climate is tropical, with temperatures ranging from 24 to 31°C and humidity being more than 80% in average. There are two rainy seasons, one from September to November and the other one from February to May (Bouyou-Akotet et al. 2003).

The population of Tsamba Magotsi was 12 000 in 2003, with 4 400 people living in Fougamou. The population is estimated to have grown to 12 400 in 2012 (Noelle Moussavou, personal message)[4].

The population is mainly Bantu tribes, and a small minority of Pygmies is still living in a traditional way in villages inside the forest, far away from the rest of the Gabonese population. The Bantu population belongs to different ethnic groups, with some of them speaking their own languages as well, but those languages are if at all spoken at home, main language is clearly French.

Main activities are agriculture, hunting and fishing (Zoleko Manego et al. 2017). There are two hotels and some restaurants providing local food.

As Gabon is a country to which a large number of people have migrated, a part of the population of Tsamba Magotsi are African migrants, mainly from Mali, but also other West- and central African countries. Most migrants live in the town of Fougamou or larger villages, typically running small businesses, for example corner stores.

There is a regional governmental hospital in Fougamou and nursery stations in the surrounding villages. Nurses and at some days a physician are working at

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[4]Noelle Moussavou is the official working in the ministry of intern affairs who was responsible for the 2003 census in the region.

Figure 6: Map of Tsamba Magotsi (Google 2016)

Figure 7: A part of the small town of Fougamou[5]

the hospital, which is technically poorly equipped. There is a maternity ward run by midwifs, sufficiently equipped for obstetrics in uncomplicated deliveries. Women in need for a caesarian section are send to Lambaréné, either to the Albert Schweitzer hospital or to the governmental hospital called "Hopital Georges Raiwiri".

Once a week a dentist and his team come over from the Albert Schweitzer hospital to treat patients at the regional hospital Fougamou.

Located next to the hospital, the Ngounié Medical Research Centre provides routine laboratory services to the hospital, but has also been active in research as a satellite site of the Centre de Recherches Médicales de Lambaréné (Ramharter et al. 2007) and has recently become an independent institution

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[5] Usage of the photo with kind permission of Florian Thol

Figure 8 The Ngounie Medical Research Center[6]

called "Centre de Recherches Médicales de la Ngounié", CRMN (Zoleko
Manego et al. 2017). Figure 8 shows about one half of the building hosting the
CRMN.

From 2009 until 2013, the Ngounié Medical Research Center has been a site of
an open-label multicenter randomized controlled trial assessing the efficacy,
tolerability, and safety of mefloquine as intermittent preventive treatment in
pregnancy (IPTp) against malaria called MiPPAD (González et al. 2014). The
MiPPAD study compared mefloquine as IPTp with the normally used sulfadoxin-
pyrimethamine (SP). The women were followed up until giving birth. At the first
day of study participation and in case of fever later on during pregnancy, thick
blood smears for malaria examination were prepared. Blood samples and

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[6] Photo used with the kind permission of Florian Thol

placental samples were taken from the mother at the day of birth, and the children were followed up until the age of one year, assessing their development. Alongside the MiPPAD study, various small studies were conducted in the Fougamou area, mostly with the same study population as in the MiPPAD study, HIV-negative pregnant women.

Both the research center in Lambaréné and the research center in Fougamou cooperate closely with various European research institutions (see chapter 1.5), mainly with the tropical institute of the University of Tübingen, Germany.

2.2 Data from the 2003 census

In 2003, a census was conducted by the Gabonese government in the Tsamba Magotsi region. Field workers went to every household and asked how many people are living in each house, their age and various other information. An official working for the Gabonese ministry of interior[7] contributed this demographic data to the project in form of a table containing the number of inhabitants of Tsamba Magotsi depending on age group and sex. It was used to design an age pyramid of the population living in Tsamba Magotsi (Figure 9).

2.3 Hospital statistics

Each patient attending the hospital in Fougamou or one of the rural health stations was recorded by a nurse writing by hand into a record book, including the following information: Date of the visit, patients family name, patients first name, age of the patient or date of birth and reason for attending medical care, exams made and their results, date of admission and date of discharge.

At the end of each year a statistician working for the medical center Fougamou conducted those data and entered it into an Excel sheet to create an overview for the Gabonese ministry of health. This includes the number of visits, the

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[7] Noelle Moussavou is the official working in the ministry of intern affairs who was responsible for the 2003 census in the region.

amount of different diseases depending on age group and sex, the number of malaria cases and days of hospitalization due to malaria, the number of antenatal care visits, the number of births and stillbirths, and the number of births at home. This overview was used to find out the most important infectious and non-infectious diseases in the region, the number of malaria cases and patients hospitalized because of malaria symptoms per year, the number of antenatal care visits, the number of babies born per year as well as the number of babies born premature and the number of babies born with low birth weight.

2.4 Laboratory record books

For each patient having a laboratory examination done at the Ngounié Medical Research Centre, the following information was recorded by a nurse into a laboratory record book, if available: Date of the visit, name, age or birth date, sex, village or district of Fougamou, symptoms, examination asked for, malaria result and species in thick blood smear, microfilaria result and species in thick blood smear, temperature, white blood cell count, hemoglobin, hematocrit, platelets. For malaria examination and a simple blood count, venous blood was taken by a nurse using EDTA tubes. This blood was then used to prepare a thick blood smear.

Thick blood smears were prepared and examined by a laboratory technician using the Lambaréné method (Planche et al. 2001).

The data was then copied from the laboratory record book into an Excel sheet by a data clerk for the time period from 02.01.2008 until 04.11.2009. Control for correct data entry was done manually. This data was used to show the amount of microscopically diagnosed malaria cases per month and age group.

For microfilaria, the results were recorded in the time period from 11.08.2008 until 25.02.2009. The prevalence of microfilaria in patients attending health care at the regional hospital depending on age group was calculated using that data. The species of microfilaria as well as the amount of co-infections of microfilaria and malaria were analyzed.

2.5 Screening in pregnant women

For pregnant women, a distinct laboratory book was used including the following information: Date of the visit, name, age, village or district of town, result of thick blood smear including parasite count and species.

The thick blood smears were prepared and examined by a laboratory technician as described above (chapter 2.4), using the Lambaréné method (Planche et al. 2001).

Using that data, distribution of malaria species, prevalence of microfilaria at first antenatal care visit from 30.10.2008 until 30.04.2009 as well as the average parity depending on age was calculated.

2.5.1 Anemia and stillbirth

The hemoglobin level and number of stillbirths of every participant attending the first study visit of the MiPPAD study was recorded by researchers and digitalized using the software OpenClinica®. This data was used to calculate the prevalence of anemia and stillbirth rate in pregnant women.

2.5.2 HIV, Hepatitis B, Syphilis, Rubella and Toxoplasmosis

From May 2010 until October 2011, venous blood was taken by a nurse from every pregnant woman at first antenatal care visit and tested for HIV, Hepatitis B, Syphilis, and antibodies against rubella and toxoplasmosis by a laboratory technician.

Full blood was taken from EDTA tubes and centrifuged. Serum was then used for the tests. VIKIA® HIV ½, Determine® or Uni-Gold™ Recombigen® HIV rapid tests were used for HIV antibody-detection, in case of positivity the test was re-done the same day with the same serum using another company's rapid test. Testing for Syphilis was done using an in vitro, visually read,

qualitative immunoassay to detect antibodies against Treponema pallidum (Alere Determine™) or a Treponema pallidum particle agglutination assay (MikroTrak® Syphilis TPHA 100). Testing for Hepatitis B surface antigen (HBsAg) was done using a VIKIA ® HBs Ag rapid test. Testing for antibodies against toxoplasmosis and rubella was done using a rapid test as well.

The result of every woman screened was written into a serology-log by a laboratory technician containing date, initial, and result for HIV, Hepatitis B, syphilis, rubella and toxoplasmosis. The data was then entered into an excel sheet. Using that data, the prevalence of HIV, Hepatitis B and syphilis in pregnant women as well as the prevalence of antibodies against rubella and toxoplasmosis in pregnant women was calculated.

2.5.3 Schistosomiasis

From September 2009 to December 2011, a clinical trial assessing the efficacy of mefloquine IPTp against *Schistosoma haematobium* was conducted at the Ngounié Medical Research Centre in Fougamou and the Medical Research Unit in Lambaréné (Basra et al. 2013).

The screening log of the part of this study that was conducted in Fougamou was used to find out the prevalence of *Schistosoma haematobium* in pregnant women in the Tsamba Magotsi region. Schistosomiasis was diagnosed by egg dectection in urine samples (Basra et al. 2013).

2.5.4 Microfilaria

From June to August 2011, 56 pregnant women living in Fougamou and surrounding villages were screened for Microfilaria using a concentration technique, the Saponin method (Noireau and Apembet 1990), for a research project conducted by a medical student. The screening log of that project was used to calculate the prevalence of Microfilaria in pregnant women.

Data from the laboratory book for pregnant women was used to calculate the prevalence of Microfilaria in pregnant women found in thick blood smears. The thick blood smears were prepared and examined as described in chapter 2.4, using the Lambaréné method (Planche et al. 2001).

2.6 Cross-sectional surveys in special populations

From 2008 until 2011, screening surveys were conducted by researchers working for the Centre de Recherches Médicales de Lambaréné to detect areas of high prevalence of malaria or urinary schistosomiasis. The screening logs of those surveys were filtered for data being conducted in areas belonging to the Tsamba Magotsi region.

2.6.1 Malaria screening in villages

Two small cross-sectional surveys were conducted in the Tsamba-Magotsi region in 2008 and 2009. 149 participants older than 16 years of age (median 40 years) were screened for malaria in June and July 2008. Field workers and nurses conducted thick blood smears from volunteers in Fougamou and the villages of Bemboudie, Fanguindaka, Grand Odavo, Kessi, Kuagna, Mamiengue, Mandilou, Nzemba, Oyenano, Petit Odavo and Tchad. Another malaria-screening was conducted from November 2008 until March 2009 including 91 children and 26 adults (18 years and older). The median age was 12 years. This survey was held in Fougamou and the villages of Mandilou, Petit Odavo, Mamiengue, Ojenano and Zile.

2.6.2 Schistosoma haematobium screening in villages

Two small screening surveys for urinary Schistosomiasis were conducted in villages belonging to the Tsamba Magotsi region. One was conducted in August

and September 2009, with 68 participants older than two years of age (median age 22 years) living in the villages of Sindara and Lasong.

Another screening for urinary schistosomiasis was conducted in the villages Oyenano and Odavo in July 2011 including 87 participants older than 5 years of age (median 36 years).

2.7 Statistical analysis

Statistical analysis was done using Microsoft Excel 2010 and jmp® 10. Graphs were created using jmp® 10 or Microsoft Word 2010. 95% confidence intervals were calculated with jmp® or an Excel tool named "statconf". When calculating 95% confidence intervals with "statconf" at the base of nominal data, exact binominal values were used. Lower confidence limits as well as upper confidence limits were recorded. For calculating medians, jmp® 10 was used. An 1-alpha value of 0.05 was chosen.

