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Water diseases: dynamics of malaria and gastrointestinal diseases in the tropical Guinea-Bissau (West Africa)

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Master in Public Health || Thesis ||

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“A saúde é um resultado e um motor de progresso. É o centro da nossa visão de um futuro mais sustentável, inclusivo e próspero e é fundamental para a agenda de paz e segurança.”

“Quando investimos em saúde - particularmente de mulheres e adolescentes - construímos sociedades mais inclusivas e resilientes.”

O secretário Geral da ONU António Guterres

Fórum Universal dos Cuidados de Saúde – Tóquio (2017)

ABSTRACT

Guinea-Bissau is a small West African country listed among the poorest countries in the world. After 530 years of European colonial rule, became independent in September 1973. The first 7 years following the independence showed a rapid growth in all societal areas, including the health sector, essentially due to the combination of East-West International cooperation, that started during the colonial war (1963-1974). Following the 1980 coup d'etat, lead by the military, conditions deteriorated from infrastructures to the provided social services. Moreover, the solutions implemented by the International Monetary Fund and the World Bank failed, particularly in the health sector. The service deteriorated and a large part of the population lost access to free healthcare provided by local and expatriate officers. In this study, the environmental situation and key diseases indicators (malaria, diarrhea in both adults and children) were studied in Bolama, the former colonial capital, located in the island with the same name in the Bijagós archipelago. The regional hospital occupies presently former Portuguese army barracks after the destruction of the large colonial hospital c.a. forty years ago. The present infrastructures cares for about 10,206 inhabitants of the Bolama sanitary region, but has no running water, no electricity, no operation theatre, no imagiology, although a basic clinical lab exists. A sink latrine (open pit) is located in the backyard, caring for the entire hospital. In the case of need, patients are evacuated by private boat, a journey that can last between four and eight hours, depending on the tide. Raw health data used for this study were manually retrieved from the Bolama hospital logbooks for children and adults. Access to data was granted by the clinical directors from 2006 to 2010. Data were assembled in a spreadsheet and organized by years and months. Meteorological data for the study period in Bolama city was supplied by the head of the Bolama regional Meteorological Service. Several health centers are aggregated to the regional hospital of Bolama, headed by basic health agents (ABS-Agentes Básicos de Saúde), women and man that have some literacy and basic health training, and are able to fill logbooks and prescribe medicines from antimalarial drugs to paracetamol and antibiotics. The hospital is headed by a medical doctor, usually absent, and care is eventually provided by an expatriated doctor but not on a

permanent basis, and also by health officers with four years of medical training abroad, and by nurses graduated in the country. The sub-Saharan location of Guinea-Bissau is not favorable in the present climate changing process. Two clear seasons occur in what precipitation is concern - a dry from December to April, when rain is less than 2 mm, and a wet one during the remaining months of the year. The rain usually peaks in August, but increased values may occur in July, as in case of 2008. The hottest month of the year is generally May and the coldest January. Important year-to-year precipitation variability was noticed during the study period. The year 2010 was particularly wet (2,260 mm). In what temperature is concerned, the values were rather stable, the mean annual temperature ranging from 24.5°C to 29°C. Most of the population has no access to running water and the available is of doubtful quality. Rivers and streams, most temporary, are not a source for water and the population relies on hand-dug or bore wells. Several of them dry during the hottest period of the year, increasing the burden of daily life. Malaria, the major cause of morbidity in the country had no clear seasonal pattern when analyzing the five years framework. On the other hand, diarrhea followed a clear seasonal pattern. Numbers peaked systematically at the on set of the wet season i.e. in May to June when the first rains occurred. Usually, a smaller peak was found at the beginning of the year, when the temperatures dropped. Also, the country is periodically ravaged by cholera outbreaks leading to epidemics that can spread over several months, as in 2008.

In conclusion, the study of the number of disease cases (malaria, gastrointestinal and others) and its possible correlation with the two different seasons, could lead us to draught some possible solutions, framed in the socio-economic reality of the population, in order to help them to achieve more quality of life and a better health.

Keywords: Water, gastrointestinal diseases, malaria, Guinea-Bissau.

RESUMO

A Guiné-Bissau é um pequeno país da África Ocidental considerado um dos países mais pobres do mundo. Após 530 anos de domínio colonial europeu tornou-se independente em Setembro de 1973. Os primeiros 7 anos após a independência mostraram um rápido crescimento em todas as áreas sociais, incluindo no sector da saúde, essencialmente devido à combinação da cooperação internacional Leste-Oeste, iniciada durante a guerra colonial (1963-1974). Depois do golpe de estado de 1980, conduzido por militares, as condições deterioraram-se quer em termos de infraestruturas, quer em toda a esfera social, incluindo na área da saúde. As soluções implementadas pelo Fundo Monetário Internacional e pelo Banco Mundial fracassaram, particularmente no sector da saúde. O serviço deteriorou-se e grande parte da população perdeu o acesso aos cuidados de saúde gratuitos prestados por agentes locais e internacionais. Neste estudo, a situação ambiental e os principais indicadores de doenças (malária, diarreia em adultos e crianças) foram estudados em Bolama, a antiga capital colonial localizada na ilha com o mesmo nome no arquipélago dos Bijagós. O hospital regional ocupa atualmente um antigo quartel do exército Português após a destruição do grande hospital colonial há aproximadamente quarenta anos. A infraestrutura actual serve os cerca de 10 206 habitantes da região sanitária de Bolama, mas não tem água corrente, electricidade, bloco operatório ou imagiologia, embora exista um laboratório clínico básico. Uma latrina (fossa aberta) localizada nas traseiras, serve todo o hospital. Em caso de necessidade, os pacientes são evacuados por barco particular, uma viagem que pode durar entre quatro e oito horas, dependendo da maré. Os dados brutos de saúde utilizados para este estudo foram obtidos manualmente nos livros de registo do Hospital de Bolama, para crianças e adultos. O acesso aos dados foi concedido pelos diferentes diretores clínicos de 2006 a 2010. Os dados foram compilados informaticamente e organizados por anos e meses. Os dados meteorológicos para o período de estudo na cidade de Bolama foram fornecidos pela chefe do Serviço Meteorológico regional de Bolama. Vários centros de saúde estão agregados ao Hospital Regional de Bolama, são chefiado por Agentes Básicos de Saúde - ABS, mulheres e homens que pelo menos, sabem ler e alguma formação básica em saúde, capazes de preencher livros de registo e prescrever medicamentos como drogas antimaláricas, paracetamol e antibióticos. O

hospital é dirigido por um médico, geralmente ausente, e os cuidados são eventualmente prestados por um médico expatriado, embora não de forma permanentemente, e ainda por técnicos de saúde com quatro anos de formação médica no estrangeiro e por enfermeiras formadas no país. A localização subsaariana da Guiné-Bissau não é favorável no presente contexto de alterações climáticas. Durante o ano podem ser identificadas, de forma clara, duas estações, a seca de Dezembro a Abril, quando a precipitação é inferior a 2 mm, e a das chuvas durante os restantes meses do ano. O máximo de pluviosidade é habitualmente registado em Agosto, mas podem ocorrer excepções e pode chover, como no caso de Julho de 2008. O mês mais quente do ano é geralmente Maio e o mais frio Janeiro. A variação de precipitação interanual foi visível no período do estudo. O ano de 2010 foi particularmente húmido (2260 mm). Relativamente à temperatura, os valores foram bem mais estáveis, com a temperatura média anual a variar entre 24,5 °C e 29,0 °C. Maio é geralmente o mês mais quente. A maioria da população não tem acesso a água corrente e a disponível é de qualidade duvidosa. Rios e riachos, maioritariamente temporários, não são uma fonte de água e a população depende de poços abertos à mão e, em menos escala, de furos. Vários deles secam durante o período mais quente do ano, aumentando a dificuldade da vida diária para as pessoas. A malária, a principal causa de morbilidade no país, não apresentou um padrão sazonal ao longo dos cinco anos estudados. Por outro lado, as doenças diarreicas apresentaram claramente um padrão sazonal, aumentando sistematicamente no início da estação húmida, ou seja, entre Maio e Junho, com o início da época das chuvas. Normalmente, um outro aumento, ainda que menor, é encontrado em no início do ano, durante o período mais frio. O país é periodicamente devastado por surtos de cólera que conduzem a epidemias, como em 2008, quando 14 228 casos foram diagnosticados e 225 pessoas morreram.

