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The Characterisation of Vulnerability to cholera outbreak amongst slum-dwelling populations from a WASH Perspective: The Case of city of Yaounde in Cameroon

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ABSTRACT
Cholera is a major public health concern. Outbreaks are associated to poor access to water, sanitation, and hygiene (WASH) knowledge and practices. In addition, the outbreak of the disease is linked to overcrowding and movement of infected persons from points of contamination to others. Areas that were non-endemic are becoming a hotspot for the disease. For example, in the city of Yaounde in Cameroon cases were recorded in 2018 and many others in the last decade. This recurrence has been linked to the sprawling population without a corresponding improvement of access to basic services and needs including clean water, hygiene, and sanitation. This situation in Yaounde like many other cities in the country is compounded by the fact that the country in general is not making significant inroads towards localising SDG6 which seeks to "Ensure availability and sustainable management of water and sanitation for all". In this study statistical analysis of the data from a stratified sample of 210 households in 07 slum dwelling neighbourhoods in the city of Yaounde revealed that respondents were unaware and lacked adequate public health information related to cholera. 40, 96% were aware of 02 causes of cholera among the 05 major causes identified in the study. While most households were aware of potential spread of cholera through actions such as eating without washing hands, 50, 96 % were not aware of other threats including poor handling of their faecal waste and body fluids especially of suspected cases in the community. Furthermore, using computational analysis of scores from interviews of households on their knowledge and applicability of cholera-related hygiene and precaution measures, a global vulnerability index for the neighbourhoods was generated. The findings reveal that more than 88% of indices from the 7 seven neighbourhoods ranged between 2.5 and 4.5 above the 0-1.5 scale for low vulnerability. In addition, bacteriological analysis of the boreholes and open well water samples from the neighbourhoods revealed the presence of numerous faecal polluting bacteria above the 110UFC/100mL limit recommended by WHO. The combined bacteriological analysis and the vulnerability index indicate that the slum neighbourhoods of Yaounde were highly susceptible to cholera outbreaks. Based on these findings a cholera vulnerability map was drawn for the city of Yaounde. This was followed by some recommendations including a multi-stakeholder approach for engagement to contribute towards cholera outbreak preparedness and sustainable case management in the identified hotspots.
Keywords: cholera, SDG6 / WASH / vulnerability / fecal pollution / environmental health education

1. Introduction

1.1. Background

Despite a favourable hydrographic network and receiving a good amount of rainfall by many African countries along the equator, access to safe drinking water and water for other uses such sanitation and hygiene is challenging. The World Health Organisation estimates that worldwide, four billion cases of cholera and related diseases such as diarrhoea occurs, with 88% linked to unsafe drinking-water (WHO, 1996). This global institution further points out that the occurrence of cholera is enhanced by certain socio-environmental factors including the potential to access basic services including hygiene and sanitation. Some studies have shown this link between cholera outbreaks and poor water delivery and poor sanitation practices of population, mostly in overcrowded neighbourhoods (Guévart et *al*, 2006). In addition, in their research Legba et *al* (2017) equally showed this link between cholera occurrence and lack of clean water. However, they went further to demonstrate the rise of transmissions because of direct contact between healthy and infected persons. This was mostly in overcrowded milieus and in contexts where health facilities were poorly developed and maintained.

In Cameroon, cholera constitutes a major public health challenge since 1971(Djomassi et al. 2013). The national surveillance data indicate that the period from 2000 and 2012, were peak periods in the country. During this period, a total of 43474 cases of cholera with 1748 deaths were recorded, giving a case fatality rate of approximately 4.0% (Ngwa et al. 2016). Some outbreaks were recorded in 2014, 2015 and 2018.

Some researchers have asserted that rural and peri urban areas have been the most affected by cholera outbreaks (Ngwa et al. 2015, Munier et al. 2015). In the Central Africa sub region, some of the worst affected areas include the Northern regions of Cameroon and the areas around Lake Chad due to their poor access to basic services. The risk of spread of Cholera from these hotspots to other areas including cross-border spread remains high. This risk has been linked to increasing movement of the population fuelled by socio-political tensions and environmental challenges including climate change in these regions and its environs (Ateudjieu et. al.2019). Where these populations settled only compounds the challenges of access to basic services in these areas and the potential threat of cholera.

