Disease Burden on a Riverine Population Dependent on a Peri-urban River: Insights from Hospitalization Data in Akonolinga, Cameroon

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Abstract Pristine or near-pristine freshwater rivers provide numerous ecosystem services to riverine communities. Yet they could be a significant public health threat due to contamination and pollution. This study assessed the disease burden among the population of Akonolinga, on the banks of River Nyong in Cameroon. Semi-structured questionnaires were administered to ten medical facilities within the town. Hospitalization and laboratory diagnosis logs for the year 2020 were reviewed. Results showed that $44.4 \pm 1.15\%$ of the respondents had recurrent foodborne diseases between 1 to 10 times a year, and there was strong positive correlation between the rate of foodborne diseases and that of waterborne diseases (rho = 0.881, p = 0.002). Foodborne disease cases were highest during the dry season ($66.67 \pm 1.73\%$). Malaria was most prevalent (27.8%) but statistically similar to prevalence of typhoid (22.2%) and diarrhea (22.2%). Bacteria were the major causative agent of diseases, dominated by members of *Salmonella* (30.3%), *Pseudomonas* (21.2%) and *Escherichia* (21.2%). The prevalence of *Salmonella* was statistically higher than that of *Trichomonas*, *Shigella*, *Amoeba* and *Staphylococcus*. These results are suggestive of a contaminated environment, poor hygiene etc. which would necessitate behavioural change within the population for better management.

Keywords: disease burden, bacteria, food poisoning, waterborne diseases, riverine population

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1. Introduction

Freshwater rivers are essential to life and livelihoods of riverine populations. They provide numerous ecosystem services and resources such as water for domestic use, bathing, laundry and recreation, fishing and other aquatic resources [1], sand mining [2], bait collection etc. These services are especially pre-eminent when the river is in pristine or near-pristine condition. In this state, the river has the potential to contribute maximally to rural/urban livelihoods and the economy as a whole.

However, most rivers in developing countries meandering through several urban and peri-urban areas are susceptible to effluent discharges of various forms [3], refuse dumping [4], defecation, riparian vegetation destruction and sedimentation which results in stagnant water ponds along the river course, among other degrading influences.

When this happens the ecosystem services and resource potential is degraded. Concomitantly, the river could become a public health threat if effluent and other discharges contain pathogens and other toxicants as is often the case [5]. Sedimentation and stagnation of water results in breeding grounds for the Anopheles mosquito, the vector of the malaria parasites which cause the disease of highest health significance in the tropics.

A first glimpse into the public health threat posed by such degraded rivers is usually through surveys of residents' perceptions. For a clearer picture, a study of hospitalization records and laboratory diagnostics logs is necessary. The River Nyong is an important river in the South Region of Cameroon, meandering through both rural and urban areas. As such it is susceptible to pollution and contamination with various effluents and contaminants, although studies on this river system are rare. Inhabitants of Akonolinga, a major town along its banks, depend on its waters and resources for various

services, without a clear understanding of its public health significance. Nkemyi et al. [27] have studied perceptions of the population of Akonolinga on the health safety of using the River Nyong and its resources, and shown that there is a general perception that using the river and its resources exposes them to various waterborne and foodborne diseases. Yet as Bisholo et al. [6] reported, perceptions of populations on causes of diseases and disease burden are sometimes inconsistent with hospitalization data.

The aim of this study therefore was to assess the disease burden among the population of Akonolinga from hospitalization and laboratory diagnosis data. This study is significant in that it provides insights into effective disease loads among a riverine population dependent on the pre-eminent River Nyong in Cameroon.