Palavras-chave: Água, doenças gastrointestinais, malária, Guiné-Bissau.

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INTRODUCTION

Country description

In September 1973, after almost 530 years of colonial rule, Guinea-Bissau declared the independence from Portugal, which was recognized by 38 countries (globalsecurity.org), although the former colonial power acknowledged it one year later, after the Portuguese April Revolution. Since then has been experiencing political and military instability (Bordalo & Savva-Bordalo, 2007), with 22 military coups or tentative to overthrow of the government (Bordalo, personal comunication), considered by the World Bank as one of the most coup-prone and politically instable countries in the world (World Bank, 2018).

Geography

Guinea-Bissau is a small African country located in West Africa, flanking the North Atlantic Ocean, with a coastline of 350 km (Figure 1). Located between Guinea-Conakry and Senegal, has a total area of 36,125 km^2 22.16% of which is water (8,005 km^2) (CIA, 2017).

The relief is not very rugged and its altitude does not exceed 40 m, with the exception of the Boé hills in the south-east, which reach 300 m. Cultivable land amounts to 1.1 million hectares and cultivated land to 548,000 hectares, of which 55 percent is annual crops and 45 percent is permanent crops (FAO AQUASTAT, 2005). In Guinea-Bissau 55.2% of the land is forest and the other 44.8% is used for agricultural propose (CIA, 2017).

Climate

The climate is tropical, hot and humid with monsoonal-type rainy season from June to November, with southwesterly winds, and a dry season from December to May with northeasterly harmattan winds blowing from the Sahara desert (Bordalo & Savva-Bordalo, 2012). The average annual rainfall is 1,577 millimeters, and in addition to this volume of precipitation, the country also receives an important water supply from neighboring countries (mainly from Guinea and Senegal) (MSP, 2009).

People

Guinea-Bissau population is very dependent on subsistence agriculture, timber exports and cashew nuts, the selling of fishing licenses, and foreign assistance. The latter may represent over 60% of the national budget (Bordalo, personal comunication). In Guinea-Bissau, rice is the staple food. Agriculture is dominated by two productions: rice and cashew. The country has a very old rice tradition, while the development of cashew is recent (20 years). Rice is mainly cultivated in mangroves and in smaller proportion in lowlands or in rain fed crops. The varied natural environment allows for a range of food crops such as millet, sorghum, maize, cassava, sweet potato and groundnut (formerly cash crops), and as well as cotton. The country has real potential for fruit trees through its orchard of mango, citrus and banana (FAO AQUASTAT, 2005). About two-thirds of the population relies on cashew-nut harvesting (World Bank, 2018), which involves the entire rural families from February to May.

Generalized poverty accentuates the vulnerability of the whole population: 69.3 % of the Guinean population lives below the national income poverty line; 80.4 % lives in multidimensional poverty, suffering deprivations in health, education and living standards in the same household, while 58.4 % of the population lives in severe multidimensional poverty (UNIOGBIS, 2017). This country lacks educational infrastructure, school funding, materials and qualified teachers (CIA, 2017). The link between poverty and poor health conditions leads to increased maternal mortality rates in Guinea-Bissau, being among the highest in the world, and the population to a very low life expectancy, 55.5 years according to the Human Development Report (2016) (UNIOGBIS, 2017).

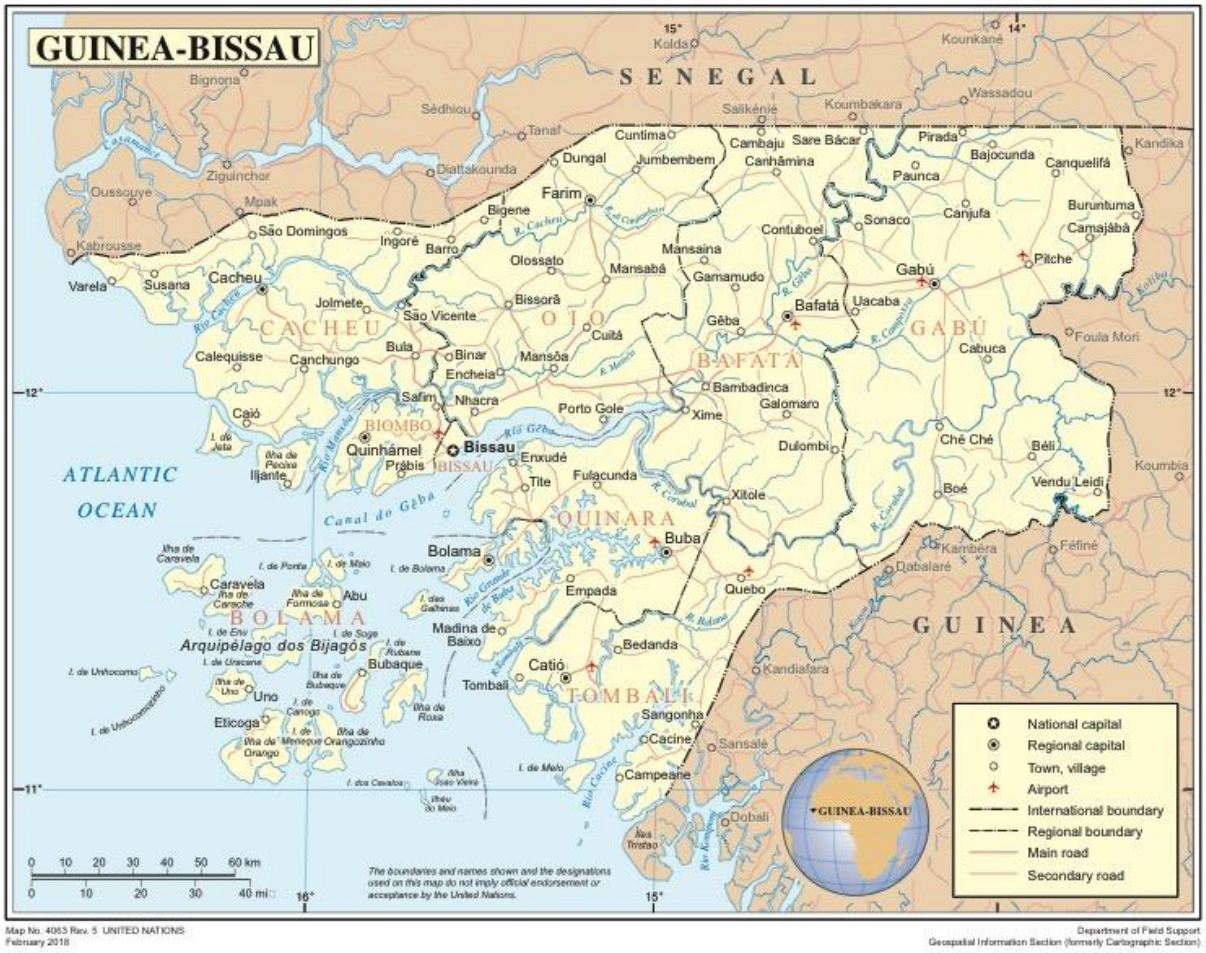

Figure 1 - Illustrated map from Guinea-Bissau (United Nations, 2018).

Administrative division

The total population in Guinea-Bissau is 1,888 million people distributed administratively by nine regions: Bolama/Bijagos, Cacheu, Biombo, Bissau, Quinará, Tombali, Oio, Bafata e Gabu (MSP, 2008). The Bolama/Bijagos consists primarily of 88 islands and islets, although a substantial part is also located in the continent, facing the Quinará region (Figure 1).

Ethnic distribution

Over 20 different ethnic groups are spread all over the country (Figure 2), such as Fulani, Balanta, Mandinga, Papel, Manjaco, Beafada, Mancanha, Bijago, Felupe, Mansoanca, Balanta Mane, For example in the N-NE areas are populated essentially

by Fulani and Mandiga, the hinterland E of the capital by Balanta, Papel around the capital, and within the islands – Bijago.