3 Results

3.1 Population

In a census conducted by the Gabonese government in 2003, it was recorded that there were 11 999 people living in Tsamba Magotsi in 2003, with one third (4 402 inhabitants) of the population living in Fougamou. 48% "of the population in Tsamba Magotsi was younger than 19 years old (2003) and there was a sex ratio of 0.9 (male/female)" (Zoleko Manego et al. 2017). Figure 9 shows the age distribution in the department, illustrating a high percentage of children and adolescents in the population. There were few people around 50 years of age, and a small peak of women in the age group of the 65 to 75 years old. The population structure indicates high birth rates and is indicative for an expansive population pyramid.
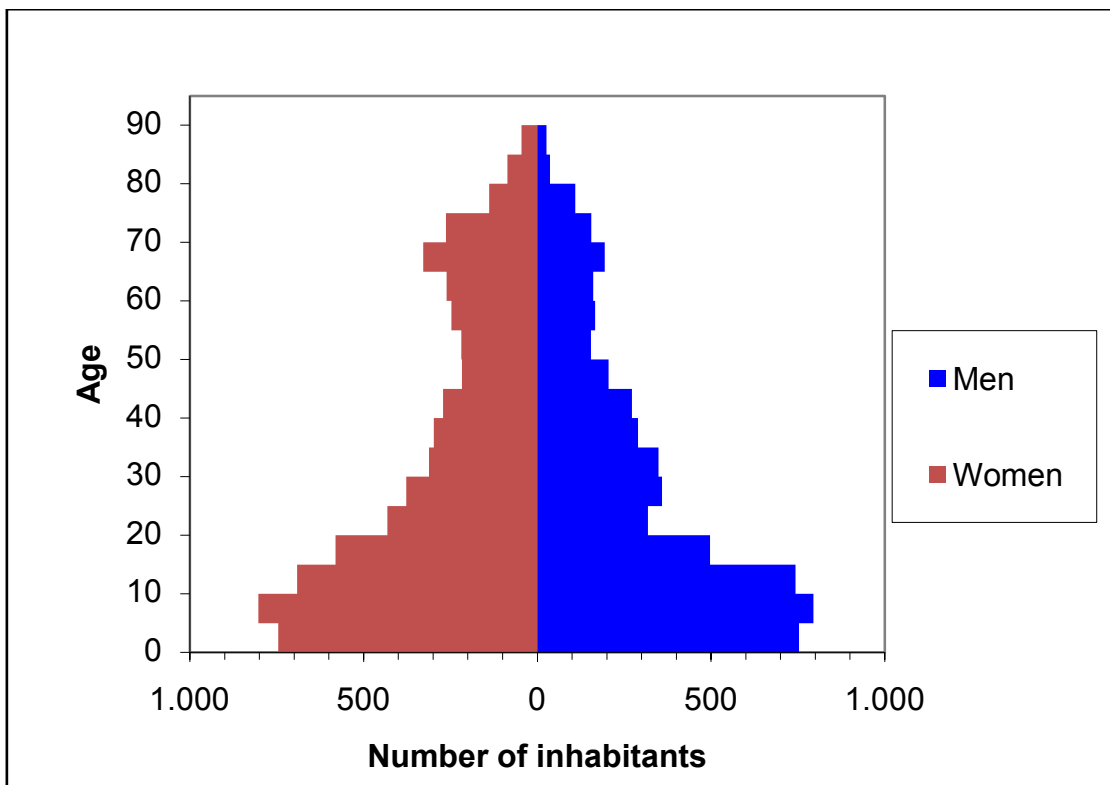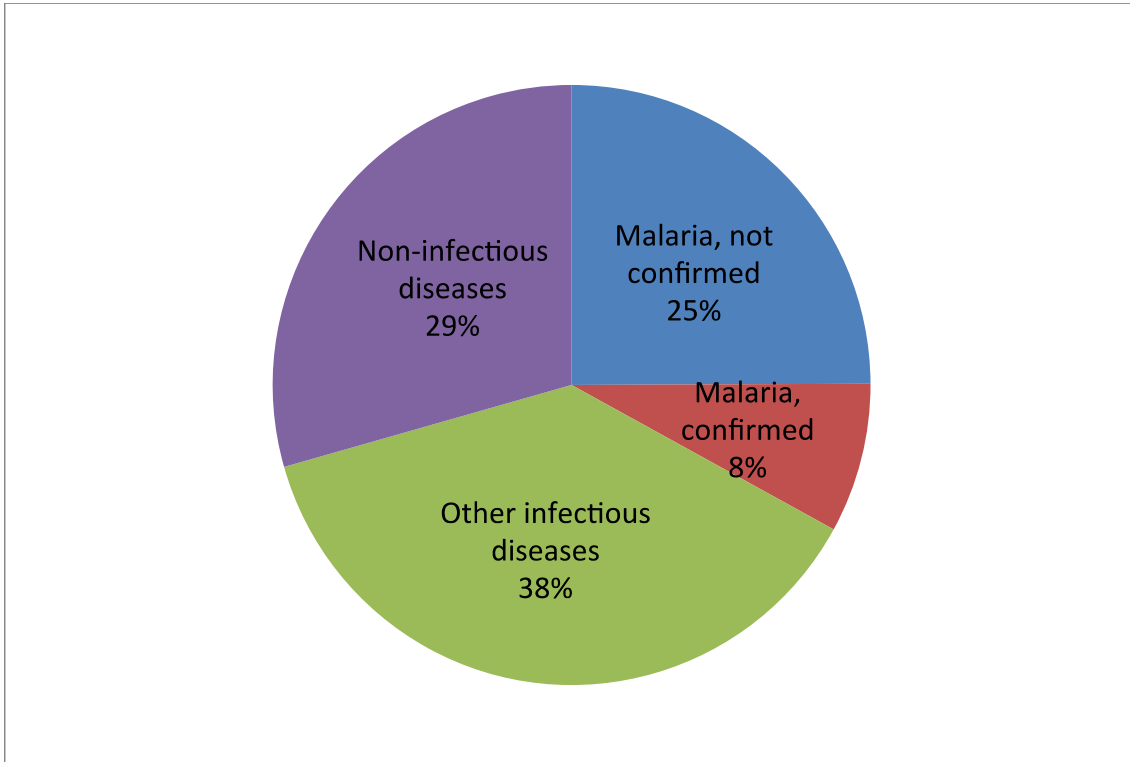

Figure 9: Age distribution in Tsamba Magotsi, 2003

Figure 10: Disease burden in Tsamba Magotsi, 2010

3.2 Disease burden in Tsamba Magotsi

More than 10 000 patients attended the regional hospital in Fougamou or one of the nursery health stations in Tsamba Magotsi in 2010. 6900 consultations were held at the hospital and more than 1000 patients were hospitalized that year. As shown in Figure 10, infectious diseases were diagnosed in 71% of patients attending health care, non-infectious diseases accounted for just 29% of the diagnoses and malaria made up nearly one third of the cases (Zoleko Manego et al. 2017).
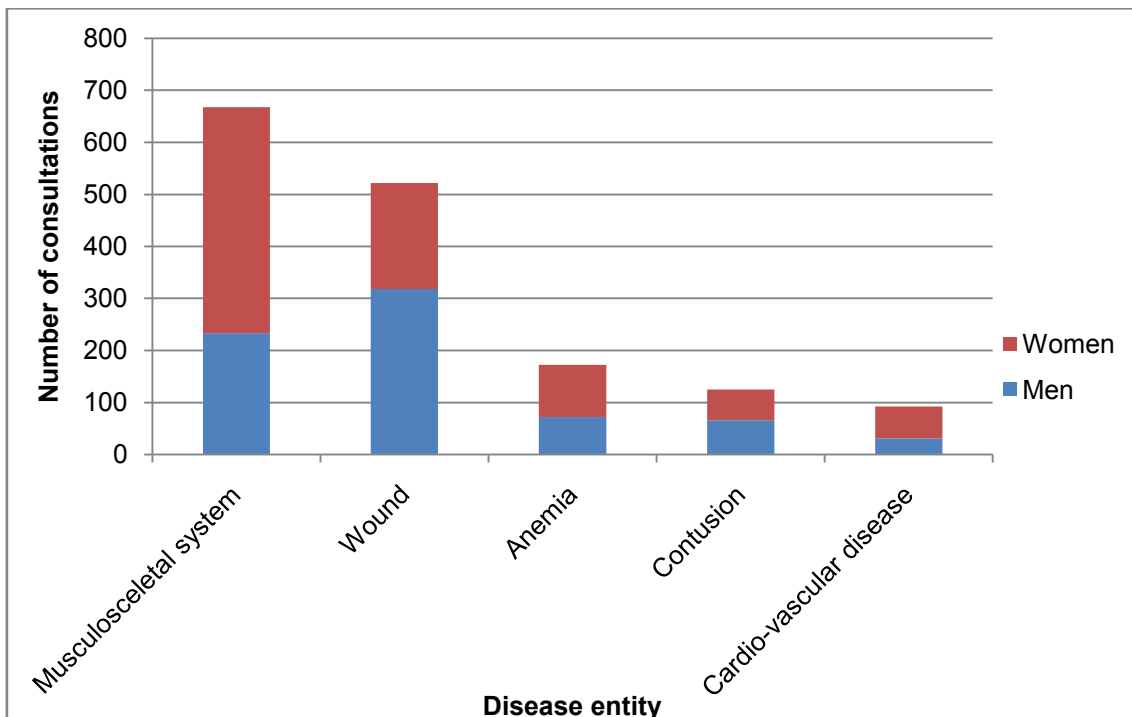
3.3 Non-infectious diseases

Non-infectious diseases were more common in adults than in children. Musculoskeletal pathologies and wounds were the most common non-infectious

reasons for attending health care (Figure 11), followed by anemia, contusion and cardio-vascular disease. The most common musculoskeletal pathologies were lumbago (229 cases), rheumatoid arthritis (182 cases) and arthrosis (124 cases). While men more commonly presented with wounds, musculoskeletal pathologies were more common in women.

Anemia is a common burden in the region, especially in children and women, with a high prevalence in pregnant women (see chapter 3.5: Maternal health). There were 172 cases of anemia in non-pregnant patients recorded for 2010, as shown in Figure 11.

Figure 11: Most frequent non-infectious diseases, hospital Fougamou 2010

Cardio-vascular disease was mostly arterial hypertension. 75 cases of arterial hypertension and four cases of heart insufficiency were recorded in 2010. Five cases of rheumatic cardiopathy and eight cases of not specified cardiovascular disease were recorded that year. Considering the 182 cases of rheumatoid

arthritis and five cases of rheumatic cardiopathy, 187 patients presented with rheumatic diseases.

3.4 Infectious diseases

Figure 12 shows infectious diseases other than malaria diagnosed more than a hundred times in Tsamba Magotsi in 2010. Most infectious diseases occur more often in children than in adolescents and adults. Only pneumonia, abscess and adnexitis occurred more often in patients older than 15 years of age. The most prevalent infectious diseases apart from malaria were gastro-enteritis and intestinal helminths, being diagnosed more than 700 times each in 2010, with especially children being at risk. Other common infectious diseases were flu and acute bronchitis, both accounting for 500 or more cases in 2010, while Rhinitis, abscess, conjunctivitis, salpingitis and pneumonia were diagnosed less than 200 times each (Zoleko Manego et al. 2017).