2. Materials and Methods

2.1. Study Site

This study was carried out in Akonolinga, the divisional headquarters of the Nyong-et-Mfoumou Division, Centre Region of Cameroon. Akonolinga has a population of roughly 21300 inhabitants [7] and lies along the banks of the River Nyong, the second largest river in Cameroon, with a drainage basin of 27800 km^2 (Figure 1). The vegetation cover in the entire watershed is dominated by semi-deciduous forests and cropland. Being a riverine town, fishing is a mainstay of the economy, in addition to agriculture, services and commerce. Therefore the population depends directly or indirectly on the River Nyong and the ecosystem services it provides. Within the town of Akonolinga, there are ten medical centres comprising one district hospital, one mission hospital, five health centres, and three private clinics with laboratory facilities that attend to the health needs of the community. The District Hospital is a government facility designed to serve the needs of a municipality. It is one level above a health Centre. The health centres are community-level health facilities mainly equipped for first-level intervention, with more challenging cases referred to the District Hospital. The Mission Hospital has the level of sophistication similar to the District hospital, but is owned by a religious organization. Private clinics could have different levels of sophistication based on the owners' resources. In the case under study, they were of the same rank or slightly inferior to the government health centres. This classification follows the standard for the Ministry of Public Health in Cameroon. For ethical reasons, the facilities are not named in this study. All facilities carry out consultation and laboratory diagnosis to various levels. According to the Krejcie and Morgan [8] table, all ten health units comprised the sample (for N = 10, s = 10), and so all were included in the survey.
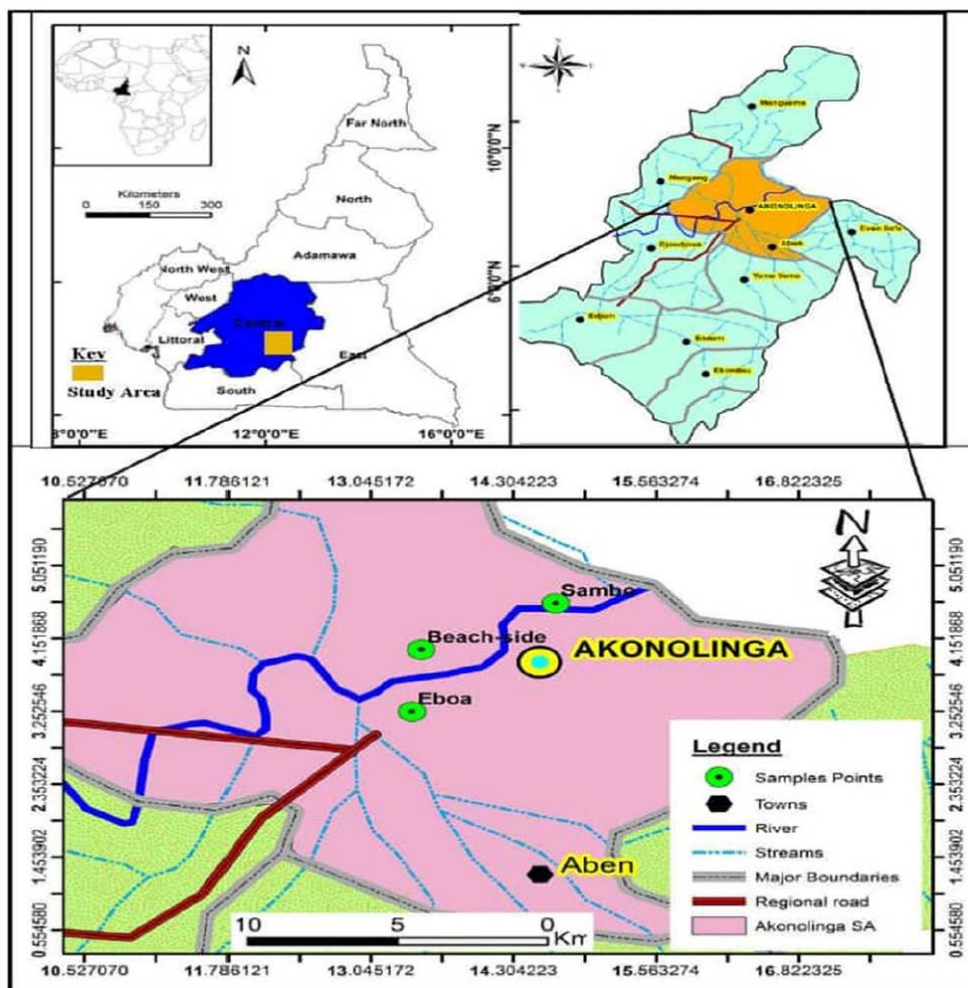