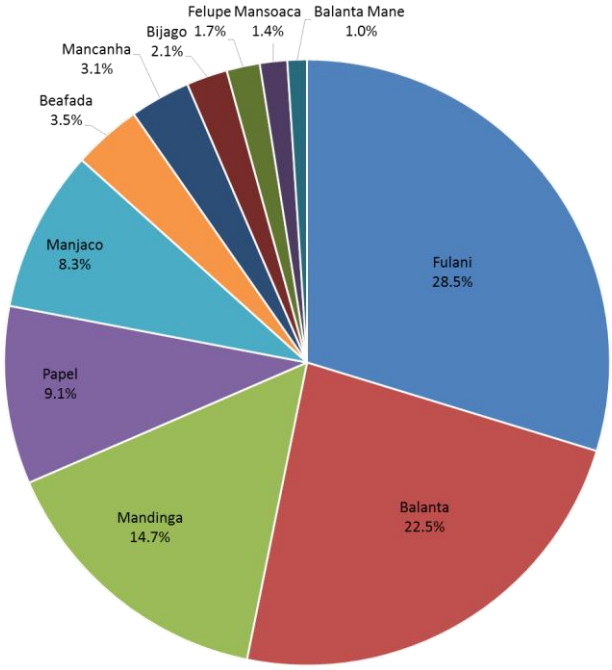

Figure 2 - Guinea-Bissau – Ethnic distribution, adapted from (CIA, 2017)

The official language is Portuguese, although spoken by a minority of the population that rather uses Crioulo as *lingua franca*. Muslims are the largest religious group (45.1%), followed by Christians (22.1%), animists (14.9%), none 2% and unspecified 15.9% (2008 est.) (INE, 2009).

The population is young and is growing (Fig.3), sustained by high fertility (total fertility rate 5.13 children per woman). Nearly 42 % of the population is under the age of 15 and 19.7 % is aged between 15 and 24. Between the age 15 and 64 is 55.5 % of the population and only 3 % as more than 65 years of age (United Nations, 2017).

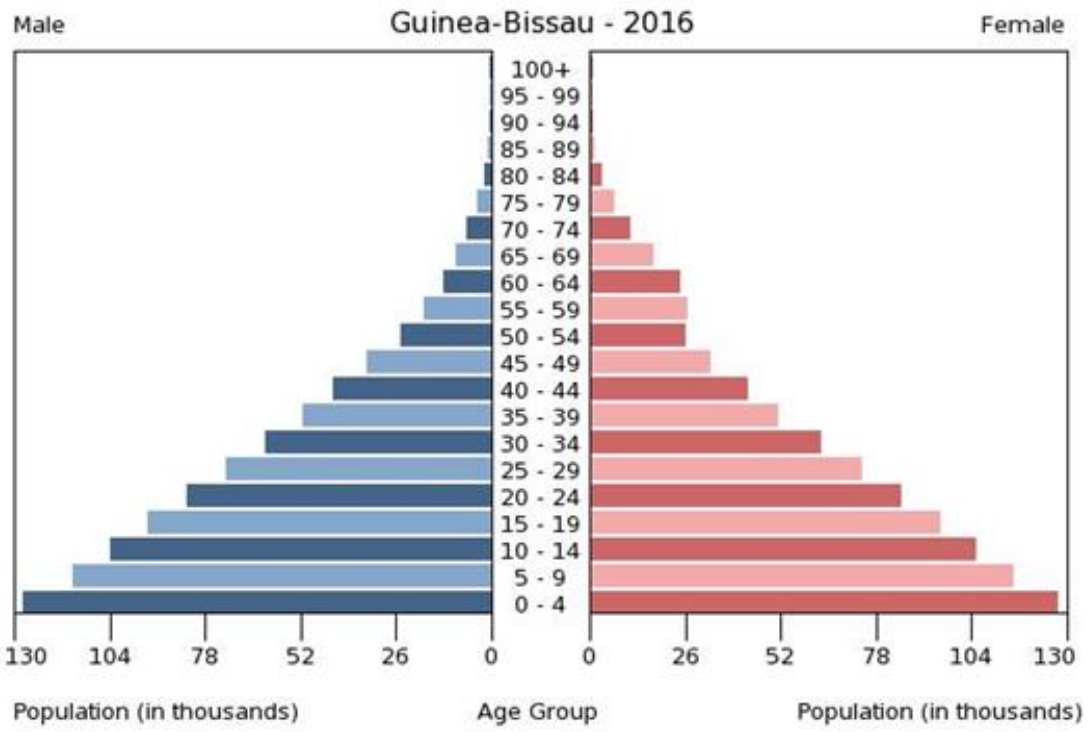

Figure 3 - Population Pyramid AFRICA - GUINEA-BISSAU (CIA, 2017)**.**

Healthcare network

Guinea-Bissau has National Health Service (NHS) organized in three levels: local, regional and central. At the base are the structures of community initiatives (Basic Health Units supported by community health workers and traditional birth attendants) that are the more structures of health care delivery. Also at local level, there are the Health Centers whose nomenclature A, B and C distinguishes them from their capacity to (more or less complex care, such as surgeries in health centers A). These Health Centers can still be classified in rural and urban areas. At the regional level, there are the Regional Hospitals (MSP, 2008). Availability of health care infrastructures is not the same as genuine availability of health care infrastructure. The information available reports 701 basic/community health units (only 466 working), 107 health centers, and 6 hospitals, including 5 regional (Silva, Cardoso, & Neves, 2007) all included in the public sector (WHO, 2017).

Despite these reasonable numbers, various of these health posts are semi-functional or dysfunctional, lacking health care workers, electricity or water supplies, with related

cases of delivering babies by candlelight and with no access to sterile water (UNIOGBIS, 2017). The maintenance status of these buildings is frequently very poor due to a lack of money for regular conservation. Many of them are run-down and in urgent need of renovation. In Guinea-Bissau exists a privation of the needed human resources for health, and this is regularly mentioned as one of the major challenges the country faces in delivering quality care to its population. Language barriers have also a great impact on contact to health care of the population (UNIOGBIS, 2017).

Many health posts remain at a significant distance from the population they are to serve, and 52 % of people have to travel for over an hour to reach the most basic health care facility. The road network is limited and in a fragile condition. The expensive telephony is inconsistently available blocking communication between health facilities (UNIOGBIS, 2017). Scarce supply throughout the country of electricity directly compromises the ability of health care facilities to utilize key equipment such as ventilators, radiological machines, or even to perform basic procedures with lighting (MSP, 2008).

Health indicators

In Guinea-Bissau there is a tremendous lack of human resources in health sector, being this one of the major challenges of the country in delivering quality care to its population. In 2014, there were 1.7 doctors per 10,000 people. Presently, there are only three pediatricians available, all expatriates, for a population of approximately 720,000 children under the age of 15. There are only four obstetricians and around 34 skilled midwives and one anesthetist (expatriate). Guinea-Bissau also faces a scarcity of other key personnel to the health sector including demographers, epidemiologists, and health care managers and administrators (UNIOGBIS, 2017).

The estimated maternal mortality ratio in 2004 was 910 deaths per 100,000 live births, amongst the worst in the world (Silva et al., 2007). In 2013, the maternal mortality ratio was of 560 deaths per 100,000 live births (WHO & UN, 2015). The leading cause of maternal deaths due to obstetric complications is hemorrhage, accounting for over 40 % of obstetric deaths, with other causes including postpartum infections, dystocia, hypertensive diseases of pregnancy, and complications of abortions. The country is

almost at the bottom in the world with respect to maternal health outcomes (Silva et al., 2007).