3.4.1 Malaria

Malaria is the most common reason for seeking health care in the region, being suspected in 3491 (33%) of the patients treated at the regional hospital Fougamou in 2010 (Figure 10, Zoleko-Manego et al 2017).
Most patients presenting with symptoms typical for malaria were treated based on clinical suspicion, without preparing a thick blood smear or using a rapid diagnostic test. In 8% of all patients attending the hospital or one of the village health stations malaria was confirmed by thick blood smear.
The cases of malaria were strongly season-dependent (Zoleko Manego et al. 2017), with most cases occurring from September to February, and therefore during the strong rains (September to November) and the following three months (December to February), as Figure 13 indicates. The malaria incidence
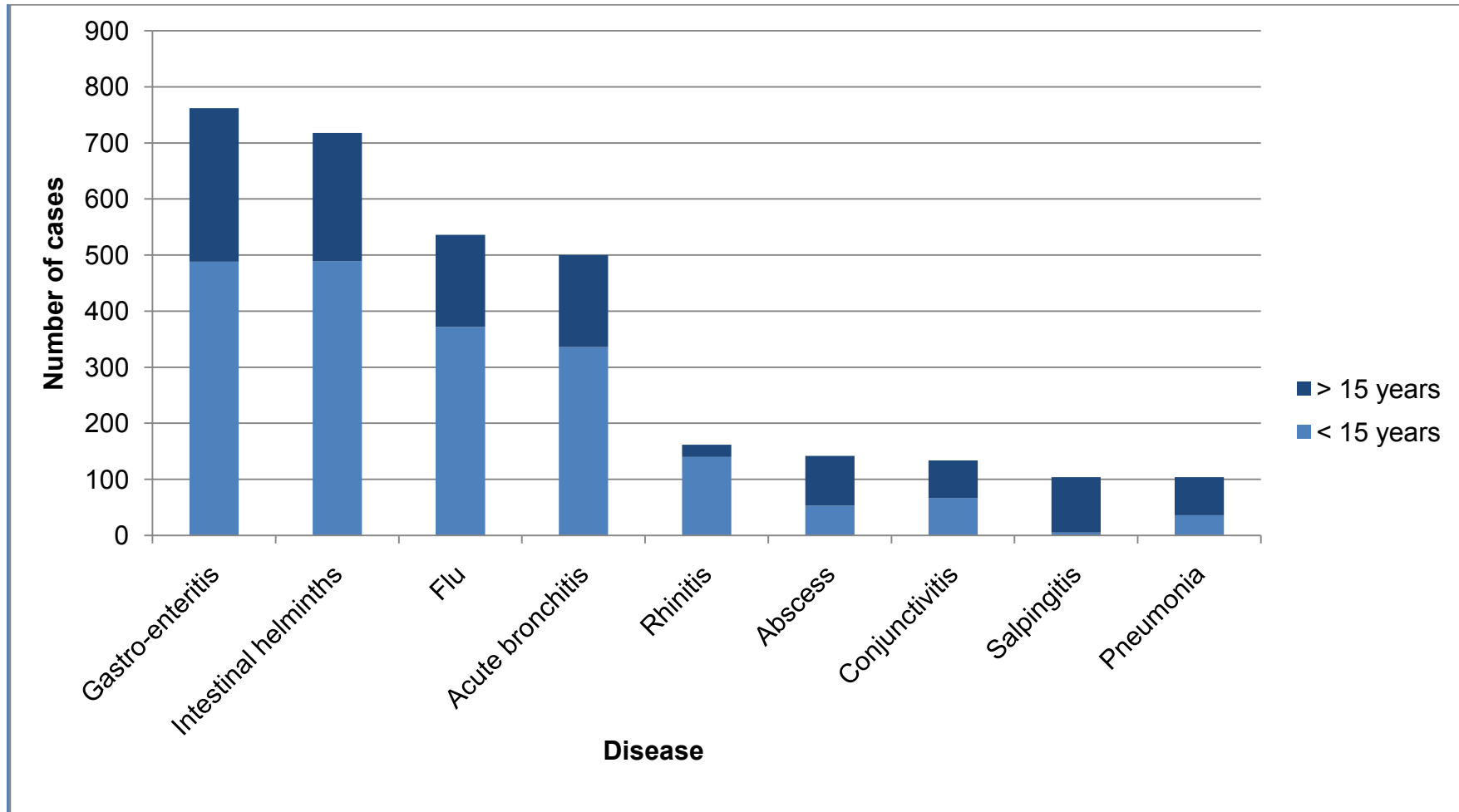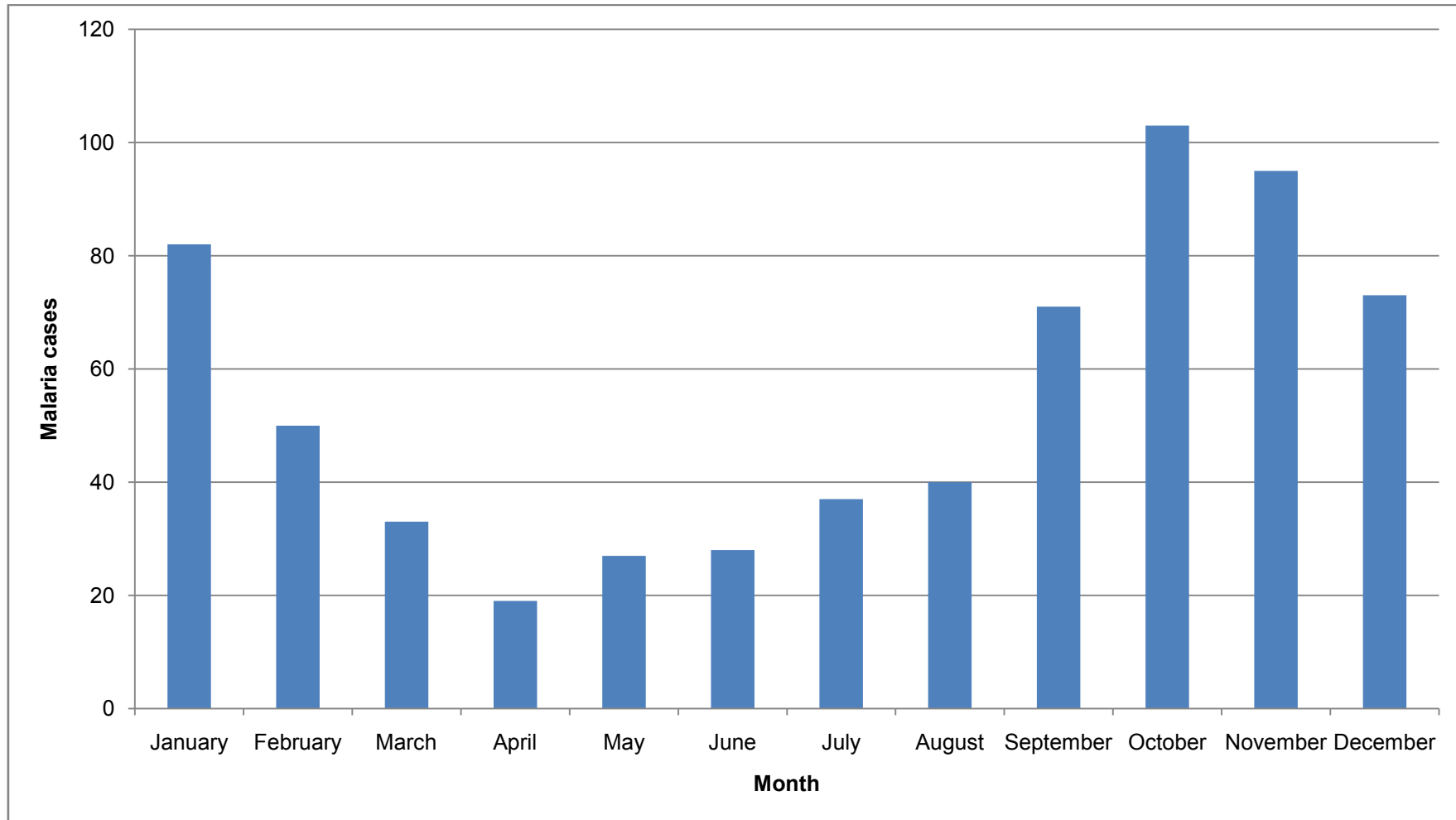
Figure 12: Most important infectious diseases other than malaria, hospital Fougamou 2010

**Figure 13: Confirmed malaria cases in the hospital Fougamou 2008 (Zoleko Manego et al. 2017)**

in the second rainy season (which occurs from February to May), and in the three month after the second rainy season was the lowest of the whole year though (Figure 13).

A decrease of malaria cases with age can be seen in Figure 14. The great majority of malaria cases were children, especially those under five years of age. There were more than 300 cases of malaria in children under five years old diagnosed in 2008, and more than 100 cases in the five to ten years old. In the age groups of the 10 to 15 and the 15 to 20 years old, there were about 50 cases of malaria diagnosed, and even less in those older than 20 years of age (Figure 14). It has to be taken into account though, that Figure 14 shows malaria cases, not the malaria incidence (which is measured in per cent of the age group), and the majority of Tsamba Magotsis population is of young age (Figure 9).

In 149 asymptomatic participants older than 16 years of age (median age 40 years) screened in the months of June and July in 2008 in Tsamba Magotsi, P. spp. was found in 11.5% (95% CI 6.8-17.8) of thick blood smears.
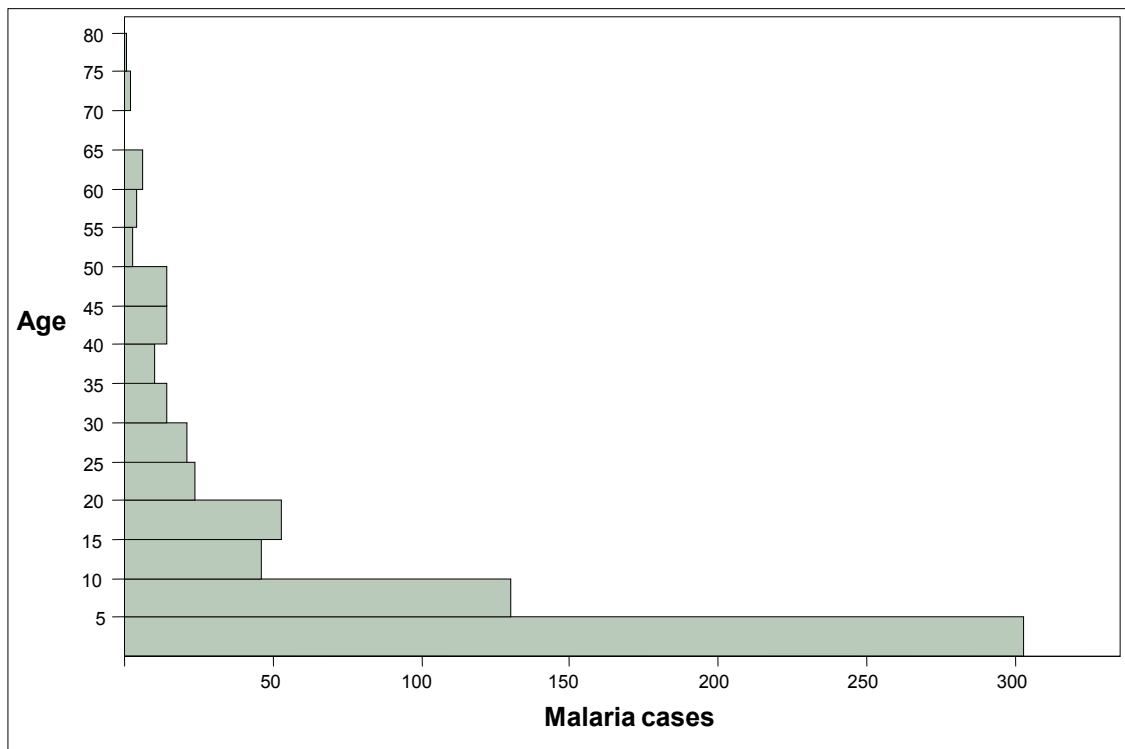
Figure 14: Age of malaria patients, hospital Fougamou 2008

In another malaria-screening survey in asymptomatic individuals conducted in the region from November 2008 until March 2009 with mostly children (median age 12 years), the prevalence was 10.8% (95% CI 6.2-20.6).

Malaria was mainly caused by *Plasmodium falciparum*: The malaria species was identified in 81 thick blood smears taken from pregnant women at first antenatal care visit at the hospital in Fougamou in 2010, 79 (97.5%) were *P. falciparum*, 1 (1.2%) was *P. malariae* and 1 (1.2%) was a *P. falciparum/P. malariae*-coinfection. No infection with *P. ovale* or *P. vivax* was diagnosed.


3.4.2 Filariasis

1167 thick blood smears from patients attending the hospital in Fougamou from August 2008 until February 2009 were searched for Microfilaria.

Figure 15 shows the age distribution of the patients tested for microfilaria of that survey. The vast majority of patients tested for microfilaria were children younger than 10 years of age: 662 patients were younger than 10 years of age, 230 were 10 to 20 and 136 between 20 and 30 years old. 155 (13.3 %) of the tested patients were positive for microfilaria (95% CI 11.3-15.2%). In 46 cases the species was identified. The only species identified were Loa loa and Mansonella perstans (Mp): 23 (50%) were Loa loa, 16 (35%) Mansonella perstans (Mp) and 7 (15%) coinfections.