Figure 1. Map of Akonolinga showing its location beside the River Nyong, Cameroon

2.2. Study Design and Methods

This study was hospital-based and a mixed methods research approach was applied. Prior to this study, Ethical Clearance was obtained from the Institutional Animal Care and Use Committee (UBIACUC) of the University of Buea, Cameroon. Semi structured questionnaires were administered to the different hospitals in the study site, one per hospital, following piloting and validation. The questionnaire was administered in person to the senior medical doctors or nurses in each facility, and it covered aspects related to the disease burden within the community; most frequently reported disease symptoms, most frequently diagnosed diseases etc. This was followed up with a desktop study of laboratory diagnosis results for the year 2020, with records provided by the laboratory scientist under instruction of their management. In this phase of the study, the most frequent pathogens identified were recorded. For this desktop research phase, data were recorded as per cases reported, not per patient. Therefore re-infected patients were recorded as independent or new cases, since the intention was to identify infection levels and disease burden for the period under study. It was also difficult to separate relapsing cases once new laboratory tests were ordered and done, and these could have been included in the sample. Data collected were coded into SPSS Version 21 Statistical package and analysed for patterns and trends. Descriptive statistical analyses were done on prevalence data, following which Kruskal-Wallis non parametric ANOVA was done to test if observed differences in frequencies and incidence were actually significant. Chi Square test of association and Spearman Rank Correlation analysis was done to determine relationships between parameters for instance between the rate of food poisoning and the rate of waterborne diseases. Where necessary, significance was taken at $\alpha = 0.05$.

3. Results

3.1. Initial Perspectives of Hospital Management on the Disease Burden in Akonolinga, Cameroon

The initial clinical assessment of the medical centres on major aspects of disease burden within the population of Akonolinga is presented on Table 1. All centres reported that cases of food poisoning are recorded in the hospitals (100%). Moreover, waterborne diseases are also routinely recorded (100%), and it is normal to identify bacteria in clinical samples lifted from patients reporting with these symptoms (100%).

Table 1. Initial clinical assessment of respondents from medical centres in Akonolinga, Cameroon on the health burden within the population

Initial clinical assessment	Frequency (%)	Sample size (n)
More than one disease prevalent	100	10
Food poisoning	100	10
Waterborne diseases	100	10
Bacteria as causative agents	100	10

3.2. Actual Disease Burden of the Population Living along the Banks of the River Nyong at Akonolinga

In 10 medical centres located within the study site, the rate of food poisoning recorded among patients is presented on Figure 2. Most ($44.44 \pm 1.15\%$) of the medical facilities recorded patients who present with the symptoms 1 to 10 times annually, followed by $33.33 \pm 1.15\%$ that reported patients presenting with food poisoning symptoms 11 to 20 times a year. The pattern is similar for the rate of waterborne diseases (Data not shown). Spearman Rank Correlation analyses results showed that within the hospitals, there was a strong positive correlation ($\rho = 0.881$, $p = 0.002$) between the rate of food poisoning and the rate of waterborne disease cases reported to the hospitals.

3.3. Seasonal Variation in the Rate of Foodborne Diseases Reported in Hospitals

Figure 3 shows the seasonal variation in the rate of foodborne diseases reported to hospitals. A majority of hospitals ($66.7 \pm 1.73\%$) reported that foodborne diseases are most common in the Dry season, while $22.2 \pm 0.58\%$ reported that they see patients with foodborne diseases symptoms mainly in the rainy season. Some ($11.11 \pm 1.15\%$) medical centres do not see any seasonal effect on the reported cases of foodborne diseases (Figure 3).