Access to water of good quality and quantity remains a major challenge in major cities in Sub Saharan Africa with ailing basic service delivery systems. The global SDG 6 calls for water and sanitation for (UNDP 2015). Achieving this goal by 2030 requires making strides in areas including addressing open defecation, improved sanitation practices in and out of the home for everyone. More so the attainment of other SDGs depends on the attainment of SDG due to the intricate links between this goal and the others. For example, attaining SDG6 has the potential to support achievement SDG 3 (Good Health and Wellbeing), Promote just, peaceful and inclusive societies (SDG 16), make cities and human settlements inclusive, safe resilient and sustainable (SDG 11) (Andersson et al. 2016). With focus on the health and wellbeing of communities, the absence of water in the right quality and quantity results in communities resorting to contaminated sources. This has a significant implication on their health as water related diseases cannot easily be avoided in such circumstances (Mahvi 2007). The transmission of diseases in turn sets a ripple effect which touches on other sectors.

As earlier highlighted, much focus has been on rural areas as cholera hotspots due to the socio-economic status and environmental challenges that characterise these places. However, the challenge of limited access to basic services such as water, hygiene and sanitation infrastructure are not limited to rural areas. Some urban areas in Cameroon equally constitute cholera hotspots (Akoachere et al. 2013). For example, in the major cities of Yaounde (political capital) and Douala (economic capital) of Cameroon, from 2012 till date seem to demonstrate this (Ngang et al, 2015). The issue of poor accessibility to the basic services was glaring from this period and resulting in serious unrest especially in these two cities where a mix of the urban rich and poor live (Ngang et al, 2015). In Yaounde for example, only 35 percent of the population (estimated at 3million) is served by pipe-borne water (below the 300,000 cubic meters needed by each households). The rapidly growing population due to influx of people coupled with changing climate makes the situation in Yaounde more

challenging. With this sprawling population in the urban areas city-wide water connection and network requires rapid expansion. Unfortunately, the government and city councils cannot afford this (Yongsi 2010). Studies have indicated that as a result of the state failure to provide this basic resources and services, the population has resorted to alternative sources for water including unsafe, wells, boreholes and open streams (polluted with household waste including faecal matter and municipal waste) especially in the crowded and slum neighbourhoods (Cohen 2006, Yongsi 2010).

The findings of the Cameroon Multiple Indicators Cluster Survey 5 (MICS5) conducted in 2014 highlights the challenge highlighted above. The report indicated that 65.1% of Cameroonians did not have access to basic services such as improved latrines (MICS 2014). This situation is further compounded by the fact that the data about WASH and its links to spread of diseases particularly in slum neighbourhoods in Cameroon remains scanty. Thus, how to engage proactive actions to prevent occurrences and manage cases particularly in identified hotspots is equally a major challenge.

According to the WHO, an effective cholera control incorporates three important phases related to preparedness, response, and recovering (post-epidemic) phases. Even though these phases need to be given equal worth, the level of preparedness is the determinant for the success of the other two phases of a cholera outbreak control (WHO 1996, 2019). However, establishing a holistic preparedness mechanism is not straight forward. Cholera preparedness is multi-sectoral, multi-disciplinary and multi-scalar. Also, preparedness interventions are more focused on enhancing awareness, surveillance, training and improving WASH at community and at Health facility levels (Ateudjieu et al.2019).

I.2. Problem statement

Since the early 1970s, cholera outbreaks in Africa are rampant in two types of spaces which determines the management approach to be adopted. Firstly, there are cholera outbreaks that occur in refugee or internally displaced people (IDP) camps. Secondly, there are outbreaks that occur in open areas, also referred to as "open cholera". Irrespective of where it occurs cholera remains a public health issue of concern.

The management of cholera has been fairly documented by the WHO (Rigby & Stasinopoulos, 2005) and International Non-Governmental Organisations such as Doctors Without Borders (Venables & Ripley, 2002) with much focus on outbreaks in refugee or IDPs camps. Unlike refugee or IDPs camps, the management of cholera in "open settings" still poses enormous difficulties for actors on the ground. Decision makers and those working in the field have no possibility of anticipating the periods and places of epidemic recurrences and the major drivers of recurrences with certainty (Venables & Ripley, 2002).