Those patients complaining about typical symptoms for loasis, as pruritus and eye worm, 22% (95% CI 13-31%, n=81) had thick blood smears positive for microfilaria, while in patients without these symptoms 12% (95% CI 10-14%, n=1042) of slides were positive.

Figure 16 shows the age of patients that were tested positive for microfilaria. The age group with most microfilaria-positive patients were the 20 to 30 years old, even though less patients were tested in this age group compared with younger age groups (Figure 15). This results in a high prevalence of microfilaremia in this age group, as shown in Figure 17. Another peak can be seen in the 60 to 70 years old in Figure 16 and Figure 17.
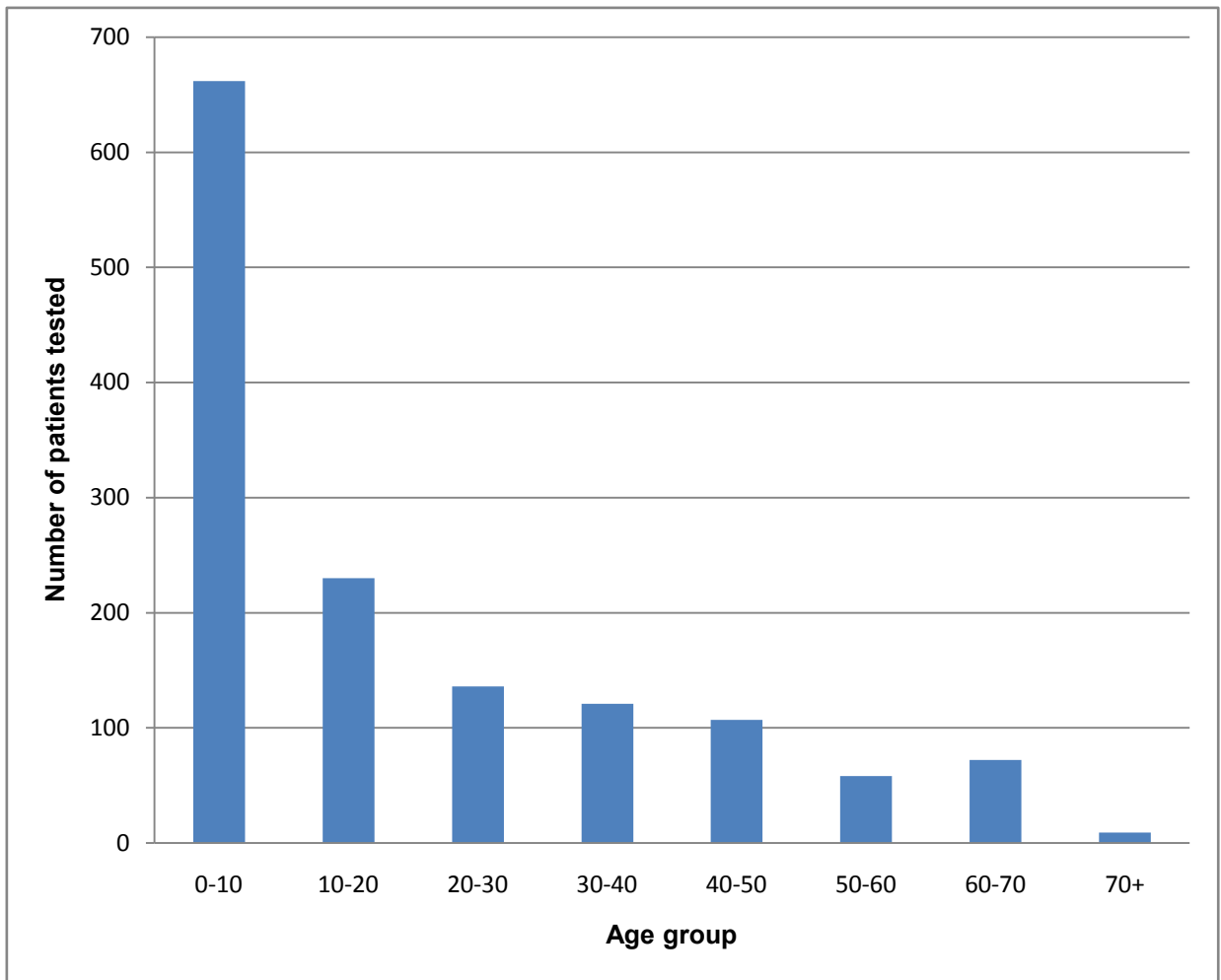
Figure 15: Age distribution of patients tested for Microfilaria, August 2008-February 2009

Figure 17 shows the prevalence of blood-smear positivity for microfilaria in patients attending health care in Fougamou, depending on age group. The prevalence increases with age: in children younger than 10 years of age the prevalence is under 5%, while in adults older than 60 years of age it is higher than 25%. It has to be taken into account though that in all age groups but the 20 to 30 years old, the cases of patients positive for microfilaria were about the same, but the prevalence increases with age because of the young age structure of the population (Figure 9, 15, 16 and 17).

From October 2008 until April 2009, 144 thick blood smears taken from pregnant women attending the maternity ward in Fougamou were searched for
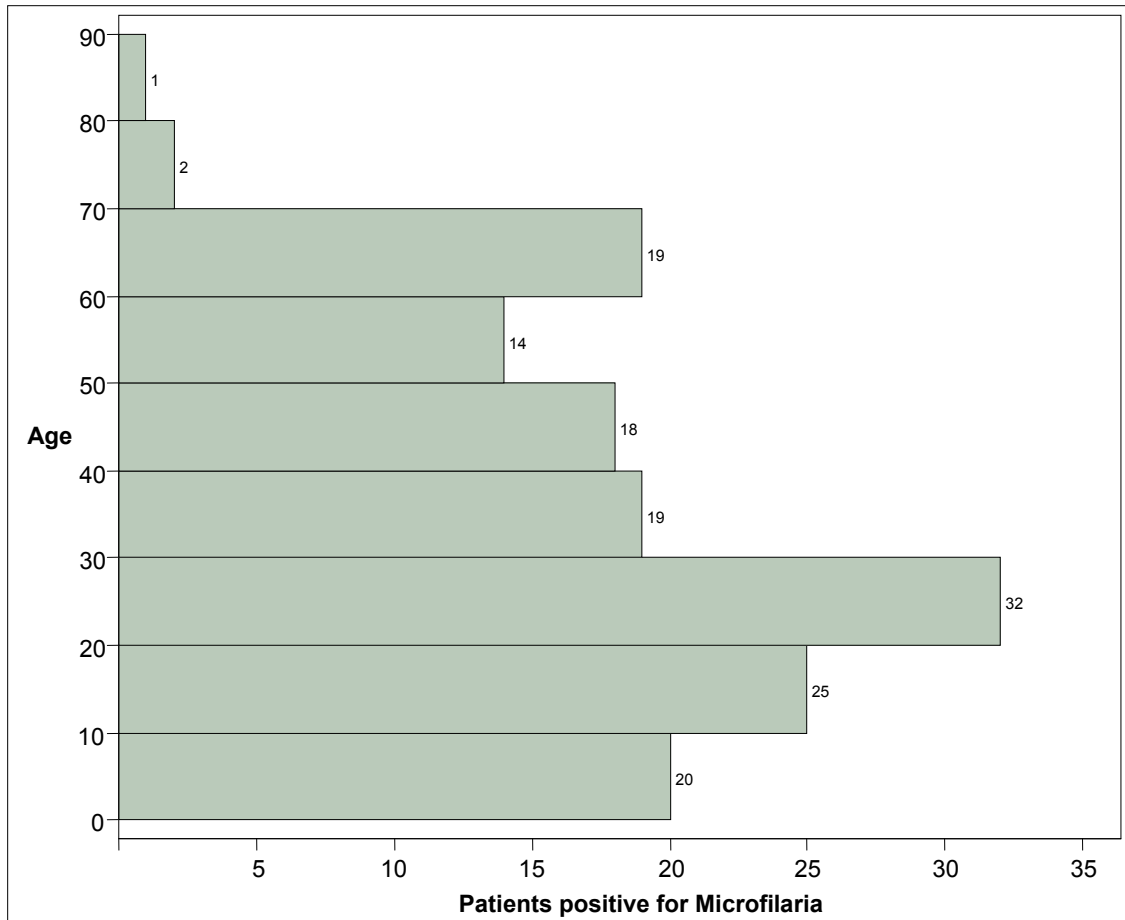
Figure 16: Age of Microfilaria positive patients, August 2008 - February 2009

microfilaria. In 32 (22.2%, 95% CI 15.3-29.1%) microfilaria were found.

In 21 of the 32 slides the species of Microfilaria could be identified. In eleven of the 32 slides the species was identified to be *Mansonella perstans*, nine were *Loa loa*, and one *Loa loa/Mansonella perstans* coinfection. In eleven cases the species was not identified.

Using a concentration technique, a higher prevalence was found compared to the prevalences found in the screenings mentioned above: 56 pregnant women were screened for microfilaria, the blood samples were analyzed using the Saponin method (Noireau and Apembet 1990). In this screening conducted from June until August 2011, 25 (44.6%, 95% CI 31.3-58.5%) of the 56 women were tested positive, as shown in Table 1.

In 14 (25%) of the positive blood samples tested using the concentration method the species was identified as *Mansonella perstans*, in seven (12.5%) as Loa loa. In four cases the species could not be identified.
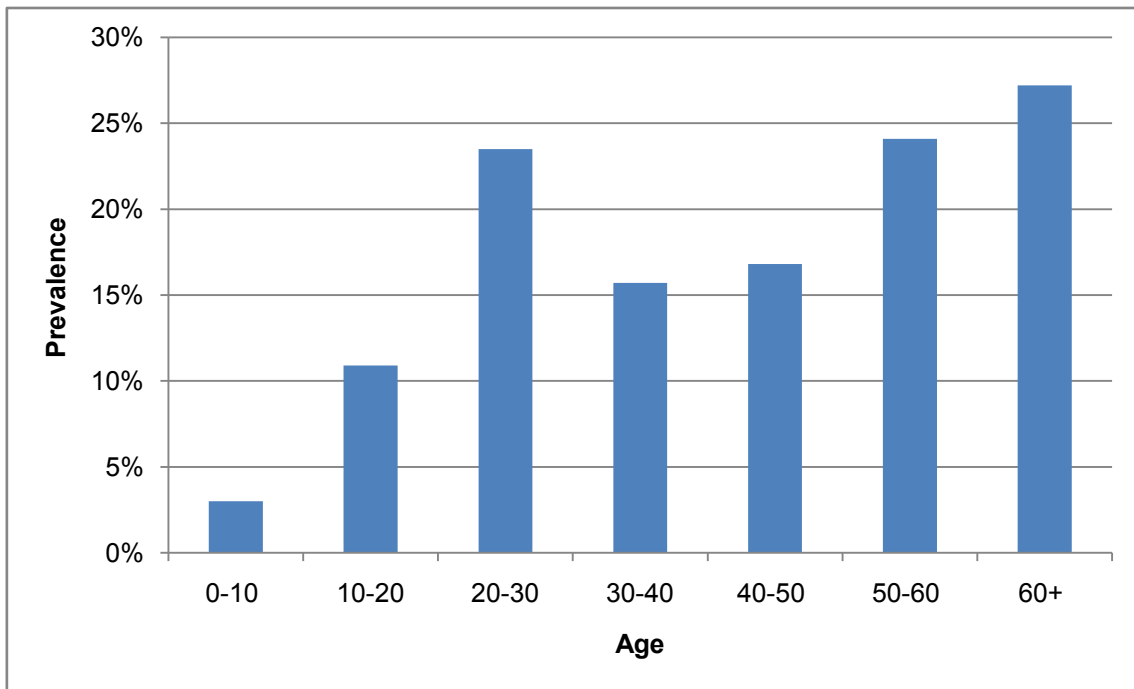
Figure 17 Prevalence of Microfilaria in hospital patients dependent on age group, Fougamou 2008 - 2009

3.4.3 Microfilaria and malaria co-infection

33 (2.8%) of 1167 blood slides taken from patients attending the hospital in Fougamou were positive for both microfilaria and malaria.