3.4. Distribution of Major Diseases Recorded in Medical Facilities in Akonolinga, Cameroon

Distribution of diseases registered in the health units are presented on Figure 4. Among the diseases most recorded in hospitals are malaria (27.8%), diarrhoea (22.2%), typhoid (22.2%) and amoebic dysentery (8.3%). Other diseases reported in lower frequencies include gastritis, sexually transmitted infections etc. In this riverine community exposed to water and fish from the River Nyong, amoebic dysentery, diarrhoea and typhoid are important diseases. Together these make up 72.2% of all cases reported in the 10 medical centres within the study site.

Results of Kruskal-Wallis non parametric ANOVA comparing the prevalence of the different diseases reported in the 10 medical centres are presented on Table 2. Malaria prevalence which is the highest (27.8%) differs significantly from most of the other diseases with lower prevalence rates; of the three diseases indicative of risk factors of exposure to the River Nyong, the prevalence of malaria differs significantly from that of amoebic dysentery ($p = 0.0013$) but was statistically similar to prevalence of typhoid and diarrhoea. The prevalence of both diarrhoea and typhoid differ significantly from that of pneumonia, intestinal parasites and sexually transmitted infections (STIs) ($p = 0.0013$ in all cases).
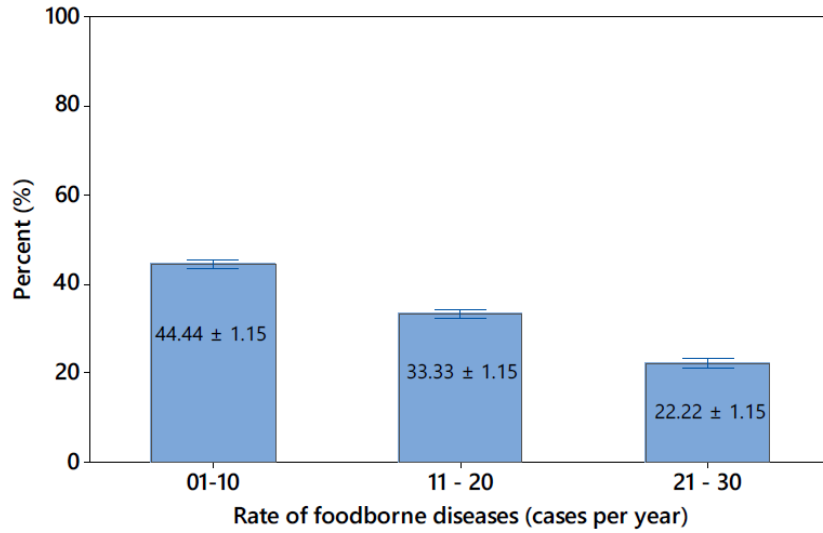
Figure 2. Rate of foodborne diseases recorded in 10 medical centres in the study site (Bars represent means ± standard error)
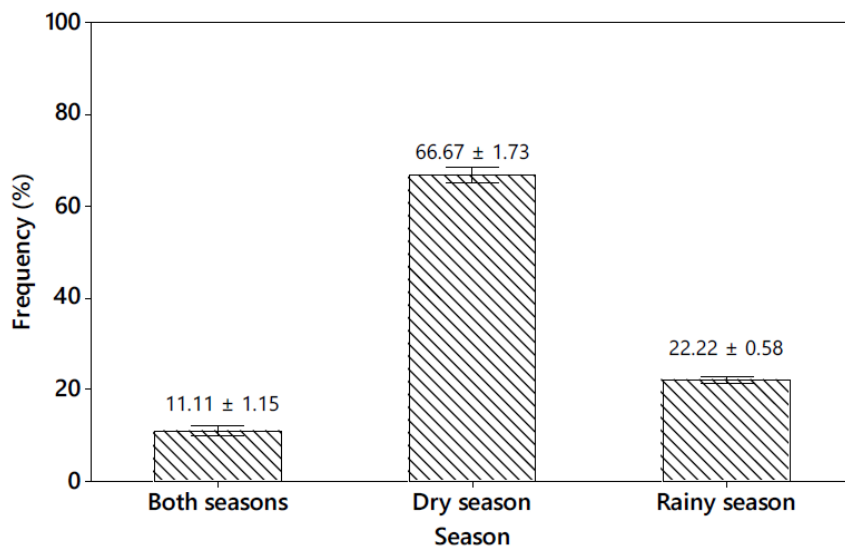
Figure 3. Seasonal variation in foodborne disease cases reported to hospitals in Akonolinga, Cameroon (Bars represent means ± standard error)
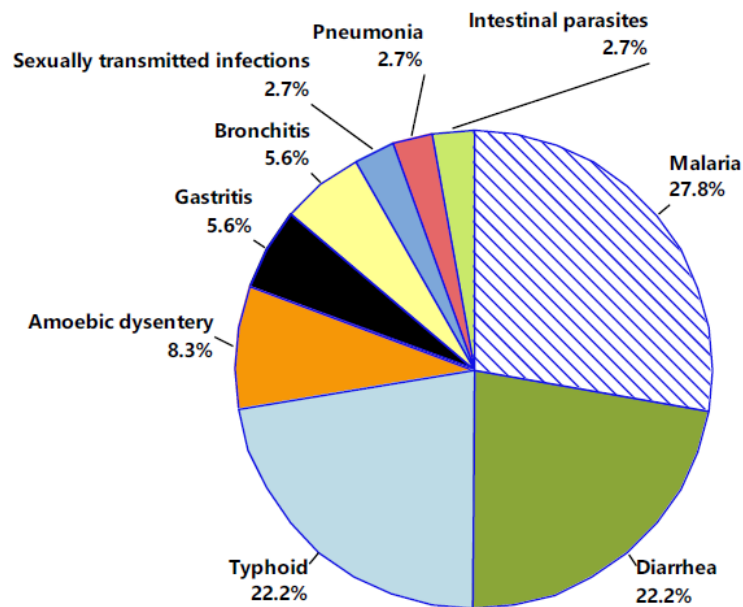
Figure 4. Diseases recorded among the population in hospitals within the study site