Some cities in Cameroon have experienced recurrent episodes of open outbreaks and this has been for several reasons. Some of these include poor knowledge on WASH by populations, poor general knowledge on cholera, hygienic behaviours, and attitudes of populations towards infected person both at home and in health facilities. The Cameroon government's efforts on preparedness, response, and recovering (post-epidemic) phases have largely remained insufficient. Furthermore, the level of understanding of vulnerability levels by major decision makers including the Cameroon Ministry of Public Health, the heads of health facilities (public and private), district health services, regional delegation of public health, local councils and NGOs remains low. These issues identified vary from one community to another with glaring rural, urban and gender divides.

Studies to understand these challenges to better inform decision making especially in urban cities like Yaounde and Douala remains a challenge. These cities are attracting populations from other rural and less affluent cities and regions and neighbouring countries. The urban sprawl is not accompanied by a corresponding increase basic services such as water, and hygiene services. Although the cities of Yaounde and Douala remain major concerns with respect to cholera, Yaounde needs more attention. This is because although the Littoral

region has reported almost one third (29.6%) of all cases nationwide more frequent outbreaks have been recorded in Yaounde, with six outbreaks in the last decade (EU, UNICEF 2020).

While sporadic actions have been taken by health authorities towards this cases, the subnational and national cholera vulnerability mapping are not fully developed to enhance better responses. As a result, the preventive actions including the significant amount of resources (material, human and financial) deployed by the government of Cameroon through its National Response Plan against Cholera is not based on the levels of vulnerability of the different populations. The prevention measures contained in this Plan including vaccination surveillance, prepositioning of supplies for case management, training, coordination, operational research, resource mobilization and monitoring have proven to be effective where such efforts had been deployed. In addition, there measures have been short lived and thus only laying a solid foundation for episodic resurgences and the potential for cholera to become endemic while spreading beyond the current hotspots.

The shortcoming highlighted above could be address through the development of vulnerability maps at different scales. This will be a step towards enabling the government and its partners to better tailor their efforts where it is much needed. In addition, there is still a significant need to improve community knowledge on WASH and direct engagement with population to improve their understanding of the cholera and building community engagement towards curbing disease in sustainable ways.

The overall objective of this study is to identify and describe the vulnerabilities of population vis-à-vis cholera using a WASH perspective in targeted slum neighbourhoods of Yaou.de.

This study specifically seeks to accomplish the following:

- Evaluate the levels of understanding by populations of the common drivers of cholera outbreaks.
- Map the different levels of associated vulnerabilities
- Propose a sustainable environmental-health awareness and education plan
- To make recommendations for a multi-stakeholder approach for the implementation of such a plan as a contribution towards sustainably reducing the public health threat.

Importance of the study

This study has sustainable benefits at different areas as described below.

On the scientific level, the evaluation of the levels of vulnerability to cholera will provide a database for the establishment of an adequate and more effective plan of health and environmental education for the prevention of cholera infections.

On the economic level, vulnerability mapping allows targeted prevention actions to be carried out, thereby contributing to a reduction in the resources (human, material and financial) allocated to combat cholera by the state of Cameroon. The cost saving by the government and its partners will result in resources deployed to other important sectors needing attention.

On the educational level, this study will make it possible to better understand the communication vectors and routes of transmission of the disease amongst the population in the study area. Understanding the level awareness of the population will enable tailoring capacity building needs to bridge capacity gaps amongst the population in the study area. The success of this will support scaling up of capacity building events to other populations with similar contextual characteristics like the study area.

2. Methodology

2.1. Study setting

The study was conducted in 07 slump neighbourhoods (Nkolbisson, Etoa-Meki, Cite-Verte, Jouvence, Bonas, Essos, and Ekonou) identified in 07 Subdivisions that make up the City of Yaounde (see the map below).