In patients being tested positive for microfilaria in the thick blood smear exam, the prevalence of malaria was significantly lower than in those being tested negative for microfilaria. In patients negative for microfilaria, the prevalence of malaria was 33.2% (95% CI 30.3-36.0%, n=1000), while in patients positive for microfilaria, malaria parasites were found just in 21.7% (95% CI 15.1-28.3%, n=152) of the slides.

The prevalence of Microfilaria was significantly lower in malaria-positive patients than in malaria-negative patients. In malaria-positive patients it was 9.6% (95% CI 6.59-12.56, n=376) while in malaria-negative patients it was 15.1% (95%CI 12.59-17.61%, n=788).

In 144 thick blood smears taken from pregnant women as described in chapter 3.4.2, this correlation could not be found. Four (2.8%) women were infected with both malaria and microfilaria.

3.4.4 Urinary schistosomiasis

As shown in Table 1, in 591 HIV negative pregnant women participating in the MiPPAD study in Fougamou the prevalence of *Schistosoma haematobium* in urine at first antenatal care visit was 6.8% (95% CI 4.9-9.1%, Zoleko Manego et al. 2017). There was no significant difference in *S. haematobium* prevalence between the distinct villages.

In a screening for urinary schistosomiasis conducted in August and September 2009, with 68 participants older than two years of age (median age 22 years) living in the villages Sindara and Lasong, the prevalence was 5.9% (95% CI 1.6-14.4%, n=68).

In another screening, conducted in the villages Oyenano and Odavo in July 2011 including 87 participants older than 5 years of age (median 36 years), the prevalence of urinary schistosomiasis was 3.4% (95% CI 0.72-9.7%).

3.4.5 HIV, HBV and Syphilis

The prevalence of HIV in pregnant women screened for the MiPPAD study was 6.2% (95% CI 4.2-8.2%), while the prevalence of Hepatitis B virus was 7.3% (95% CI 5.0-9.6%) in that study population (Table 1). The prevalence of *Treponema pallidum* was 2.5% (95% CI 1.1-3.4%) in pregnant women, as shown in Table 1 (Zoleko Manego et al. 2017).

3.4.6 Hepatitis B and HIV coinfection

Four of 33 HIV positive pregnant women were co-infected with Hepatitis B (12.1%, 95% CI 3.4-28.2%). There was one woman co-infected with HIV and *Treponema pallidum.*

Table 1: Prevalence of infectious diseases in pregnant women, 2010 – 2011 (Zoleko Manego et al. 2017)

Pathogen	N	+	%	95% CI	Method
HIV	550	34	6.2	4.2-8.2	rapid test
HBV	506	37	7.3	5.0-9.6	rapid test
T. pallidum	518	13	2.5	1.1-3.4	rapid test
S. haematobium	591	40	6.8	4.9-9.1	Microscopy
Microfilaria	144	32	22.2	15.3-29.1	blood smear
Microfilaria	56	25	44.6	31.3-58.5	concentration technique

3.5 Maternal health

3.5.1 High number of pregnancies in adolescent women

From 2008 until 2011, 1665 pregnant women attended Fougamou's maternity ward for antenatal care. Figure 18 shows the age distribution of those women, highlighting a high number of pregnancies in adolescents and young women.

A peak can be seen in the age group of the 17 to 19 years old, afterwards the prevalence decreases slightly with age. The median age of pregnant women attending antenatal care at Fougamou's maternity ward was 23 years (Zoleko Manego et al 2017).

The number of women attending antenatal care increased from 325 in 2008 to 444 in 2011.
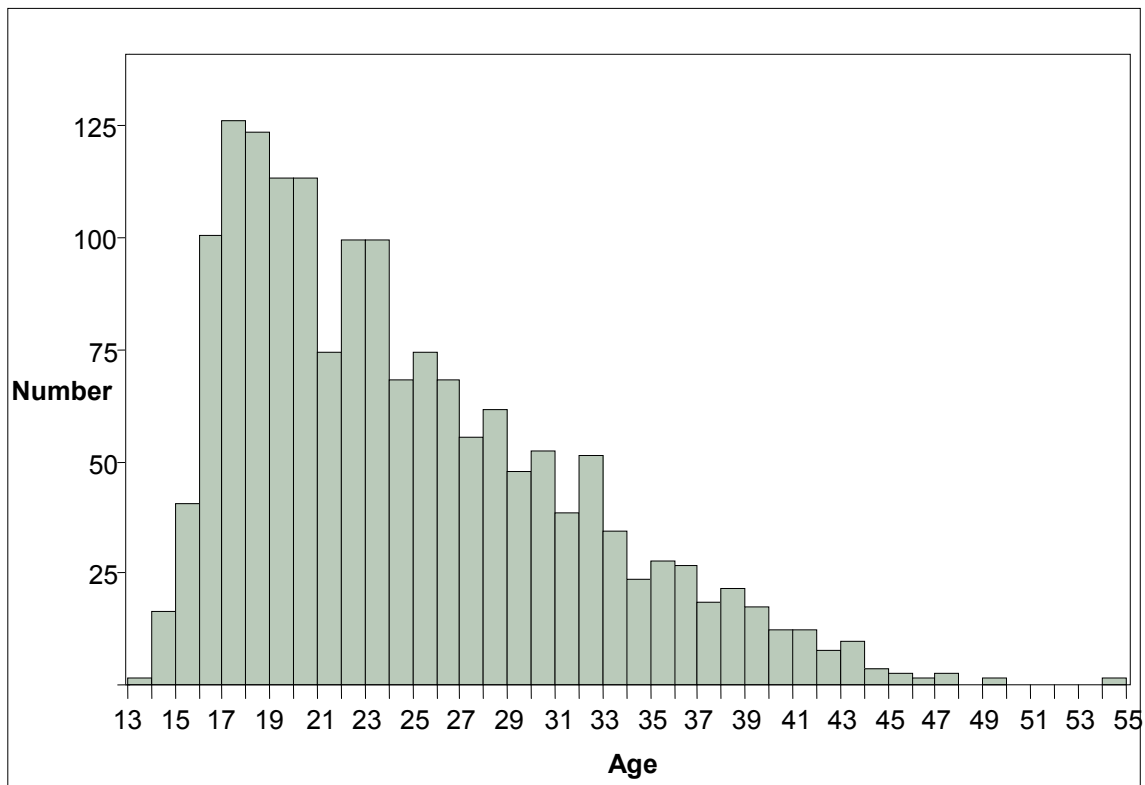
Figure 18: Age distribution of pregnant women, Fougamou 2008 – 2011 (Zoleko Manego et al. 2017)

3.5.2 Gestational age at first antenatal care visit

Table 2 shows the gestational age of pregnant women attending the first antenatal care visit at Fougamou's maternity ward.

It highlights the fact that the women in the region tend to attend maternal care quite late in pregnancy: just 25% of the women attended their first antenatal

care visit during the first four months of pregnancy (0-16 weeks). The majority (60%) of the pregnant women attended the maternity ward for first antenatal care visit at a gestational age of 17-28 weeks (Zoleko-Manego et al. 2017), 12.5% at a gestational age of 29-35 weeks and 1.8% had already a gestational age of 36 or more weeks when firstly attending antenatal care.

Table 2: Gestational age first antenatal care visit, 2008 - 2010

Gestational age at first visit (weeks)	Number of women	Per cent of women
0-16	261	25.5
17-28	614	60.1
29-35	128	12.5
36+	18	1.8
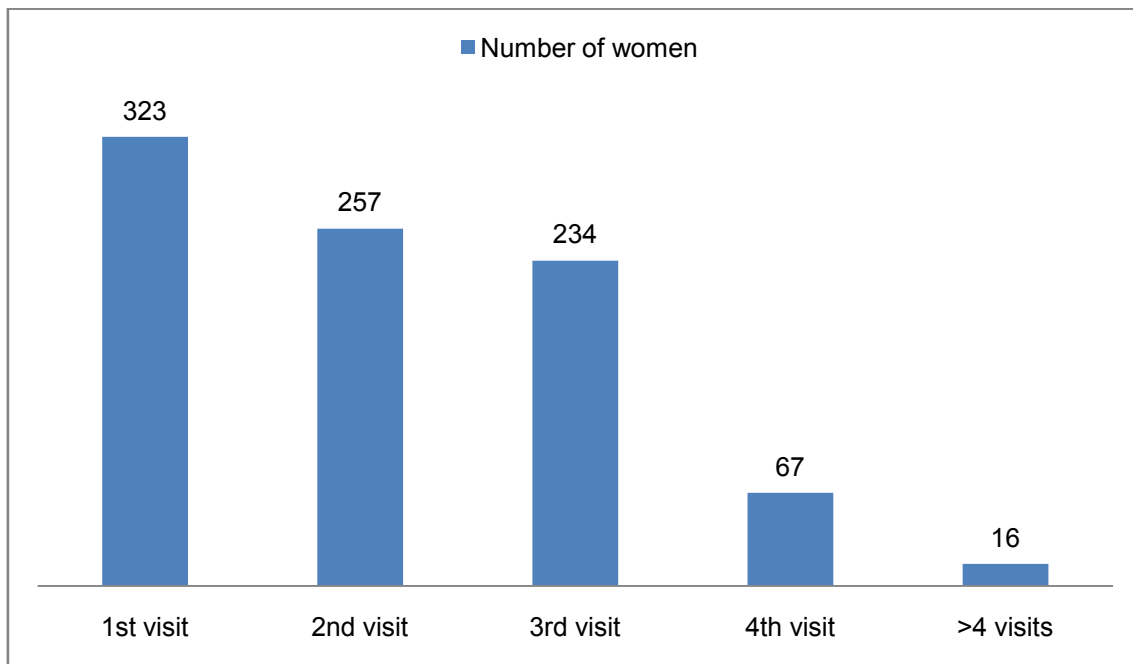
Figure 19: Prenatal health visits attended in 2010

3.5.3 Number of antenatal care visits per pregnant woman

323 women attended the first antenatal care visit at the maternity ward in the hospital Fougamou in 2010. The majority of the women (234) attended three antenatal care visits during their pregnancy, just 67 attended a fourth and just 16 attended more than four antenatal care visits, as indicated in Figure 19.

3.5.4 Fertility

273 births in average per year were registered by the maternity ward in Fougamou in the years 2008 to 2010, 275 in 2008, 310 in 2009 and 275 in 2010.This does not include the caesarian sections, which are sent to the Albert Schweitzer Hospital in Lambaréné (Zoleko Manego et al. 2017). Also there are some women going to Lambaréné for delivery because of the better conditions in case of complications. Also it is likely that some babies are born at home without being registered by the maternity ward, especially in remote villages of the Tsamba Magotsi district. As shown in table 3, 6% of all babies that were registered by the maternity ward were born at home in 2009 and 8% in 2008 and 2010 (Zoleko Manego et al. 2017).

3.5.5 Prematurity, stillbirth and abortion

Depending on the year, the prematurity rate varied from 6 to 12 per cent, and 4 to 8 per cent of newborns had low birth weight.
The stillbirth rate was 1.7% (2008). Two stillbirths occurred at home in 2008, all other stillbirths occurred at the hospital. 7.1% (95% CI 4.7-10.2%, n=379) of all women participating in the MiPPAD study reported that they have had at least one stillbirth before (Zoleko Manego et al 2017).
Ten and six spontaneous abortions were recorded by the hospital Fougamou in 2008 and 2009, respectively. Six and five provoked abortions were recorded in 2008 and 2009, respectively. The real number of both spontaneous and

provoked abortions is higher though, as not all women with an abortion attend the hospital. Provoked abortions are illegal in Gabon, causing a high number of not registered abortions.