In Guinea-Bissau, only 45 % of births were assisted by skilled personnel in 2013 and 2014. The infant mortality rate was of 60.3 per 1,000 live births in 2016, and the under-five mortality rate was of 92.5 per 1,000 live births. Of deaths under five, many are amongst children in their first month of life: the neonatal mortality rate was 36 deaths per 1,000 live births from 2010 to 2014 (MICS 5, 2014) and of 39.7 deaths per 1,000 live births in 2015 according to the (World Bank, 2018). Regularly cholera shakes the country. During the 2008 epidemic, 14,228 cases of cholera were identified, and 225 people died, and a more recent (2012) outbreak yielded 3,280 cases and 22 deaths (Machado & Bordalo, 2016). The major causes of death for children under five are communicable diseases, particularly malaria, diarrhea, and respiratory illnesses. Patients generally pay a consultation fee at a health care facility, out-of-pocket payments, at rates that appear to be the highest in West Africa, and also pay for goods such as drugs, and services including specific medical procedures. Adults usually pay 250 CFA (0.38 €) and children 125 CFA (0.19 €) for each appointment, when a 1.5 L bottle of water costs 500 CFA (Bordalo, personal comunication). Patients who do not have to pay a fee include children under five, pregnant mothers, women giving birth, and patients aged 60 and over (UNIOGBIS, 2017) This approach, known as Bamako Initiative, is the result of measures from the World Bank, International monetary Fund and the European Union in order to recover costs, a policy that clearly failed in one of the poorest countries in the world (Paganini, 2004).

Water supply

In relation to water, the fundamental problem is the access of the population to this resource with good quality, despite its abundance in almost all the national territory during most of the year. According to data from the 2006 MICS survey, 60% of the Guinean population (82% urban and 48% rural) use improved sources of drinking water such as piped water (inside and outside the home), holes and wells. Improved sources are a concept that does not deal with quality. Indeed, 80% of all water sources used by one population in Guinea-Bissau are of doubtful quality and pose a serious risk to consumers (Bordalo & Savva-Bordalo, 2012).

Resigned the people, entire generations a little all over the country have never seen a faucet, lavatory or toilet. The water for the different uses comes from shallow wells, very vulnerable to acidity, strongly corrosive to iron pipes and human teeth. Having no alternative, people consume what is available, half walls with latrines, where domestic animals, and even people defecate in the open air. Shortly the feces penetrate the sandy soil, infiltrating to the water table more and more close to the surface during the six months of rains. The buckets and ropes do the rest, transporting into the well what lies on the ground (Bordalo, 2014).

Even so, about 95% of the population needs to move up to 30 minutes to fetch drinking water. This means that only 5% have piped water in their homes (FMI, 2011), most of them within the city of Bissau. However, given the quality and precariousness of the pipeline system, the constant and prolonged water supply disruptions which have facilitated both toxic contamination in the networks and biological contamination from waste infiltrations with fecal contamination, the random location of septic tanks in relation to water wells, makes it extremely difficult to define the percentage of population that actually has access to potable water (MSP, 2008).

The proportion of the population using basic water service is 85% in urban areas and 54% in rural areas (JMP (WHO/UNICEF) (2017)). For sanitary facilities, 30% of the population in rural areas does not have them, defecating in bushes or in the fields (Figure 4 and Figure 5), being this a conservative estimation.

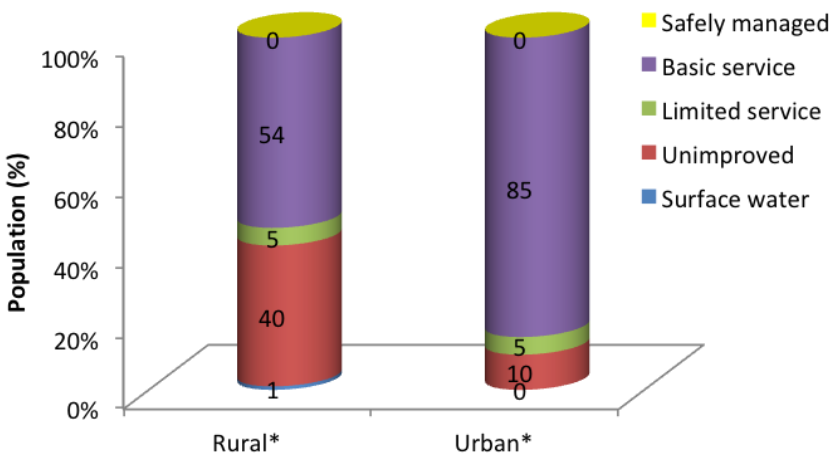

Figure 4 - Percentage of population with access to different services relating to drinking water adapted from JMP (WHO/UNICEF) (2017) No safely managed estimate values available.

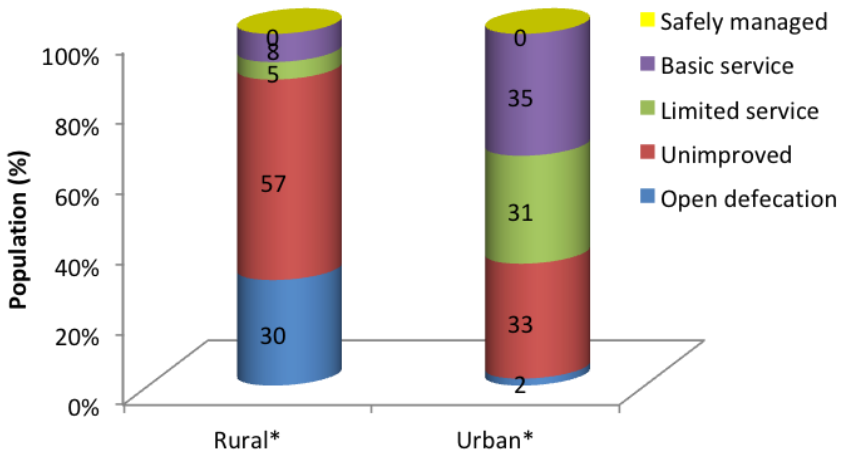

Figure 5 - Percentage of population with access to different services relating to sanitation facilities, adapted ("JMP (WHO/UNICEF)," 2017) No safely managed estimate values available.

The Bolama-Bijagos Archipelago was entitled a UNESCO Man and the Biosphere Reserve award in 1996. Bolama Island, a former colonial capital, is the most populous island, presently without a working water network (Bordalo & Savva-Bordalo, 2007).

The soils are sandy-clay, acidic and hydromorphic, with low organic matter contents. The vegetation comprises of dry, deciduous forest and semi-deciduous rain forest, palm and chew-nut forests, coastal and wet savannas and extensive mangrove forests lining the coastal one-third of the island. All ethnic groups are represented (Bordalo & Savva-Bordalo, 2012), and no tensions have been recorded.

Owing to its location, the connection to the continent is performed by narrow private hand carved wooden canoes and wooden pirogues filled with low power outboard engines. A state operated ferry between Bolama and Bissau may operate on a random basis. A trip to the capital can last between 4 to 8 hours, depending on the tide. Transportation is possible only during rising to high tide, due to the numerous sand bars, and during the daytime, only. All colonial and post-colonial lighthouses were looted over the years. In Bolama, four out of five wells that serve the majority of the inhabitants of the island are contaminated with fecal materials and some with heavy metals (Bordalo & Savva-Bordalo, 2007).

The presence of contaminants in water can have harmful health effects, including gastrointestinal illness, reproductive problems, and neurological disorders (UNAIDS, 2014).

Aim

The aim of this study was to understand the dynamics of key waterborne or water related health indicators – malaria and diarrhea (gastrointestinal diseases) coupled with the meteorological conditions, namely temperature and precipitation in the island of Bolama, the former capital of Guinea-Bissau, and to draw recommendations to tackle the problem.

MATERIALS AND METHODS

Study area

This work was based in data collected from logbooks of Bolama Hospital - Hospital Solidariedade de Bolama, in Bolama Island, between the years of 2006 and 2010. A total of 11,881 cases, regarding 6,716 children ≤15 years, and 5,166 adults > 15 years, were analyzed. The diagnosis data were gathered in 3 categories: malaria (MAL), diarrhea or gastrointestinal diseases (GID) and Other. The “Others” category includes all diagnosed diseases that were not water related to. Each one of the 3 categories was divided in two groups: children and adults.