Figure 1: Study sites (targeted slumps in Yaoundé city, Cameroon (Source: Authors)

Legend; Arrondissements=Subdivision; Quartiers cibles=target neighbourhoods

2.2 Materials

To carry out this study, primary and secondary data sources were used. For primary data collection, a questionnaire was designed for interviews, a digital camera to take photos, a Dictaphone to record exchanges and discussions during interviews. In Addition, a GPS to record geographic coordinates of survey locations and these datasets were analysed using EXCEL and SPSS software (statistics). Water samples were collected using glass boxes of 500ml each and those samples were analysed using a heating system, an incubator and bacteria growing milieu. Maps were developed using QGIS software.

2.3. Methods

A stratified sampling technique was designed and used to achieve representative estimates in target slum neighbourhoods in the seven Subdivisions of Yaounde. A total 210 structured interviews were conducted (210 households with 30 per Subdivision) and water samples collection from wells within these slump neighbourhoods. Statistical analysis focused on descriptive statistics, chi-square tests and Kruskal Wallis comparison test were used to analyse the data collected after verification. The «technique de la membrane filtrante» technic which consist of filtrating a volume of water through a sterile single membrane to obtain a bacteria cultivation milieu was done. This milieu was then heated and incubated to form bacteria colonies and the number of bacteria were counted in each colony to assess faecal pollution bacteria in water samples collected.

The vulnerability indices were computed according to the method used by the Action *Against Hunger* (or Action *Contre La Faim* (*ACF 2012*) in French). This method has been used extensively by the NGO for vulnerability assessment in cholera prone areas in Africa. The scale ranges from 0 (Very Low Vulnerability) to 5 (Extreme Vulnerability). Firstly, scores were attributed to the interviewees based on their knowledge and applicability of cholera-related hygiene and precaution measures.

The global vulnerability index for each slump was obtained by computing the average vulnerability index of all characteristics, considering the weight given to each characteristic. Using QGIS software the vulnerability indices for each neighbourhood was inputted on different maps. Based on the overall results we proposed a multi-stakeholder, awareness raising and sustainable education planning to reduce those vulnerabilities across the slums.

3. Results

3.1. Socio-economic situation of respondents

Table 1 and 2 below presents the socio-economic status (educational and income distribution respectively) of respondents stratified by slum neighbourhoods in the study area.

Table 1: Level of education of respondents stratified by neighbourhoods

Education level * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVl)	NKOLBISSON (YdéVll)	Total
Education level	Never attended school	9	7	4	4	6	3	3	36
	Some primary	4	7	6	1	3	9	5	35
	Completed primary	7	7	7	0	7	11	7	46
	Some secondary	0	6	4	14	1	3	6	34
	Completed secondary	4	0	3	5	9	2	4	27
	Reached University	6	3	6	6	4	2	5	32
Total		30	30	30	30	30	30	30	210

Table 2: Monthly Income Level of respondents stratified by neighbourhoods

Monthly income (FCFA) * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVl)	NKOLBISSON (YdéVll)	Total
Monthly income (FCFA)	Survival	12	10	13	10	13	11	12	81
	<50.000	11	9	7	4	8	10	9	58
	50.000-100.000	4	6	8	13	4	5	8	48
	>100.000	3	5	2	3	5	4	1	23
Total		30	30	30	30	30	30	30	210

Most respondents (38, 57%) live on incomes that below the basic minimum income and manage to survive daily; 17, 14% of respondents had never attended school. The chi-square test (p-value = 0, 00) showed that the education level varies significantly according to neighbourhoods.

3.2. General Knowledge on cholera amongst respondents in the surveyed neighbourhoods

Table 3: Knowledge of causes of cholera

Knowledge of causes of Cholera * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVI)	NKOLBISSON (YdéVII)	Total
Knowledge of causes of Cholera	Don't know	0	0	3	8	9	11	7	38
	01 cause known	7	0	10	7	1	3	9	37
	02 causes known	12	11	6	14	1	3	3	50
	03 causes known	11	8	4	0	16	0	7	46
	04 causes known	0	1	6	1	0	8	0	16
	05 causes known	0	10	1	0	3	5	4	23
Total		30	30	30	30	30	30	30	210