Table 3: Infants born in Tsamba Magotsi, 2008 - 2010

Year	n	Hospital (%)	Home (%)	Premature (%)	<2500g (%)
2008	275	247 (90)	23 (8)	18 (6)	21 (8)
2009	310	291 (94)	18 (6)	39 (12)	19 (6)
2010	275	252 (92)	23 (8)	30 (11)	11 (4)

3.5.6 IPTp coverage

All women attending the maternity ward in Fougamou for antenatal care visit were treated with Intermittent Preventive Treatment against malaria in pregnancy (IPTp).
In 2010, 270 women received the first dose, 219 the second dose and five women the third dose of Intermittent Preventive Treatment against malaria in pregnancy (IPTp). 27 women were hospitalized and treated because of malaria suspicion, in 16 of them malaria was diagnosed by thick blood smear.

3.5.7 Rubella and Toxoplasmosis protection

Most pregnant women were well protected against Rubella and Toxoplasmosis. 519 women were screened for Rubella anitbodies, 85.7% (95% CI 82.4-88.6%)

of them had IgG antibodies against rubella; and 96.4% (95% CI 94.2-98.0%) of 418 women screened had antibodies against Toxoplasmosis (2010-2011).

3.5.8 Anemia in pregnancy

A very high prevalence of anemia in pregnant women was found in the Tsamba Magotsi district. The majority of pregnant women in the region had hemoglobin levels lower than 11g/dl: From 2010 until 2011, 382 pregnant women participating in the MiPPAD study were screened for anemia at first study visit. 273 (71.5%, 95% CI 67.7-75.9%) had hemoglobin levels lower than 11 g/dl.

3.6 Summary of results

With about half of the population being younger than 19 years of age, the population of Tsamba Magotsi is typical for African rural regions, with high birth rates and an expansive population pyramid. Infectious diseases were accounting for the vast majority of the disease burden in the region, with malaria being by far the most prevalent infectious disease. Apart from malaria, gastroenteritis and intestinal helminths were the most common reasons for consultation in the public health sector.

A prevalence of microfilaremia of 13.3% was found in thick blood smears taken from patients attending the hospital in Fougamou. In patients infected with microfilaria, the prevalence of malaria was significantly lower than in those not infected with microfilaria (21.7%, 95% CI 15.1-28.3% and 33.2%, 95% CI 30.3-36.0%, respectively).

In pregnant women, *Schistosoma haematobium* was found in 6.8% of the urine samples taken at first antenatal care visit. The prevalence of HIV, Hepatitis B and *Treponema pallidum* in pregnant women was 6.2, 7.3 and 2.5 per cent, respectively. A high number of pregnancies in adolescent young women was found, the prematurity rate varied from 6 to 12 per cent, and 4 to 8 per cent of newborns had low birth weight. The stillbirth rate was 1.7%.

Anemia in pregnancy is a common problem in the region, 71.5% of 273 women screened at first antenatal care visit had hemoglobin levels lower than 11 g/dl.

4 Discussion

Most countries in sub-Saharan Africa do not have functioning demographic and epidemiological surveillance systems (Byass et al. 2014), and in 2007, Setel et al. stated that "*the vast majority of Africans are born and will die without being recorded in any document or appearing in official statistics*". Since then, achievements have been made in the field of civil registration systems (AbouZahr 2015), but it remains difficult to calculate the burden of disease, especially in sub-Saharan Africa, and Byass et al. stated in 2014 that "*the overwhelming reality is that health information systems across most of sub-Saharan Africa remain too weak to track epidemiological transition in a meaningful and effective way*". Another problem for epidemiological surveillance is that traditional medicine plays an important role in most African regions and those patients being treated by a traditional healer do not appear in the hospital statistics.

Therefore, little exact demographic and epidemiological data is available about the central African region, making it difficult to assess demographic transitions and the burden of disease for most regions.

Tsamba Magotsi is facing the same problem, the data available is fragmentary. The civil registration system is weak, the demographic data used in this study relays therefore on a census conducted in 2003.

Epidemiological estimates are equally difficult to make. For example, people living in Tsamba Magotsi but attending treatment directly in the nearby towns of Lambaréné and Mouila or looking for treatment in bigger towns, as Libreville or Port Gentil, are not registered in the data used in this study, equally the patients using traditional medicine. Also, patients are often treated by clinical suspicion, making it difficult to calculate the exact prevalence and incidence of disease. For example, malaria was mostly not confirmed by thick blood smear in the regional hospital Fougamou.

The prevalence of HIV, Hepatitis B and syphilis in pregnant women is quite exact, but just picks out some prominent diseases, leaving apart others. For instance, no studies about tuberculosis were conducted in the Fougamou area and therefore no data about the prevalence of tuberculosis in the region is available.

4.1 Population

The number of about 12 000 inhabitants in Tsamba Magotsi can be considered to be quite exact, as the official census employed field workers attending every household for an interview. It has to be taken into account though that this census was conducted in 2003 and the population could have changed during the last decade.

The age pyramid is extensive, the population young, this is typical for Sub-Saharan African rural regions. In general populations in Gabon display considerable migration both during festive seasons as well as for long term migrations within the country. These characteristics complicate demographic assessments and are a limitation of this study (Zoleko Manego 2017).

4.2 Health system

The number of nurses in Tsamba Magotsi is sufficient, while there is clearly a lack of physicians in the region, with just one physician having a permanent position in the Ngounie regional hospital who in fact is not present most of the time. There are also physicians working for the Ngounie Medical Research Centre, but those are just treating patients which are participants in research projects. The Ngounié Medical Research Centre conducts research projects in the region and provides routine laboratory exams for the governmental hospital. This benefits the local population, as participants of research studies get free medical care by the study personnel, as study physicians and study nurses, and

free laboratory examinations during the time of the study. At the same time, the local population will hopefully benefit from the increased knowledge about the regions diseases and their treatment.

The lack of skilled health care personnel is a problem in Africa in general and in Sub-Saharan Africa especially. Sub-Saharan Africa has got the highest burden of disease worldwide and at the same time the lowest number of doctors and nurses per inhabitant (Crisp and Chen 2014). A large number of African health professionals intend to migrate (Awases et al. 2004).

While most well-equipped health care institutions tend to be in urban areas (Kuate Defo 2014), rural areas worldwide face the problem of a lack of health care professionals: *"Remote rural and poor populations are often not able to attract or retain health professionals"* (Crisp and Chen 2014).

4.3 Disease burden

The high prevalence of infectious diseases and the relatively low prevalence of non-infectious diseases show that in the Tsamba Magotsi region, unlike other regions in sub-Saharan Africa (Nyirenda 2016), the epidemiological transition is not yet to be seen. Unlike the situation in Gabon`s capital Libreville, where non-communicable diseases as for example diabetes are becoming more and more prevalent (Padzys 2015), modern lifestyle associated diseases do not play a major role in the Tsamba Magotsi district (Zoleko Manego 2017).

4.4 Non-infectious diseases

Non-infectious diseases play a minor role in the region compared to infectious diseases. Non-infectious diseases are dominated by musculoskeletal pathologies and wounds, which are probably caused by hard work in the forest and on the plantations, which are mostly used for subsistence farming. Wounds were more common in men, and musculoskeletal pathologies more common in

women. This can be explained by the fact that in the rural region of Tsamba Magotsi, men traditionally hunt, fish and clear the forest for the small plantations, and women work on the plantations thereafter and work in the household. Hunting and clearing the forest is connected with a high risk for accidents and therefore wounds, while the daily work on the plantations and carrying the harvest back home at the end of the day plus hard work at home, for example washing the laundry by hand, is physical stress for the musculoskeletal system, mostly for the back, causing the predominant back pain.

The high number of contusions, nearly equally distributed in men and women, is likely to be caused by accidents due to physical work, as the majority of Tsamba Magotsi's population is working physically, which increases the risk of accidents.

Rheumatic diseases are a common burden in the region, with 187 cases of rheumatic diseases, mostly rheumatoid arthritis.

Cardio-vascular diseases are the fifth most common non-infectious reason for seeking health care in the region, with clearly less cases than wounds or musculoskeletal pathologies. Interestingly, the cardio-vascular diseases were more common in women than in men in Tsamba Magotsi.

No malignant diseases were diagnosed in Tsamba Magotsi in 2010, which could be due to the fact that it is difficult to diagnose cancer with the limited technical equipment in the region.

4.5 Infectious diseases

The disease burden in Tsamba Magotsi, with infectious diseases dominating, is typical for the African region, as illustrated in Figure 1 (WHO 2016).

Tsamba Magotsi is a rural region, therefore it might take more time for the epidemiological transition from predominantly infectious to predominantly non-infectious diseases (Omran 1971) to take place than in urban settings in central Africa, as the lifestyle in rural African regions is by far more traditional than in

the bigger cities as for example Libreville and Port Gentil, where especially the young people are living a modern, westernized lifestyle.

4.5.1 Malaria

The data taken from the hospital statistics cannot be used to calculate the exact burden of malaria in the region, because patients are often clinically suspected to have malaria and treated without being tested by a laboratory exam. The data show clearly, though, that malaria is the most common reason for attending health care in the region.

This finding is in line with the WHO data naming malaria as a major contributor to burden of disease and as a major cause of death in the Sub-Saharan region (WHO 2016).

The season dependency of malaria cases confirms the findings of Jäckle et al., who analyzed malaria prevalence in pregnant women in the same region and found an overall *P. falciparum* prevalence of 16% in women attending first antenatal care visit in 2008 to 2011 at the regional hospital in Fougamou. The prevalence was highly season-dependent, with especially young women being at risk (Jäckle et al. 2013).

The prevalence of blood smear positivity was found to be around 11% in two small cross-sectional surveys conducted in asymptomatic individuals in the region; one of those surveys was conducted during dry season in children, the other one during rainy season in adults. This finding is lower than the overall prevalence of 16% found in pregnant women by Jäckle et al.; which can be explained by the fact that malaria is known to be more prevalent in pregnant women. Also it has to be taken into account that the number of individuals tested in this small screenings were quite low (149 and 91 participants, respectively, see chapter 2.6.1), which is a limitation of this two cross-sectional epidemiological surveys.

In the year 1998, the Roll Back Malaria initiative was launched. It connected and coordinated various public and private organizations committed to the fight against malaria (Nabarro DN and Tayler EM, 1998). This concerted campaign

was financially well equipped and had a significant effect on the burden of malaria in Africa. The incidence of clinical cases of malaria fell by 40% and the prevalence of infection with *Plasmodium falciparum*, the most prevalent parasite causing malaria in the region, halved between 2000 and 2015 (Bhatt et al. 2015).

4.5.2 Filariasis

While in asymptomatic non-pregnant patients the prevalence of microfilaria diagnosed by thick blood smear was 12%, it was 22% in pregnant women measured by thick blood smear. The sensitivity is limited when detecting Microfilaria by thick blood smear (Noireau and Apembet 1990) which is a limitation to this study.

56 pregnant women were screened for microfilaria by a concentration method. 25 (44%) of the blood samples were found to be positive. This small cross-sectional study is using a good diagnostic method but it`s limitation is the small number of participants.

The findings are underlining the findings of a study conducted in Gabon in 2011 which found a prevalence of microfilaremia of 18.6% for Loa loa, 9.3% for Mansonella perstans and 3% co-infections in the Ngounie area using both thick blood smears and a concentration technique for each blood sample (Akue et al. 2011). Tsamba Magotsi is a department of the province of Ngounie.

Another study about filariasis in central Africa found a high prevalence of history of eye worm in Gabonese villages using the so called "Rapid Assessment Procedure for Loiasis" (RAPLOA) questionnaire (Zouré et al. 2011).

4.5.3 Microfilaria and malaria coinfection

The prevalence of malaria was significantly lower in patients positive for microfilaria than in patients negative for microfilaria. In patients negative for microfilaria, the prevalence of malaria was 33.2% (95% CI 30.3-36.0%,

n=1000), while in patients positive for microfilaria, the prevalence of malaria was 21.7% (95% CI 15.1-28.3%, n=152). It has to be taken into account that this is found using the thick blood smear technique, which is not as sensible as a concentration technique (Noireau et al. 1990).