Table 2. Kruskal-Wallis test results on the prevalence of the major diseases reported in 10 medical centres within the study site

H = 32.16	DF = 10	P = 0.000
H = 45.85	DF = 10	P = 0.000 (adjusted for ties)

Groups	Z vs. Critical value	P-value
Malaria vs. Pneumonia	4.14305 >= 2.908	0.0000
Malaria vs. Intestinal parasites	4.14305 >= 2.908	0.0000
Malaria vs. STIs	4.14305 >= 2.908	0.0000
Malaria vs. Gastritis	3.68271 >= 2.908	0.0002
Malaria vs. Bronchitis	3.68271 >= 2.908	0.0002
Malaria vs. Amoebic dysentry	3.22238 >= 2.908	0.0013
Diarrhoea vs. Pneumonia	3.22238 >= 2.908	0.0013
Diarrhoea vs. Intestinal parasites	3.22238 >= 2.908	0.0013
Diarrhoea vs. STIs	3.22238 >= 2.908	0.0013
Typhoid vs. Pneumonia	3.22238 >= 2.908	0.0013
Typhoid vs. Intestinal parasites	3.22238 >= 2.908	0.0013
Typhoid vs. STIs	3.22238 >= 2.908	0.0013

STI = Sexually transmitted infections.

3.5. Prevalence of Causative Agents of Diseases Reported in the Study Sites

In all medical centres in Akonolinga, bacteria were identified as the major causative agents of diseases diagnosed in the different laboratories. Analysis of laboratory diagnosis records revealed that the following bacteria genera were predominant: *Staphylococus, Salmonella, Shigella, Escherichia and Pseudomonas.* Other non-bacterial causative agents include *Trichomonas* and *Amoeba*. Figure 5 shows the relative abundances of the different genera based on records of laboratory diagnosis in the different hospitals. The most prevalent causative agents are bacteria of the genera *Salmonella* (33.3%) followed by *Pseudomonas* and *Escherichia* (21.2% each). The least frequent causative agents are the genera *Amoeba* (non-bacterial parasite) and *Shigella* (6.1% each). Results of Kruskal-Wallis non-parametric ANOVA on the incidence of the different genera are presented on Table 3. The incidence of *Salmonella* in clinical samples analysed in the different hospitals differs significantly from that of *Trichomonas* (parasite), *Amoeba* (parasite), *Shigella* and *Staphylococcus* ($p < 0.05$ in all cases). The incidence of *Salmonella* is statistically similar to that of *Escherichia* and *Pseudomonas*, whose incidence are statistically different from that of *Trichomonas* ($p = 0.0076$ in both cases).
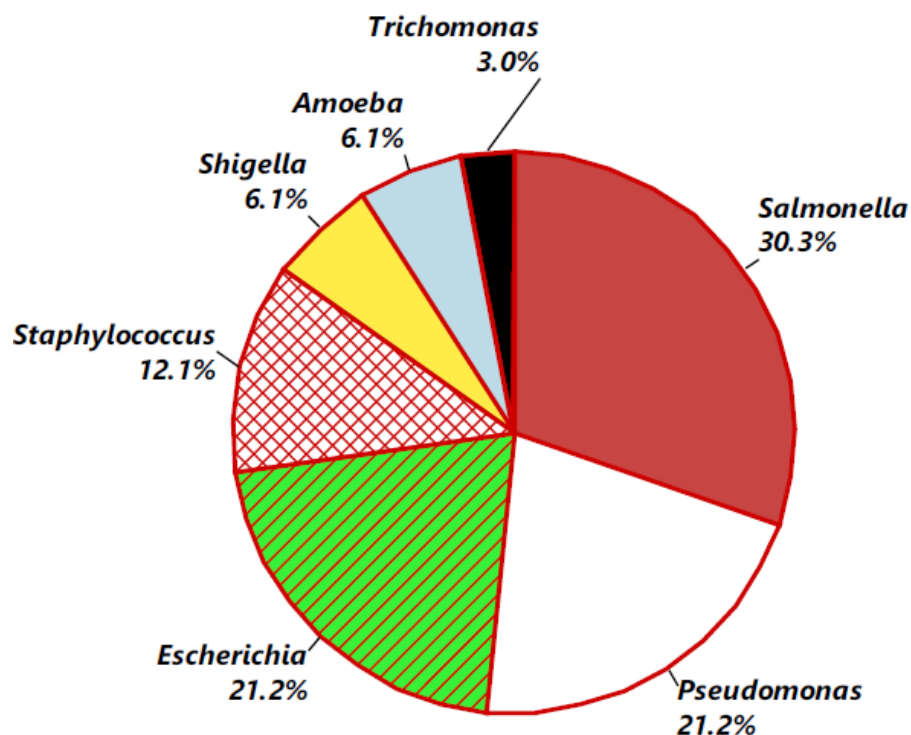

Figure 5. Distribution of genera of causative agents (bacterial and non-bacterial) diagnosed in hospitals within the study site

Table 3. Results of Kruskal-Wallis test comparing the medians of incidence for the different genera of causative agents in the study sites

H = 19.94	DF = 6	P = 0.003
H = 26.67	DF = 6	P = 0.000 (adjusted for ties)

The following groups showed significant differences (adjusted for ties)

Groups	Z vs. Critical value	P-value
Salmonella vs. *Trichomonas*	4.00261 >= 2.593	0.0001
Salmonella vs. *Shigella*	3.55788 >= 2.593	0.0004
Salmonella vs. *Amoeba*	3.55788 >= 2.593	0.0004
Staphylococcus vs. *Salmonella*	2.66841 >= 2.593	0.0076
Trichomonas vs. *Pseudomonas*	2.66841 >= 2.593	0.0076
Trichomonas vs. *Escherichia*	2.66841 >= 2.593	0.0076