Table 4: Knowledge of prevention measures against cholera in the surveyed neighbourhoods

Konowledge of prevention measures against cholera * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVI)	NKOLBISSON (YdéVII)	Total
Konowledge of prevention measures against cholera	Don't know	4	5	5	6	9	13	7	49
	01 or 02 measures	4	1	0	1	10	1	5	22
	03 or 04 measures	6	11	17	3	6	1	5	49
	05 or 06 measures	11	2	5	7	5	6	8	44
	07 or 08 measures	4	8	2	8	0	9	0	31
	09 or 10 measures	1	3	1	5	0	0	5	15
Total		30	30	30	30	30	30	30	210

Many respondents have knowledge about 02 causes of cholera (23, 61%); 23, 33% of respondents don't know any prevention measure regarding cholera. The chi-square test (p-value = 0, 00) showed that the general knowledge on cholera vary significantly across neighbourhoods

3.3. Hygiene

Table 5 below shows that many of the neighbourhoods rely on taps for their water supplies. However, it was observed that most of these home connections were supplied by privately owned boreholes powered by pumps against a fee paid to the owners of such schemes. The public water supply network was absent in most of the neighbourhoods selected for the study. Because a majority could not afford to pay the fees for private supply network, they (79.53%) rely on open wells streams for drinking water and water for other needs.

Table 5: The source of drinking water in the surveyed neighbourhoods

Drinking water source * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVI)	NKOLBISSON (YdéVII)	Total
Drinking water source	Well	5	0	0	5	0	4	0	14
	Drillling	9	5	7	10	9	9	10	59
	Tap	16	21	15	15	14	12	15	108
	Mineral	0	4	8	0	7	5	5	29
Total		30	30	30	30	30	30	30	210

Table 6: Knowledge on prevention of contamination from water sources in the surveyed neighbourhoods

Knowledge against water sources contamination * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVI)	NKOLBISSON (YdéVII)	Total
Knowledge against water sources contamination	Don't know	10	3	1	3	2	2	5	26
	01 measure	6	12	21	11	10	7	13	80
	02 measures	14	1	5	15	0	8	12	55
	03 measures	0	14	2	1	17	12	0	46
	04 measures	0	0	0	0	0	1	0	1
	05 measures	0	0	1	0	1	0	0	2
Total		30	30	30	30	30	30	30	210

From table 6, 12, 38% of respondent don't know any measure to be taken against water pollution; 10% of respondents don't have any knowledge on where to pour their wastewater. The chi-square test (p-value = 0, 00) showed that the hygienic practices vary significantly across neighbourhoods

3.4. Potential hygienic behaviour towards cholera patient

Table 7: Knowledge on precaution to handle body fluids (vomit etc) and faeces from infected persons from in the surveyed neighbourhoods

Precautions measures in handling tools and vomits of a cholera patient * Survey location Crosstabulation

Count

		Survey location							
		ETOA-MEKI (Ydél)	CITE-VERTE (Ydéll)	BONAS (Ydélll)	EKOUNOU (YdélV)	ESSOS(YdéV)	JOUVENCE (YdéVI)	NKOLBISSON (YdéVII)	Total
Precautions measures in handling tools and vomits of a cholera patient	Don't know	14	13	16	22	15	13	14	107
	01 measure	8	8	7	8	14	10	11	66
	02 measures	8	9	7	0	1	1	5	31
	03 measures	0	0	0	0	0	6	0	6
Total		30	30	30	30	30	30	30	210

More than 50 % of respondents didn't know any protection measure in handling stools and vomit of a cholera patient. The chi-square test (p-value = 0, 00) showed that such behaviour varies significantly across neighbourhoods

3.5. Faecal pollution bacteria

Table 8: Distribution of faecal pollution bacteria per water (well)/borehole samples

	Sample 1	**Sample 2**	**Sample 3**	**Sample 4**
Faecal pollution bacteria (UFC/100mL)	730	652	408	360

Although drinking water is expected to have a zero bacteria (coliform) level per 100ml of water, the US National Research Council (US) recommends an allowable bacterial numbers for drinking water vary from 100/ml to 500/ml of colony-forming units applicable to different jurisdictions (USNRC 19770). On the other hand, the WHO indicates that drinking water with bacterial values between 110 UFC/100mL and 1000 UFC/100mL are a potential threat to public health (WHO 2010).