In pregnant women, this correlation could not be found, which might be due to the small group of women tested (n=144) with just four women being infected with both microfilaria and malaria.

4.5.4 Urinary schistosomiasis

In 591 HIV negative pregnant women the prevalence of *Schistosoma haematobium* eggs in urine at first antenatal care visit was 6.8%. This finding can be considered to be quite exact, as a relatively high number of urine samples were studied and a concentration method was used for examination. This prevalence is low in comparison with 12% found in pregnant women in Lambaréné in 2003 to 2004 (Adegnika et al. 2010). However, this point estimate does not adequately reflect the wide variability of schistosomiasis prevalence depending on the geographical location. Schistosomiasis prevalence is highly variable reflecting the transmission characteristics of this trematode disease. Schistosomiasis is transmitted by snails living in standing or slow floating waters (Zoleko Manego et al. 2017).

Interestingly, no differences in schistosomiasis prevalence were found for the different villages in Tsamba Magotsi. It has to be taken into account though that the prevalence can differ strongly even inside of a village, depending on where the women wash their laundry and themselves. Also, in this study just pregnant women were tested. Concerning the general population, limited data about urinary schistosomiasis is available for the region.

In a small screening for urinary schistosomiasis with 68 participants which was conducted in 2009, the prevalence was 5.9%. Another screening for urinary schistosomiasis, conducted in the villages Oyenano and Odavo in 2011 including 87 participants showed a prevalence of 3.4%. These two small cross-sectional studies have the limitation of a small number of participants. Also, they

just take into account some villages and do not represent the whole Tsamba Magotsi district.

4.5.5 HIV

The prevalence of HIV in pregnant women screened at first antenatal care visit was 6.2% in Tsamba Magotsi. This finding is slightly higher than the prevalence of 5.2% published by the WHO for Gabon (UNAIDS 2013), but lower than 7.2% reported in pregnant women attending the Albert Schweitzer hospital in Lambaréné in 2008 (unpublished data, 2008)[8]. The prevalence of HIV in
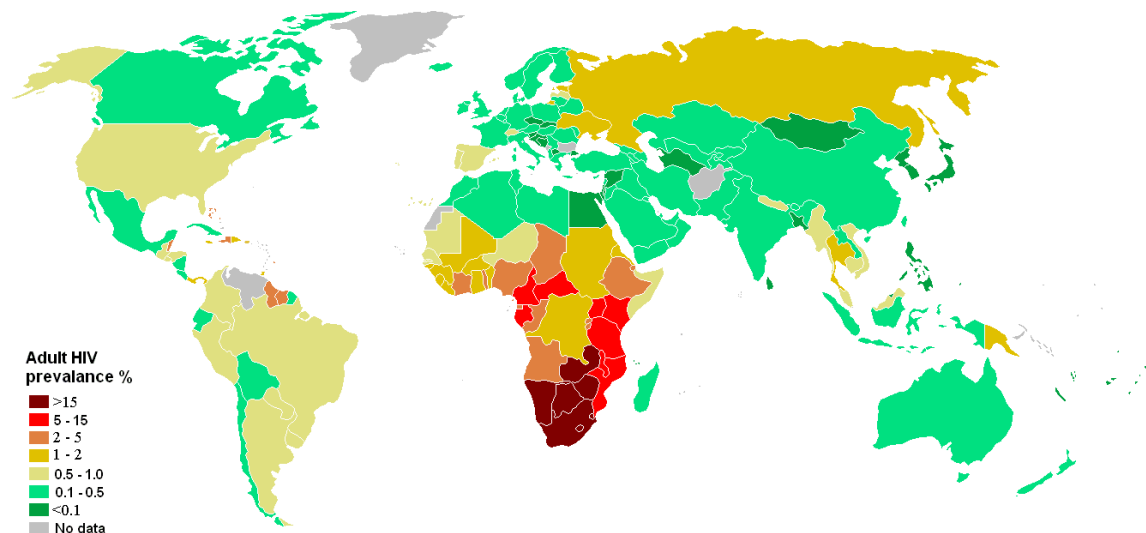
Figure 20: Prevalence of HIV globally (American Association for the Advancement of Science 2010)

pregnant women is not an exact measurement for the prevalence in the general population (Zoleko Manego et al 2017), because according to the UNAIDS GAP report "women account for 58% of the total number of people living with HIV" in the sub-Saharan region, where a group specially at risk are the young women: *"Globally, 15% of all women living with HIV aged 15 years or older are young*

[8] Annual directors report, Albert Schweitzer Hospital 2008

women 15–24 years old. Of these, 80% live in sub-Saharan Africa. In this region, women acquire HIV infection at least 5–7 years earlier than men" (UNAIDS GAP report 2014).

According to the UNAIDS GAP report, the number of annual infections with HIV is decreasing globally, and people infected with HIV are living longer because of anti-retroviral therapy. Therefore, the prevalence of HIV is still increasing. Despite some success in coverage, *"three of five people living with HIV are still not accessing antiretroviral therapy"* (UNAIDS 2014).

Figure 20 is a map published by the American Association for the Advancement of Science in 2010 showing the adult prevalence of HIV around the world. The highest prevalence rates are found in Africa, especially in the southern African region, where prevalences of more than 15% are found, while in eastern and central African countries, the estimated prevalences vary from 5 to 15 per cent are found. The prevalence of HIV for Gabon is indicated to be 5 to 15 per cent, which is in line with the 6.2% found for Tsamba Magotsi in this study.

Hepatitis B, 2007

Countries/areas with moderate to high risk of infection
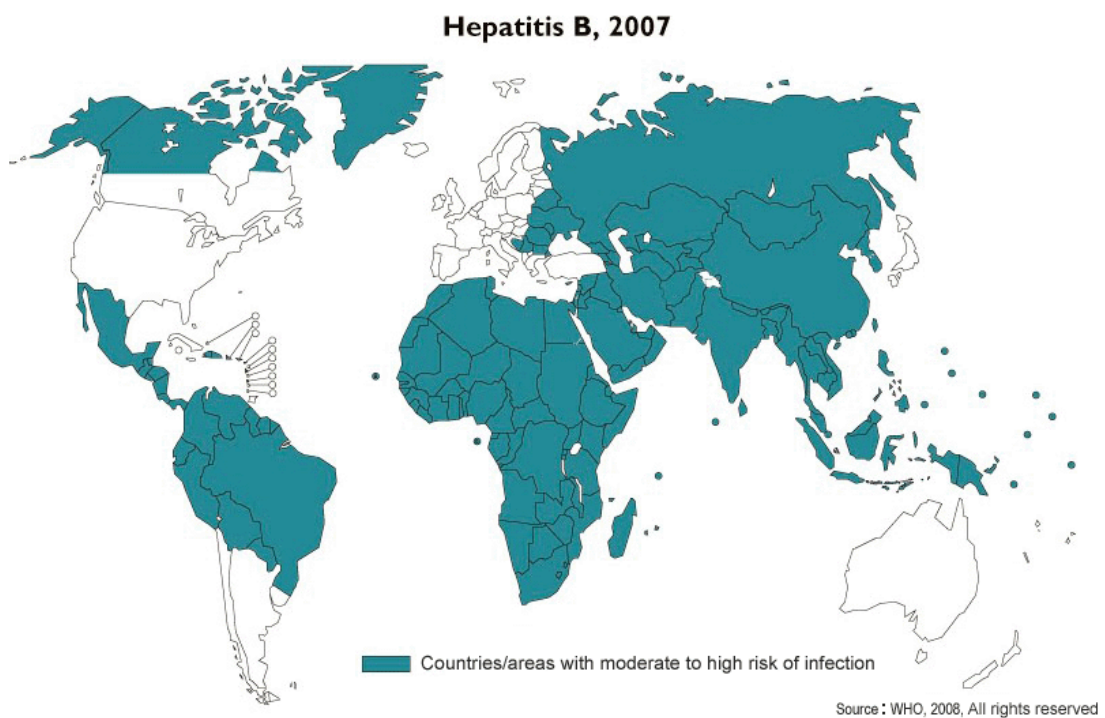
Figure 21: Areas at moderate to high risk of Hepatitis B infection (WHO media centre 2016)

4.5.6 Hepatitis B

The prevalence of Hepatitis B was 7.3% in pregnant women screened at first antenatal care visit in this study. This is lower than a prevalence of 9.2% found in pregnant women in Gabon in 2005 by Makuwa et al. but about similar to a prevalence of 7.6% in rural populations in northern Gabon published by Makuwa et al. in 2009.

The high prevalence of Hepatitis B is a serious public health problem especially in Africa, Asia and South America. According to the World Health Organization (WHO), *"an estimated 240 million people are chronically infected with hepatitis B (defined as hepatitis B surface antigen positive for at least 6 months)"* (WHO Media centre 2016).

Figure 21 shows regions at moderate to high risk of infection with Hepatitis B. The whole African continent is indicated as a region with moderate to high risk of Hepatitis B infection, as well as Asia with the exception of Japan, the Arabian peninsula and central America, the northern part of South America and the northern part of Canada and Alaska. It can be seen that in the poorer countries the risk of Hepatitis B infection is higher than in rich countries.

## 4.5.7 Hepatitis B and HIV coinfection

Four of 33 HIV positive women were co-infected with Hepatitis B (12.1%, 95% CI 3.4-28.2%). This finding underlines other studies showing that 10% of the HIV positive population is co-infected with Hepatitis B worldwide with co-infections being more common in areas of high prevalence for both viruses (Thio 2009, Kourtis et al. 2012).

4.5.8 Syphilis

The prevalence of syphilis of 2.5% found in pregnant women in this study is quite low compared to older data from Franceville and the rural Nouna area, were the prevalence of syphilis in adults was 8.3 and 25.5 per cent, respectively

(Bertherat et al. 1999, Zoleko Manego et al. 2017). The WHO estimates a Syphilis prevalence of 3.5% in females and 3.9% in men in the African region (WHO 2008).

Figure 22 shows the prevalence of syphilis in pregnant women in 2008 and 2009 (Newman et al. 2013), highlighting relatively high prevalence's in the sub-Saharan region and a prevalence of 0.5 to 0.9 per cent for Gabon, which is lower than the 2.5% found in pregnant women in this study.
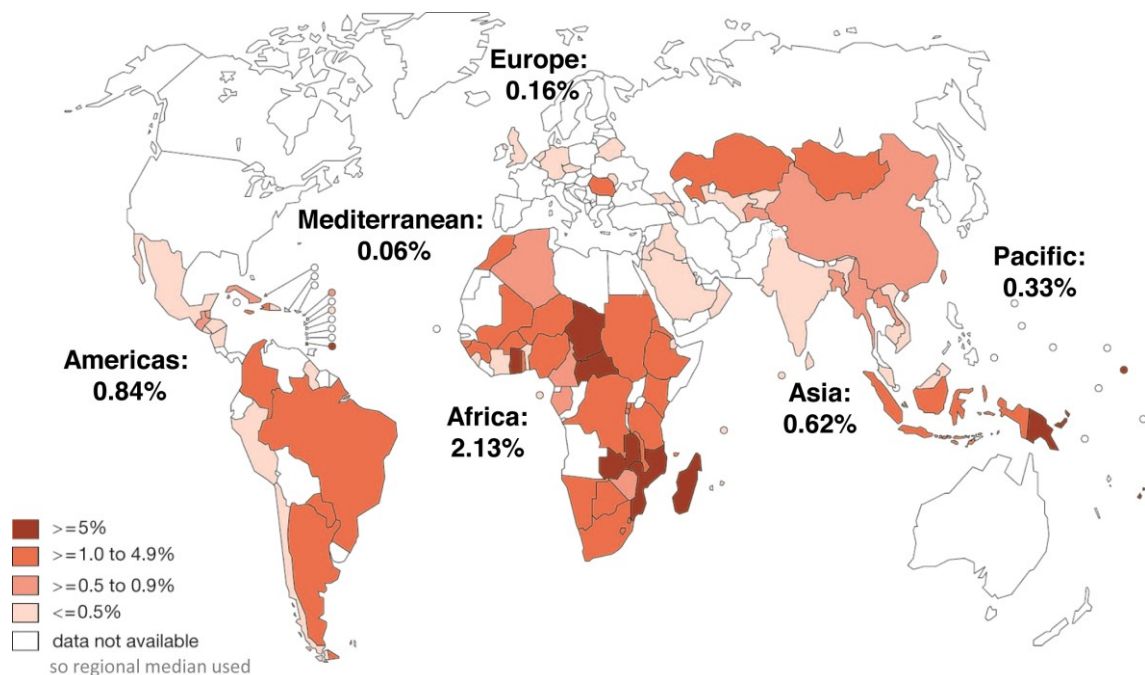
Figure 22: Prevalence of Syphilis in pregnant women attending antenatal care (Lori Newman et al. 2013)

4.6 Maternal health

As shown in Figure 18, the majority of pregnant women is rather young in the Fougamou region. The prematurity rate varied from 6 to 12 per cent, depending on the year, and 4 to 8 per cent of newborns had low birth weight. The stillbirth rate was 1.7% in this period of time, which is exactly the same percentage found in online WHO databases for Gabon (WHO 2009). Ten and six

spontaneous abortions were recorded in 2008 and 2009, respectively. Six and five provoked abortions were recorded in 2008 and 2009, respectively. The real number of spontaneous as well as provoked abortions is probably higher as most women attend the hospital only in case of complications. In the case of provoked abortions, this is due to the fact that abortion is illegal in Gabon.