4. Discussion

Water related diseases have been broadly defined as those diseases that occur as a result of exposure to water, water-related pathogens, toxic substances, water shortage or contamination during adverse events, as well as to vectors with a part of their lifecycle in water [9]. They have thus been classified as water washed, water borne, water based or insect vector related based on the route of entry into the human body. Water washed diseases (Scabies, Typhus, Yaws, Relapsing fever, Impetigo, Trachoma, Conjunctivitis and Skin ulcers) are those that occur as a result of freshwater scarcity and are transmitted by contact with poor quality water and the route of contamination is usually cutaneous; waterborne diseases are transmitted orally by ingestion of water contaminated by pathogens, and their symptoms are usually diarrheal in nature. Water-based diseases such as Schistosomiasis are caused by parasitic organisms released by aquatic host organisms [10]. On the other hand, foodborne diseases are caused by ingestion of food contaminated with bacterial, fungi, viral pathogens or toxins and contamination can occur anywhere along the production, processing and consumption chain. According to Nwabor et al. [9] food borne diseases can occur when contaminated water is used for preparing food.

Within our study site, foodborne and waterborne diseases were prevalent among patients' initial complaints presented to hospital staff. This is probably because of diarrheal symptoms experienced by patients, their understanding of recent activities/behaviours/risk factors and perhaps points to the subconscious perception within the population that exposure to the waters of the River Nyong could be hazardous to health [27]. The River Nyong flows through several urban and peri urban areas where it is exposed to effluents from various uses. Therefore it is possible that along its route, contamination with various pathogens or toxicants occurs, especially in the more urbanized areas, consistent with findings by Iqbal et al. [11] on the Gomti River in India. These pathogens/contaminants in turn cause diseases to humans using the river either for bathing, fishing, sand mining, agriculture or simply for recreation. This is consistent with findings by Alves et al. [12] on the Capibaribe River in Brazil. Yang et al. [13] have reported that socio-environmental factors such as population density, surface water temperature, water surface area and the rate of rainfall are significantly correlated with prevalence of waterborne diseases. Unavailability of pipe borne water and dependence of rural communities on surface water often contaminated with faecal matter, poor hygiene and lack of sanitation infrastructure have also been reported as the key contributors to rising prevalence of water and foodborne diseases [14]. In the current study, although Akonolinga is supplied with pipe borne water, there is still dependence on River Nyong for other activities and resources, which increases exposure and contamination risk.

To date, Africa bears the highest burden of food poisoning and food-borne diseases in the world. According to Bisholo et al. [6] there is a 27.3% prevalence of food borne diseases in the Eastern Cape of South Africa reported by patients but which is inconsistent with hospital admission records. Our findings reveal that a majority of patients are treated for food poisoning and waterborne diseases to the exclusion of water based diseases between 1 and 10 times yearly. This leaves a significant proportion that are affected more than 10 times yearly. This is a very high rate of recurrence of the diseases, suggesting that the causes are ubiquitous within the population. These are directly related to the drinking water, sanitation and hygiene situation within the communities and as reported by Ruiz-Diaz et al. [15]; level of education, socio-economic status and the water supply situation are essential contributing factors. The population of Akonolinga is highly dependent on the River Nyong for various uses, and although there is significant coverage of the town with pipeborne water, the influence of the River Nyong is still pervasive through consumption of fish and other aquatic life, recreation, sand mining, laundry etc., such that water- and food borne diseases risk becoming endemic in the area.

There is a strong seasonal effect in the distribution of foodborne and waterborne diseases in the study site, with a majority of the hospitals reporting that these diseases are most prevalent in the dry season. The dry season is characterised by decreased rainfall and low levels of water in the reservoirs even for the pipeborne system. Therefore there are behaviour changes associated with water use, for instance a tendency towards economising water, and switch to more risky water sources for domestic use [16] and these behaviour changes can lead to contamination and diseases in humans. As reported by Akinyemi et al. [17] in a study in South West Nigeria, the dry season is associated with very high water insecurity scores, and this in turn has a strong association with diarrheal diseases among the population. Our results are consistent with these findings.