The samples from the wells and boreholes in the surveyed neighbourhoods contains values that lie between 360 UFC/100mL and 1000 UFC/100mL. This bacteria load indicates that the drinking water sources in the neighbourhoods are a potential threat to the health of the residents.

3.6. Vulnerability indices

In this study, the Action *against Hunger* (or Action *Contre La Faim* (*ACF*) in French) scale for ranking vulnerability level according to vulnerability index developed in 2012 and extensively been used in vulnerability assessment in cholera prone areas was applied. The Scale grade vulnerability according to the following scale:

[0 - 0,5] Very low vulnerability

[0,5 - 1,5] Low vulnerability,

[1,5 - 2,5] Average vulnerability

[2,5 - 3,5] High vulnerability

[3,5 - 5] Extreme vulnerability

Table 9: Vulnerability index versus survey location

Vulnerability / Neighbourhood	Vulnerability to knowledge on cholera	Vulnerability to hygienic behaviour	Vulnerability to attitude towards cholera patient	Vulnerability to socio-economic	Global vulnerability
Etoa-méki (Yaoundé I)	3,22	2,51	4,27	2,75	3,11
Cité-verte (Yaoundé II)	2,64	2,52	3,99	2,93	2,79
Bonas (Yaoundé III)	3,06	2,33	4,38	2,98	3,00
Ekounou (Yaoundé IV)	2,72	2,80	4,47	2,77	2,97
Essos (Yaoundé V)	3,01	1,99	4,26	3,10	2,88
Jouvence (Yaoundé VI)	2,84	2,43	3,75	3,03	2,85
Nkolbisson (Yaoundé VII)	2,85	1,86	3,90	3,13	2,74

We can see that vulnerability indices range from 1.86 to 4.5 on a scale of 0 to 5, with more than 88 % of indices between 2.5 and 4.5. For the overall vulnerability indices range from 2.74 to 3.11, showing that all studied slumps of Yaoundé city are averagely highly vulnerable to cholera. Based on these figures, a vulnerability map for the neighbourhoods was drawn as shown in figure 2 below.