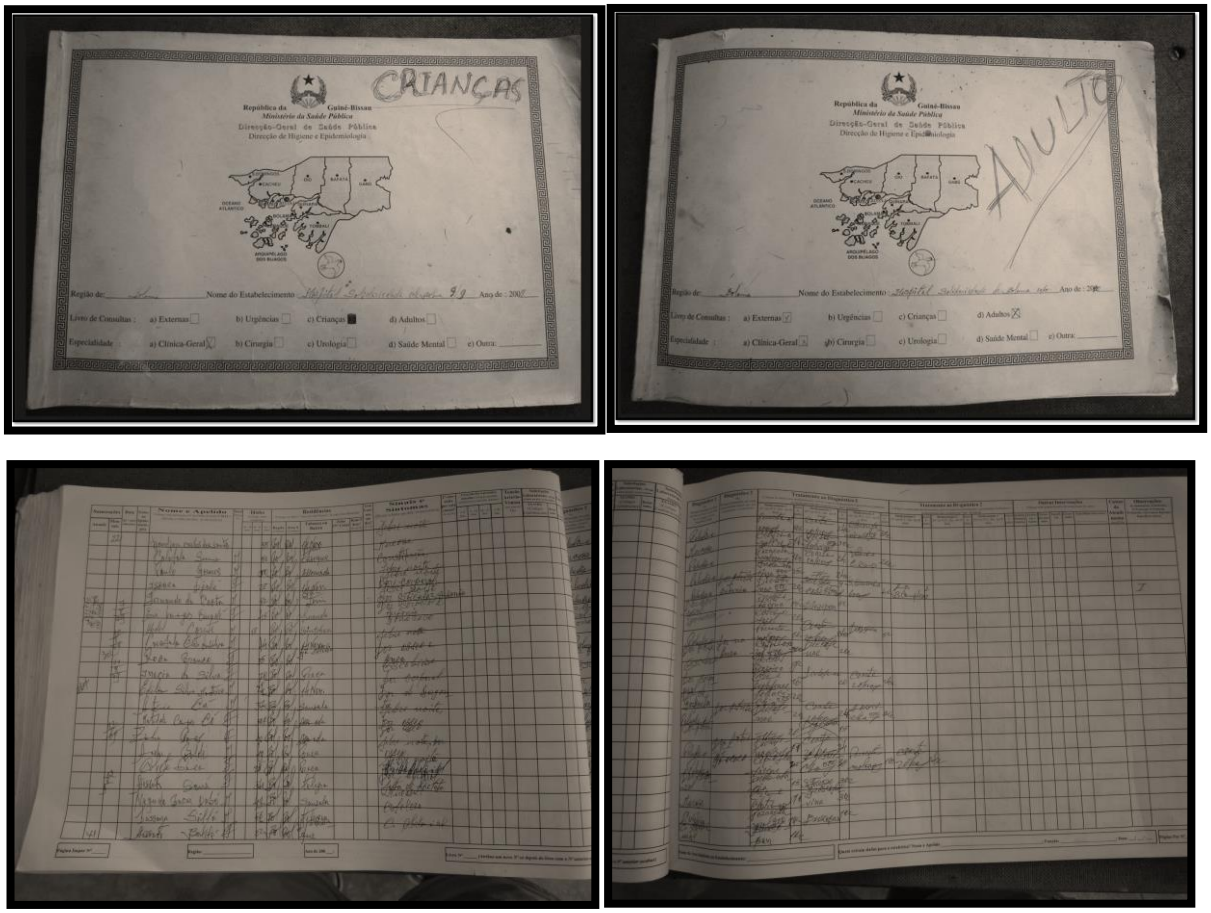

Figure 6 – Cover of hospital logbooks, Hospital Solidariedade de Bolama, children and adults, and an example of the logbook sheet.

Data referring to temperature and precipitation values, for the referred period of time (2006-2010), were supplied by the Director of Regional Office of the Meteorological Survey of Guinea-Bissau, D. Efigénia.

The daily decadal values were computed as monthly averages (temperature °C), or monthly sums (precipitation, mm). Daily average temperature as calculated as the mean of maximum and minimum values.

Statistics analyses

For statistical analyzes, we started to confirmed the homoscedasticity (Snedecor & Cochran, 1980) and normal distribution of data (Shapiro & Wilk, 1965). Next, for each disease, in the dry and wet seasons along the years (2006 to 2010) were compared by one-way analysis of variance (ANOVA) and the statistical significant difference was tested ($p < 0.05$, unless otherwise stated). Statistical analysis was performed using Microsoft Office Excel with the Data Analysis ToolPak (2018-08-20).

RESULTS

Bolama - island

Precipitation and Temperature data

The meteorological data are compiled in Figure 7. As it can be seen, no strong variations in temperature were observed though the years, with average monthly temperatures ranging from 24.5 to 29°C. On the other hand, monthly precipitation values ranged from 0 up to 654.2 mm (July 2008), with a clearly definition of the dry and rainy seasons, and with a consistent variation along the years (2006-2010). Rainy season usually begins in late May and ends by mid November. During the study period, 2010 and 2008 registered the higher total precipitation values, with 2,260 and 2,158 mm, respectively, followed by 2009 (1,889 mm) and 2006 (1,768 mm). The year of 2007 was the one where the precipitation values were lower (1,751 mm).

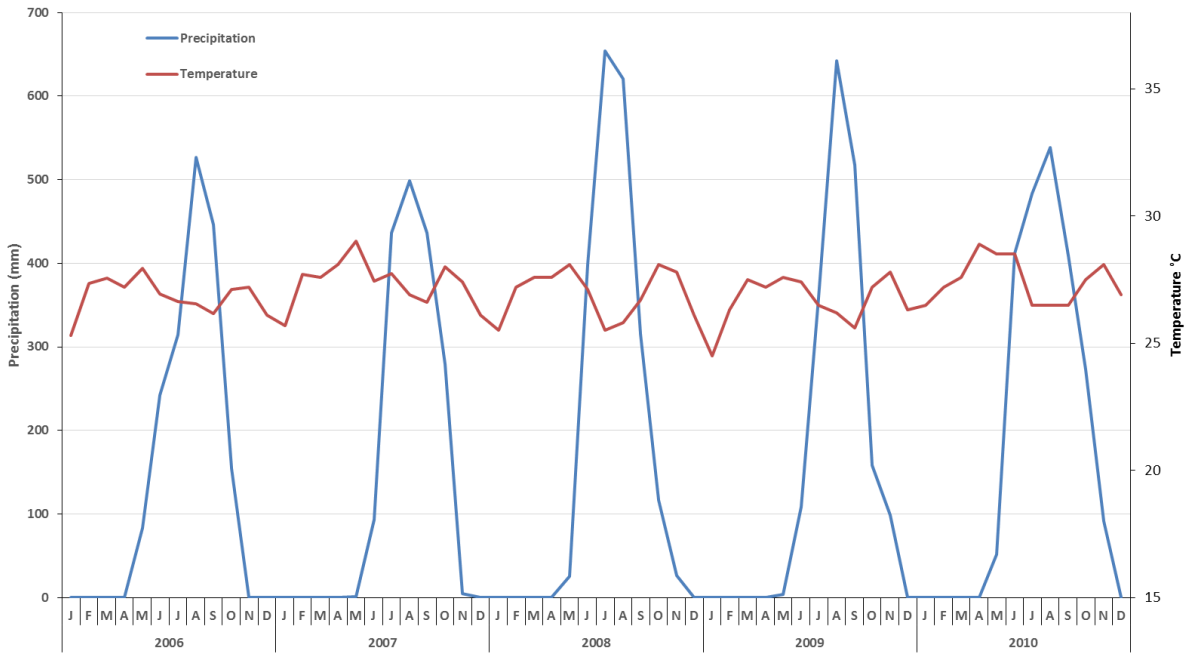

Figure 7 – Monthly precipitation (mm) and average temperature (°C) in Bolama, from January 2006 to December 2010.

Occurrence of diseases

Data from the logbooks of Bolama Hospital, collected between the years of 2006 and 2010, showed a total of 11,881 appointments, being 6,716 children (56.5 %) and 5,166 adults (43.5 %). Data were sorted according the stated in the Material and Methods section - malaria, gastrointestinal diseases and others, for adults and children.