Detailed analysis of hospitalization data shows that malaria remains the major disease in the area. According to the Severe Malaria Observatory, Malaria is the leading endemic disease in Cameroon with approximately 30% prevalence and spread across all the ten regions of the country, with the South Region in which this study was carried out being one of those with majority of Health Districts classified as Very High and High risk. Antonio-Nkonjio et al. [18] reviewed the malaria situation in Cameroon and showed that prevalence dropped from 41% in 2000 to 24% in 2017. Our findings in the current study showed a malaria prevalence rate of 27.8% in Akonolinga. This prevalence rate is based on laboratory diagnosis results, and strikingly similar to those of Antonio-Nkonjio et al. [18] although Nyasa et al. [19] reported much lower prevalence in a forest community in South West Cameroon with high levels of adoption of preventive measures. Perhaps more striking is the fact that diseases such as typhoid and diarrhoea are statistically as dominant as malaria in the study site. In the current study, prevalence of typhoid and diarrhea (22.2% each) are much lower than the 30% prevalence of typhoid nationally reported by Njoya et al. [20]. However, this is still relatively high and combined, would outpace malaria prevalence in the area. Typhoid is caused by *Salmonella typhi* and could result in diarrheal symptoms; several other bacteria could cause diarrhea in humans. These are waterborne or food borne diseases and the route of contamination is usually oral, through ingestion of contaminated water or food. In an area with high dependence on the River Nyong for various uses, it is not surprising that contamination of the water could cause high disease incidence, and these could become locally endemic. The population of Akonolinga is exposed to the main risk factors for infection with waterborne and foodborne diseases; poor waste disposal systems, poor/unknown drinking water sources, being under direct and indirect influence of the River Nyong that meanders through several urban areas and is exposed to lots of effluent discharges along its course etc. As reported by Fondongbeza et al. [21] for the Bonasama Health District in Douala, Cameroon, those exposed to these risk factors would have a higher risk of contracting these disease.

Our study of laboratory logs revealed that to the exclusion of the malaria parasite, bacteria are the greatest causative agents of diseases diagnosed, with *Salmonella*, *Pseudomonas* and *Escherichia* being the dominant genera. Members of the *Salmonella* genus are responsible for various forms of salmonellosis, some of which are characterised by diarrhea; some varieties cause typhoid fever which is a more severe disease and all are either foodborne or waterborne [20]. In most cases, typhoid fever is diagnosed as co-occurring with malaria, with which they have similar signs and symptoms [22]. Members of the genus *Pseudomonas* such as *P. aeroginosa* are ubiquitous in the environment and can cause a wide range of diseases including gastrointestinal infections and are a leading cause of septicaemia in humans [23]. *Escherichia coli* is an enteric bacteria and an indicator of faecal contamination of water sources [24,25]. Strains of *E. coli* are the most frequent causative agent of acute diarrhea [26].

These diseases are all linked to behavioural patterns associated to water and food use among the communities. In consequence, we can safely assert that the population of Akonolinga suffers a heavy disease burden caused by behavioural patterns associated with use of the River Nyong, and therefore requiring behavioural change among the population for better disease control and management.

5. Conclusion

Malaria, waterborne- and foodborne diseases are among the heaviest disease burden in the riverine community of Akonolinga, Cameroon. Predominant bacteria genera isolated in laboratories in hospitals at the study site include *Salmonella, Pseudomonas* and *Escherichia* as the main causative agents. This would explain the high levels of hospital consultations for waterborne and foodborne diseases in the study site. It is recommended to the government of Cameroon and other countries in similar situations that greater sensitization of the population is necessary to reduce anthropogenic water contamination. Also, better food and water handling such that risks of exposure are minimised, would go a long way towards minimizing the disease burden among the population.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

Ethical Clearance

Ethical clearance was obtained from the Institutional Animal Care and Use committee (UBIACUC) of the University of Buea, Cameroon.

Author Contributions

All authors designed the study and agreed on the study design, Author ABN collected and analysed the data, and drafted the manuscript; All authors read, edited and approved the manuscript.

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