As table 3 shows, the percentage of infants born in the hospital is 90 to 94 per cent, which seems to be quite high for a rural African region.

The coverage with intermittent preventive treatment against malaria in pregnancy (IPTp) is surprisingly high: In 2010, 275 women delivered in Fougamou and 270 received at least one dose of IPTp during their pregnancy and 219 received the second dose as well. This could be due to the follow-up conducted by MiPPAD study personnel for women participating in the study. The midwifery is functioning well with uncomplicated births, but in case of a complication the patient must be sent to Lambaréné, where there are two hospitals being able to deal with birth complications. This can be problematic because no functioning ambulance car is available and the 87 kilometer car drive is too long in case of a serious complication during delivery. During the study period of the MiPPAD study, the Ngounie Medical Research Center provided the possibility of free transport for pregnant women participating in the study, which could be used in case of emergency or beginning of labor. This transport was conducted by a study field worker using the research team´s car.

4.6.1 Anemia in pregnancy

Very high rates of anemia in pregnancy were found in this study. 71.5% of the pregnant women screened during the MiPPAD study had hemoglobin levels lower than 11 g/dl. This is quite a high percentage, compared with findings from Bouyou-Akotek et al., who described an anemia rate of 25% in pregnant women from Libreville in 2011 (Bouyou-Akotet et al. 2011). This difference could be due to differences in rural and urban settings. For instance, in rural settings the exposure to malaria as a contributing factor to low hemoglobin levels is higher than in urban settings.

The high rate of anemia in pregnancy found in Tsamba Magotsi could be due to the high prevalence of malaria in this region, iron deficiency, vitamin B12 or folic acid deficiency, or more than one of the mentioned causes at the same time. Also, the rate of sickle cell disease is quite high in this region, which probably is causing a small part of the low hemoglobin levels found in this study as well. In pregnant women, low hemoglobin levels can affect the unborn child. Iron and folic acid supplement was offered to every pregnant woman participating in the MiPPAD study, but the low hemoglobin levels were difficult to tackle. This could be due to low compliance in taking the supplements or other factors, which should be subject to further research.

4.7 Conclusion

Tsamba Magotsi is a rural tropical African region with a young population and an extensive age pyramid. Infectious diseases are the major health issue, and malaria is widely prevalent and the most common reason for seeking health care. Unlike other African regions, non-infectious diseases contribute a minor part to the disease burden in Tsamba Magotsi (Zoleko Manego et al. 2017). This is probably due to the traditional rural life-style in Tsamba Magotsi.
There are rural health stations in villages and a small hospital in the town of Fougamou. While the number of nurses and midwifes is sufficient, a lack of physicians is to be mentioned. A research center conducts research projects in the field of infectious diseases and epidemiology in the region.
An improvement of the public health system is needed; the social assurance for everyone living in Gabon which was initiated by the Gabonese government is an important step into the right direction.

5 Abstract

This work aims to describe the basic epidemiology of the Tsamba Magotsi region, a rural area located in the central Gabonese rainforest. Various data sources were used: A governmental census, hospital statistics, and research projects.

The population of Tsamba Magotsi is young, with an expansive population pyramid. Infectious diseases caused 71% of the disease burden, with malaria being the most common reason for attending public health care. In pregnant women, the prevalence of HIV, HBV, and syphilis was 6.2, 7.3, and 2.5 per cent, respectively. The blood-smear positivity for microfilaria was 13.3% in hospital patients, with Loa loa being the most common species. In patients infected with microfilaria, the prevalence of malaria was significantly lower than in those not infected with microfilaria (21.7, 95% CI 15.1-28.3 and 33.2, 95% CI 30.3-36.0 per cent, respectively). The prevalence of anemia in pregnancy was 71.5%. Unless other African regions and urban Gabonese settings, in Tsamba Magotsi the non-infectious diseases do not contribute a major part to the disease burden.

With the currently ongoing introduction of public health insurance and road constructions, the access to health services for the local population will hopefully be further improved. The region is suitable for further research projects in the field of tropical medicine, which can be a benefit for the local health system and the local population.

6 Zusammenfassung

Ziel dieser Arbeit ist es, eine Übersicht über die Epidemiologie von Infektionskrankheiten in der ländlichen gabunischen Region Tsamba Magotsi zu erstellen. Dafür wurden verschiedene Quellen benutzt: Ein Zensus der gabunesischen Regierung, prospektiv erhobene Daten des lokalen Krankenhauses sowie Daten von Studien, die in dieser Region durchgeführt wurden.

Infektionskrankheiten machten 71% der Krankheitsfälle aus, Malaria ist bei weitem der häufigste Grund für Konsultationen im öffentlichen Gesundheitssystem. Die Prävalenz von HIV, HBV und Syphilis bei schwangeren Frauen lag bei 6,2, 7,3 und 2,5 Prozent. Mikrofilarien wurden in 13,3 Prozent der dicken Tropfen, die von Krankenhauspatienten gemacht wurden, gefunden; Loa loa war die häufigste Spezies. Bei Patienten, die positiv auf Mikrofilarien getestet wurden, war die Malaria-Prävalenz signifikant niedriger als bei Patienten, bei denen keine Mikrofilarien gefunden wurden (21,7%, 95%KI 15,1-28,3%, und 33,2%, 95%KI 30,3-36,0%).

Im Gegensatz zu anderen Regionen in Afrika und zu urbanen Regionen Gabuns spielen nicht-infektiöse Krankheiten in Tsamba Magotsi eine untergeordnete Rolle.

Durch die derzeitige Einführung einer öffentlichen Krankenversicherung in Gabun und die Verbesserung der Anbindung der ländlichen Regionen durch den Straßenbau wird sich der Zugang zur Gesundheitsversorgung der lokalen Bevölkerung zunehmend verbessern. Die Region ist außerdem gut geeignet für weitere tropenmedizinische Forschungsvorhaben, die ebenfalls einen potentiell positiven Effekt für die Bevölkerung haben werden.

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8 Erklärung zum Eigenanteil

Die Arbeit wurde im Institut für Tropenmedizin unter Betreuung von
Prof. Dr. Peter Gottfried Kremsner durchgeführt.

Die Konzeption der Studie erfolgte in Zusammenarbeit mit
Assoc. Prof. Dr. Michael Ramharter (Gruppenleiter) und Dr. Ghyslain Mombo-Ngoma (Principal Investigstor der MiPPAD-Studie).

Dr. Ghyslain Mombo-Ngoma koordinierte und leitete die Erhebung und Archivierung der Daten des Labors in Fougamou, Mitarbeiter des Forschungslabors und ich erhoben die Daten und gaben diese in Excel-Tabellen ein.

Frederic Ehong Mezui, der Statistiker des Krankenhauses in Fougamou, gab mir die Daten der Krankenhausstatistik.

Noelle Moussavou, ein Mitarbeiter des gabunesischen Innenministeriums, gab mir Daten eines Zensus, der im Jahre 2003 in der Region durchgeführt wurde.

Eva Zettlmeissl (damals Doktorandin) steuerte die Daten eines Microfilarien-Screenings bei Schwangeren, das sie durchgeführt hatte, zum Projekt bei.

Jean Paul Momba-Ngoma (IT-Spezialist im MiPPAD-Team) half mir, Daten die im Rahmen der MiPPAD Sutdie erhoben wurden aus der Software OpenClinica® zu exportieren.

Dr. Ulysse Ateba-Ngoa (Forscher am Forschungsinstitut in Lambaréné) steuerte Daten von zwei kleinen Schistosomiasis-Screenings bei, die er mit seinen Mitarbeitern durchgeführt hatte.

Erklärung zum Eigenanteil

Florian Thol (damals Student) gab mir drei Fotos, die er in Fougamou und Lambaréné geschossen hatte und die ich in dieser Arbeit verwende.

Ich war an der Erhebung der Daten der Laborbücher sowie der Screenings bei Schwangeren beteiligt. Ich war an der Digitalisierung der Daten beteiligt (Dateneingabe durch mich persönlich sowie Überprüfung der Daten, die andere Mitarbeiter eingegeben hatten, durch mich).
Ich sammelte die Daten aus den verschiedenen oben genannten Quellen und von den oben genannten Personen, wertete sie aus und stellte sie mit Hilfe von Assoc. Prof. Dr. Michael Ramharter zusammen. Die statistische Auswertung erfolgte eigenständig durch mich. Ich erstellte die Tabellen, die Graphiken und schrieb den Text. Assoc. Prof. Dr. Michael Ramharter und Prof. Dr. Peter Kremsner betreuten mich bei der Erstellung des Manuskriptes.

Einige Ergebnisse dieser Dissertationssschrift wurden bereits in einer Fachzeitschrift publiziert (siehe Kapitel 9). Für meinen Eigenanteil an diesen Ergebnissen gilt das Gleiche wie bereits oben beschrieben.
Es wurden keine ganzen Textpassagen durch mich aus dieser Publikation übernommen. Alle Tabellen und Graphiken, die sowohl in der vorliegenden Dissertationsschrift als auch in der in Kapitel 9 genannten Publikation erschienen sind, sind von mir eigenständig erstellt worden.

Ich versichere, das Manuskript selbständig nach Anleitung durch Assoc. Prof. Dr. Michael Ramharter und Prof. Dr. Peter Kremsner verfasst zu haben und keine weiteren als die von mir angegebenen Quellen verwendet zu haben.

Berlin, den 20.Oktober 2016

Malte Witte

9 Veröffentlichungen

Teile der vorliegenden Dissertationsschrift wurden bereits in der folgenden

Publikation veröffentlicht:

Zoleko Manego R, Mombo-Ngoma G, Witte M, Held J, Gmeiner M, Gebru T, Tazemda B, Mischlinger J, Groger M, Lell B, Adegnika AA, Agnandji ST, Kremsner PG, Mordmüller B, Ramharter M, Matsiegui PB. (2017). Demography, maternal health and the epidemiology of malaria and other major infectious diseases in the rural department Tsamba-Magotsi, Ngounie Province, in central African Gabon. *BMC Public Health*, 17, doi: 10.1186/s12889-017-4045-x

Acknowledgements

Curriculum vitae

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2010-2012	Malaria research in Gabon, Medical Research Unit of the Albert Schweitzer Hospital and Tropeninstitut Tübingen