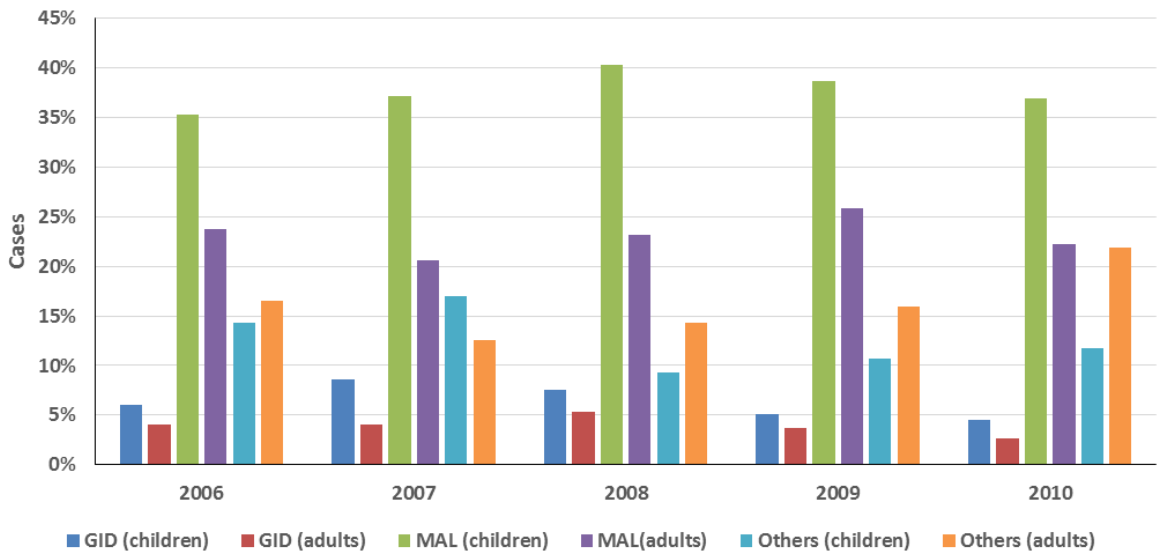

Figure 8 - Distribution of the defined 3 categories of diseases by year, in children and adults – GID - gastrointestinal diseases, MAL - malaria, Others.

From the analysis of the obtained data, malaria was by far the disease with more expression over the entire period (Figure 8).

When looking at malaria in the two different age groups, the percentage stands out in children, with values ranging from 35 to 40% of the registered cases, contrasting with 21 to 24% in adults with lower number of malaria cases.

The same pattern was observed for GID, with more cases in children than in adults. However, contrary to malaria, only a slightly difference between them was observed, with values ranging from 5 to 9% in children and 3 to 5% in adults.

In the category “other” diseases, not waterborne or water related, with the exception of 2007, a higher percentage of cases in adults were found, probably because the diseases included in this category were not typical childhood diseases, such as insufficiency, acute renal failure, arterial hypertension, gonorrhea.

It should be noted that patients with HIV/AIDS are never listed in the logbook, and screening is not performed on a regular basis, due to the lack of appropriate kits.

Precipitation vs water diseases

At this point, an interest about the total occurrence of cases (children plus adults) has arisen in what MAL and GID is concerned. In order to check if there was some relationship between the dry and rainy season in what MAL, GID and Other and precipitation were concerned, data were plotted as in figures 9 to 11.

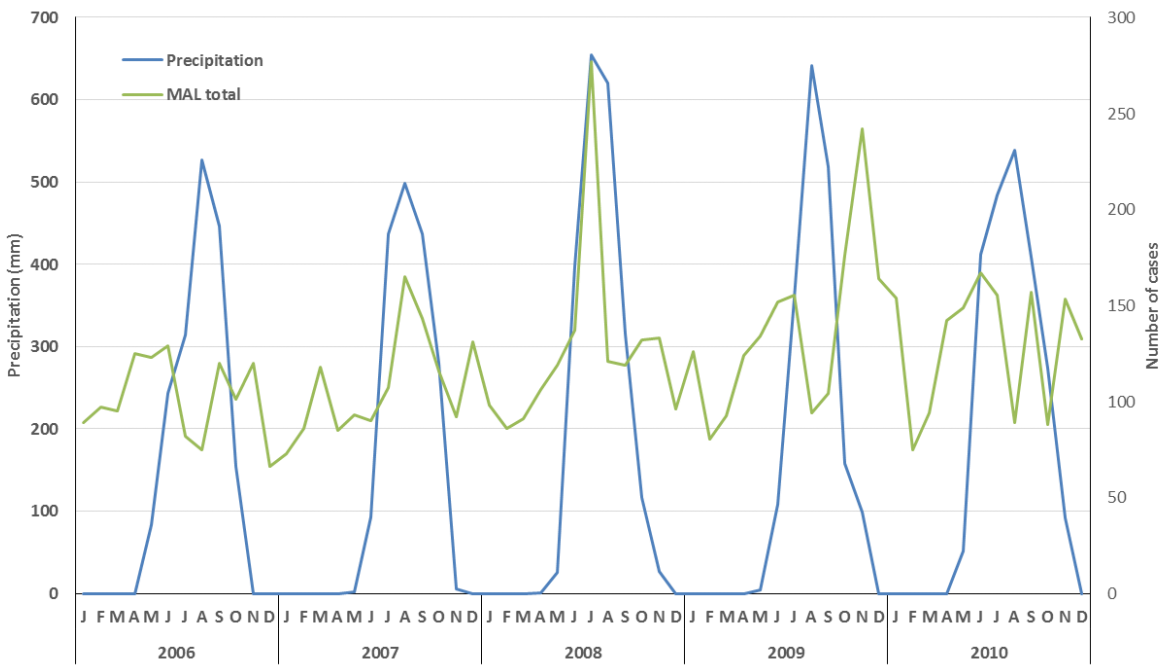

Figure 9 – Variation of precipitation intensity (mm) and the number of malaria (MAL) cases.

Looking at Figure 9, a clearly relation between the maximum precipitation and malaria peaks were observed in the years of 2007 and 2008. Interestingly, in 2009 maximum values for malaria occurred after the rainy season. On the contrary, in 2006 and 2010 those trends were reversed, with no exacerbated number of cases registered when maximum precipitation was achieved.

Initially, we expected to have, in each year, a higher number of malaria cases in the maximum of the precipitation values. Although this was true in 2007 and 2008, the trend was not observed in the remaining years as stated above.

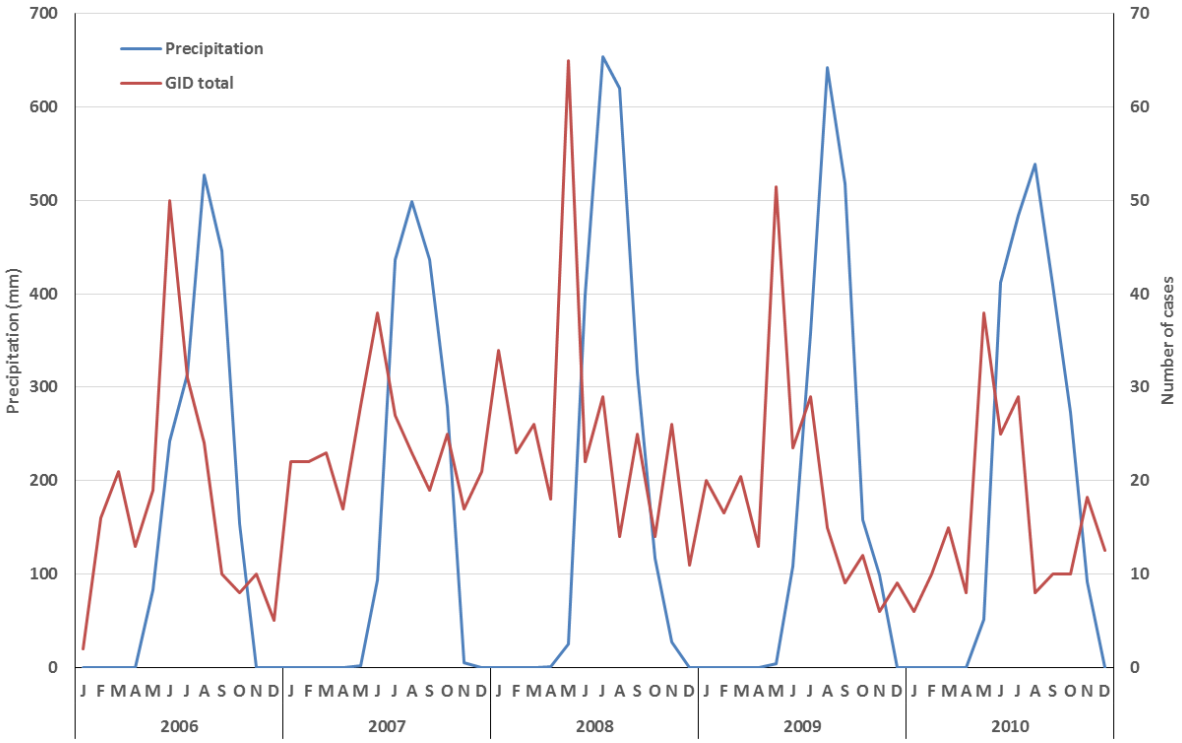

Figure 10 - Variation between precipitation (mm) intensity and the occurrence of gastrointestinal (GID) cases.

It what GID is concerned, values always peaked at the onset of the season, i.e. in May. The maximum monthly number cases occurred in June 2008 and coincided with epidemics of cholera (see the Introduction section). However, owining to the fact that no detection kits were available, the eventual number of cholera in Bolama is unknown.

It is suspected that most GID during the onset of the wet season were of bacterial origin, although this hypothesis was not tested due to the lack of data.

A smaller peak of GID was also registered during the coldest period of the year, coincident with the advent of respiratory diseases, mainly influenza, eventually due to viral proliferation.

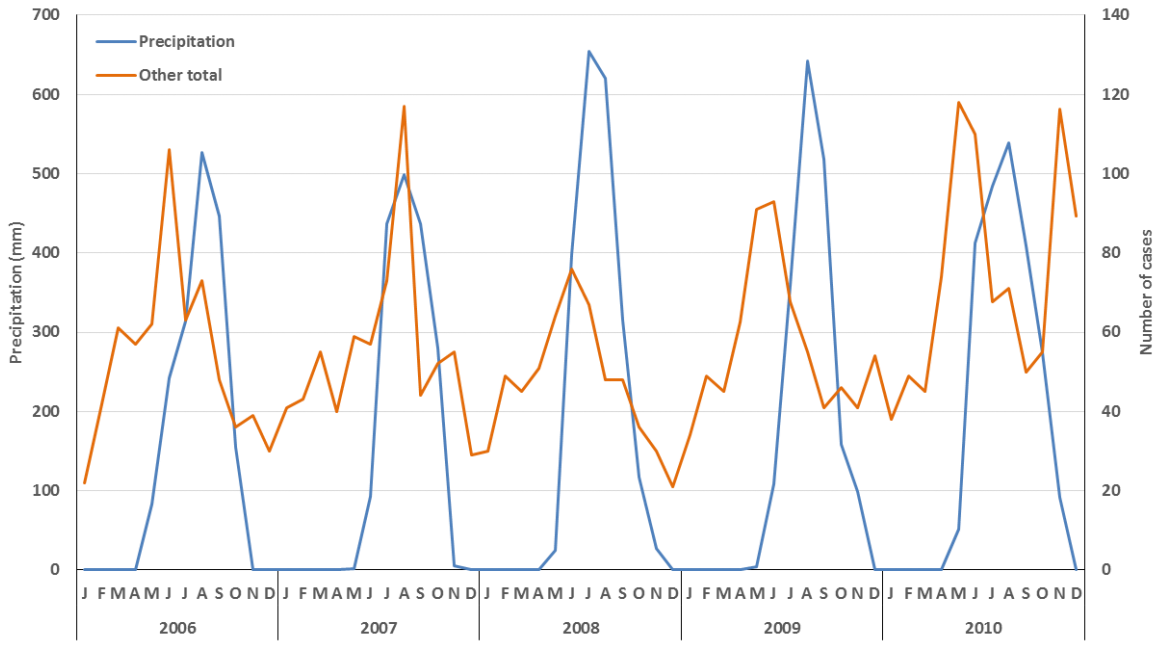

Figure 11 - Variation between precipitation (mm) intensity and the occurrence of other diseases cases.

Analyzing the data from the other diseases cases registered in the Bolama Hospital logbooks, the peak of cases in 2006, 2009 and 2010 were coincident with the end of the dry season. Interestingly, in 2007 the peak was observed in the rainy season, at the maximum of precipitation registered. Moreover, fewer cases of other diseases were reported in 2008, being the maximum number of cases observed in the very beginning of the rainy season. It is worth to note, that in 2010 another peak was observed at the beginning of the dry season.

Organizing the data in a table, and comparing the registered cases of the different diseases by the season in which they occurred (Table 1), it was possible to ascertain the significance of the seasonal dynamics.

Table 1- Seasonal (dry/wet seasons) variability for malaria (MAL), gastrointestinal (GID) and other diseases (Others) during the 2006 – 2010 studied period in Bolama.

	GID			MAL			Others		
Anos	Dry Season	Wet Season	P value	Dry Season	Wet Season	P value	Dry Season	Wet Season	P value
2006	67	142		592	630		251	388	
2007	122	160		585	714		263	402	
2008	138	169	0.017	610	905	0.179	226	339	0.021
2009	85	140		829	815		286	394	
2010	70	120		751	805		412	472	

The obtained results, observing the significance data, P value, are consensual with the previous showed trends (Figure 9 to 11), were the number of cases and the amount of precipitation were compared.

After this statistical analysis, we are able to ascertain the significant ($p < 0.05$) differences between the number of GID cases in dry season and in the wet season, being numbers higher in the latter. The same was valid for Others ($p < 0.05$). In what reported malaria cases are concerned, no significant relation between the two different seasons is found ($p > 0.05$).

DISCUSSION

Guinea-Bissau is a small country located in sub-Saharan Africa (Figure 1), a region particularly vulnerable to climate changes. The Sahel, the biogeographic zone of transition in Africa, is progressing towards the south. The precipitation decreases, many wells that serve the families dry earlier, and the population increases (Bordalo, 2014).

Situations of political and institutional instability are permanent as the use of violence in repeated coups and armed conflicts. There are few indicators on mortality and general and specific morbidities that may allow a good description and characterization of the health status of the Guinean population. The Vital Statistics System does not work and there is no compulsory registration of deaths. Most illness and death events pass outside health care structures because of their low utilization (MSP, 2008).

The overall efficiency of the health system of Guinea-Bissau among the 191 WHO member states, ranks 176 (Tandon, Murray, Lauer, & Evans, 2000), demonstrating the fragility of the system and the dire need of improving the welfare of the people. Achieving universal health care coverage by 2030 is the UN Global goal 3, will require substantial increase in health spending (Russo, 2017), but in the country, the health sector represents just 5.6% of GDP, and 8% of the public spending (World Bank, 2016).

The shortage of human resources for health, leads to the systematic use of community health workers as the basis for health programs and services (Lopes et al., 2014), replacing around the country the lack of health professionals (nurses, doctors). Moreover, the chronic low motivation of health sector workers, due to inadequate equipment and frequent delays in the payment of remunerations that are already low, lead to multiple employment and illegal collection. There are no management tools, in what human resources in health are concerned. The health professions are not standardized with no implemented careers, and in need of updating. Also, there is a lack of capacity to maintain formative supervision (Guerreiro et al., 2017). No structure providing care or management has the minimum staff required for its operation (WHO, 2013). All this instability associated with chronic delays in the payment of salaries leads, to regular strikes by health workers (Silva et al., 2007).

Looking to health indicators, in MICS 5 report (MICS 5, 2014), Guinea-Bissau has a gross birth rate of 38.5 per 1,000 births. The infant mortality (<1 year) rate is 55 per 1,000. This value increases up to 89 per 1,000 in children under the age of 5. The total mortality rate is about 54.2 per 1,000. Moreover, the mortality rate for women is higher with 55.6 per 1,000 although for men is about 52.7 per 1,000 (Estatística, 2015).

In the country, the main diseases that affect the population are malaria, diarrhea, respiratory diseases, tuberculosis, sexually transmitted diseases, including HIV / AIDS, intestinal parasites, onchocerciasis, and other endemic diseases (da Silva Bessa, 2006). These data are also confirmed by the Plano Nacional de Desenvolvimento Sanitário II, were malaria is pointed as the major cause of health problems in children <5, pregnant women, and new-born babies, but also in adolescents and in adults. Diarrhea came as the 3rd cause of morbidity and mortality for children <5, not appearing in the other age groups. The 2nd cause for children <5 are respiratory diseases (MSP, 2008).

Malaria and waterborne or water related diseases were selected for this study because Guinea-Bissau faces a critical problem concerning potable water access (Bordalo & Savva-Bordalo, 2007). The health data were supplied by the Bolama regional hospital. However, it was clear that the quality of collected data in those dilapidated facilities is rudimentary (Figure 6), because of poor infrastructure, including the absence of electricity, to support routine case reporting data, therefore very susceptible to the skills of the person in charge. In the case of Bolama and during the surveyed period (2006 – 2010), medical care was provided by an expatriated medical doctor, but not on a permanent basis, affecting the quality of diagnosis. Another important fact is that the malaria diagnosis is not a straightforward process, being more difficult to assess when lab confirmation seldom exists, whilst the gastrointestinal diseases is more evident. These facts together could explain the lack of relation observed between malaria peaks and the precipitation, but in 2007 and 2008, when expatriate doctors were in charge of most appointments at the hospital and malaria kits were also available, provided by a Portuguese medical NGO. Furthermore, in those years malaria peaks and the maximum precipitation coincided on a monthly basis, as expected (Figure 9).

In neighboring countries of the sub-region, malaria is also a problem owing of its endemic behavior. According to the most recent World Malaria Report (WHO, 2017b),

in countries such as Gambia and Sierra Leone the number of cases reached 60% in Senegal, approximately 25% in Mali, and 20% in Guinea-Conakry.

In Guinea-Bissau alone, and according to the same WHO report, in 2010 there were 1,555,869 people at risk to contract malaria in Guinea-Bissau, when 195,006 cases were identified and 296 deaths were reported. These numbers have been increasing (WHO, 2018) being the principal agent *Plasmodium falciparum* (Ursing et al, 2014), and *Anopheles gambiae* the dominant malaria vector of Sub-Saharan Africa (Oliveira et al., 2008; Sinka et al., 2010). It is known that a relationship between malaria and the cultivation of rice exists (Diuk-Wasser et al., 2007). Indeed, rice is largely cultivated in Guinea-Bissau – being the staple food. The preparation of the fields occurs in May and June, with the first rains and right after the end of the cashew nut harvest, with a strong contact with inundated lands, and therefore, arises the doubt about the influence of this activity in the outcome of malaria.

Due to the extreme poverty situation of the population, living with only 80 centimes of euro per day (Bordalo, 2014), it is pertinent to consider other paths to improve population health, since the State is unable to fulfill its commitment and western farmaceutical products may not be always available in hospitals and health centers (Diniz et al., 1996). The integration of traditional plant-derived medicine with the western approach could play an important role in primary health care. Actually, in our days, the state controlled health system relies entirely in the approach dictated by the Bamako Initiative that advocates the cost recovery, i.e. all procedures from appointments to suture thread and medicines need to be paid, leaving a substantial part of the population without access to health care due to unbearable cost. In a recent report (Diniz et al., 2000), a list of 150 plants with medical values with complementary ethnopharmacological information was compiled, and later on (Gomes et al., 2006), published a comprehensive guide of medical plants, that are abundant in the tropical Guinea-Bissau.

In the case of malaria, the treatment policy in the country was changed in 2006 to artemether-lumefantrine as the first-line treatment of uncomplicated malaria (Silva et al., 2007), and the use of the traditional plant derived medicines is not encouraged within the health sector. For example, neem extract of *Azadirachta indica*, a tree commonly found in Guinea-Bissau is a powerful natural insecticide that can be applied

directly on the human skin or to impregnate bed nets (Kumar & Navaratnam, 2013), instead of the synthetic and highly toxic foreign brands. The locally produced liquid extract is available in 10 ml glass flasks, sold essentially to the few tourists that visit the country. Also, traditional plant-based fumigants, such as lemon grass (*Cymbopogon citratus*), is available and used to be widspread in the country, particularly among the Fulani ethnic group (Moore et al. 2007).

In what gastro enteric ailments are concerned, traditional healers use different plants, such as *Terminalia macroptera* and *Cryptolepis sanguinolenta* (Diniz et Paulo 1996), commonly found in the country, owing to its antimicrobial properties, whereas in the health system the western medicines are used, if available, a tangible source of contamnation of the water for domestic use (Machado & Bordalo 2014). This study revealed, a clear relation between the largest GID peak and the on set of the rainy season. Has referred before, the uncomplicatedness of the diagnosis could have helped the quality of the data. Closely linked with poverty, poor sanitation facilities, lack of good quality water, and illiteracy, verified in Bolama and all over Guinea-Bissau, is the constructed scenario with what population has to deal in daily basis. Despite being realized great efforts to teach population the basic sanitary procedures, particularly by different NGOs and religious groups that operate locally, such as washing hands properly, the yield is doubtful since water or clean water may not be available at all. The consequences are, therefore, catastrophic, when that same inappropriate water is used to drink or prepare meals, as showed in the collected data. It is imperative to provide access to safe water to people in Guinea-Bissau, and adequate investments, to keep latrines away from wells, the rehabilitation of the water network (Bordalo & Savva-Bordalo, 2007).

CONCLUSIONS AND RECOMMENDATIONS

1. The very high number of malaria cases and the rather noticeable seasonality, at least during certain years, implies that the UNICEF/WHO recommendations, namely the use of nets are not enforced in Guinea-Bissau, in spite of periodic campaigns and free distribution to pregnant women during appointments at hospitals and health care centers may occur. Although the use of nets is not a universal solution, the use could reduce the level of infection.
2. A better malaria screening is a must. The irregularity of data are probably linked to the fact that most diagnostics are empiric, not followed by actual analysis (rapid kits, thick drop smear), due to the chronic lack of supplies at the regional hospital, and the total absence of lab facilities at the island health centers. The indiscriminate use of antimalarial drugs (Artemisinin) coupled whith prescription of antibiotics e.g. Ampicilin, Amoxicillin + Clavulanic acid, Gentamicin, reduce the efficience due to resistence. During the wet season, the unpaved streets of Bolama are flooded and pools of water may stay for weeks at a given place, a fertile ground for *Anopheles*, the carrier of plasmodium, to bread and exposing the island population to the risk of malaria
3. Recover the use of traditional insecticides e.g. lemon grass: *Cymbopogon citratus* or the abundant neem trees (*Azadirachta indica*) could be a step forward for the control of malaria spread, since most of the population can not afford the purchase of imported insecticide sprays, avaiable in local markets.
4. Gastroenteric diseases followed a clear seasonal pattern, since numbers peaked at the on-set of the wet season i.e. May to June, wen the first rains occured, immediately after the driest and hotest month of April. The aquiferes are at the lowest levels and rain water percolation from the surface as well as seapage, eventually move surface fecal contamination from animals and humans towards to water table that feeds the wells, wich supplys water for domestic use. The agents are, probably, patogenic bacteria. A second smaller peack occurred during the coldest period of the year coinciding whith the increase of respiratory events (data not shown), being supected of viral origin.
5. Without the improvement of the water suplies leading to the use of potable water, the situation tends to worse due to climate change.

6. The health status of the population of Bolama and, to a great extend of Guinea-Bissau, will not improve if the above mentioned issues are not solved in a universal way. Moreover, most funds are provided by international donners in a non integrated fashion, and eventually mismanaged due to poor governance and corruption, wich further difficults the efficiency of its application to the target population.
7. Finally, the permanent political and military instability and the present suspension of funds to the governament by leading international donners (World Bank, International Monetary Fund, EU), is another factor that increases the burden of daily life in Guinea-Bissau.

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