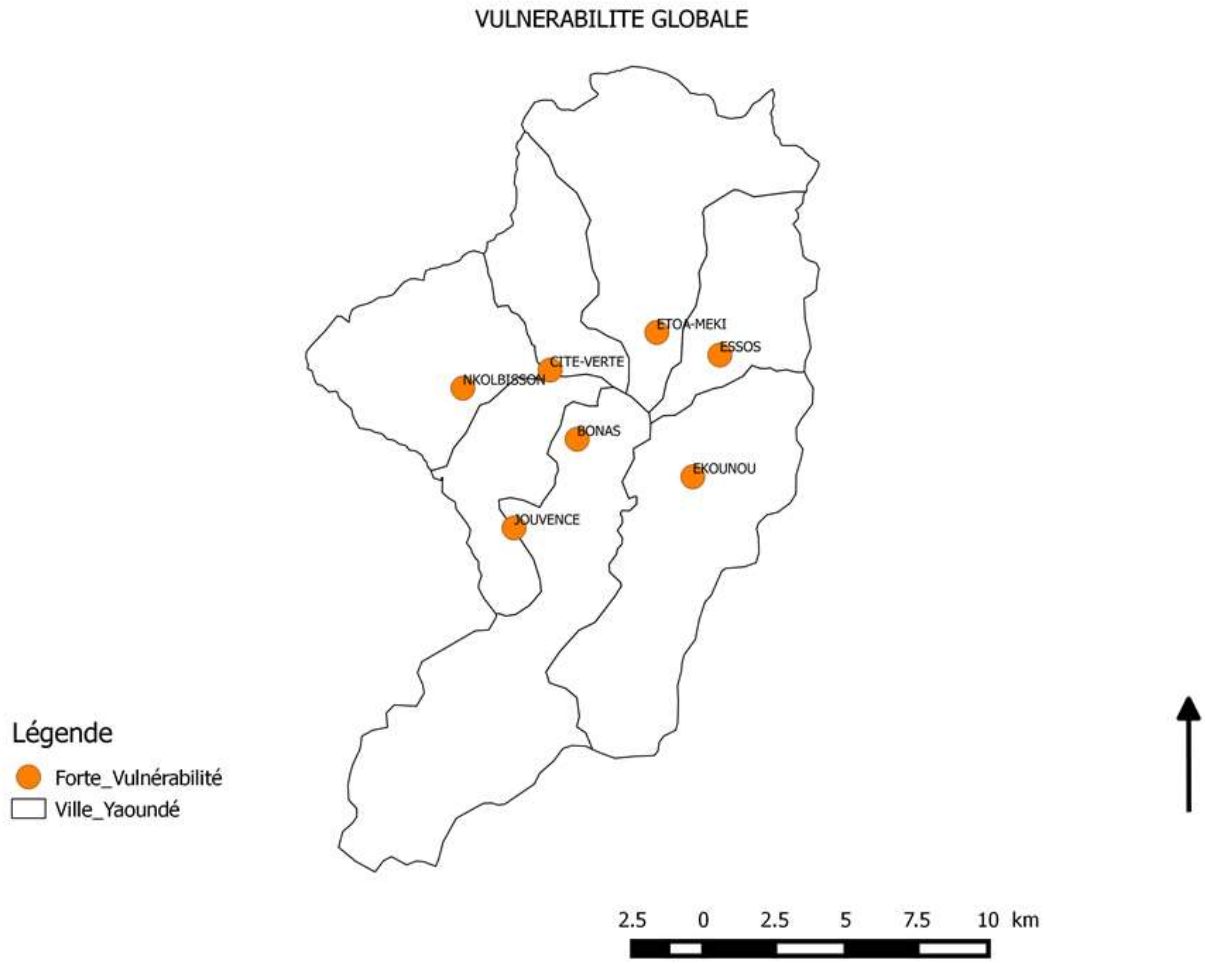

Figure 2 Map of Global vulnerability (Source: Authors)
Légende=Legend; Forte_vulnérabilité=high vulnerability; Ville Yaoundé=Yaoundé city;
Vulnérabilité Globale= Global Vulnerability.

4. Discussion

The aim of this study was to identify and describe the vulnerabilities of population vis-à-vis cholera from a water, sanitation, and hygiene (WASH) perspective. Specifically, the study seeks to use the vulnerabilities indices to propose a multi-stakeholder approach for engagement to contribute towards preparedness and to reduce the public health threat in 7 slum neighbourhoods in the city of Yaounde which are hotspots for cholera outbreak. However, an effective cholera prevention and outbreak response depends on how prepared the communities and health systems are at all level. While cholera preparedness is multifaceted and multiple-levels, awareness and improving access to water, sanitation, and hygiene (WASH) has been strongly emphasised (WHO 2020, Munier et al. 2015). Like many other disease outbreaks cholera outbreaks are polycentric in nature with the impacts severely impacting other sectors. A major global policy that seeks to address this challenge particularly related to cholera outbreaks is the sustainable development goals.

The Sustainable Development Goal (SDG6) seeks to enhance access to water, sanitation, and hygiene both at community and health facilities levels as a key to ensuring healthy communities. Therefore, one major step of curbing the spread of diseases such cholera is through ensuring access to adequate water for different uses including potable water for drinking. The results of this study reveal the weakness of state institution responsibility to ensure the availability and access to water as a basic service in the study area despite a growing population and stagnation in basic service provision. The implication of this is that the population resort to alternatives sources of water which are often unsafe exposes. These weaknesses can greatly hamper the

capacity of communities to respond and actively play their role in preventing new outbreaks or preventing resurgence in areas that have recorded outbreaks in the past.

The quality of water available to communities is a key indicator of their level of vulnerability to infections such as cholera. Some important studies have shown that the presence of faecal pollutants in water sources above acceptable levels can easily spread diseases from the point of contamination and affecting whole communities far beyond these points (Tumwine et al. 2002; Feumba et *al*. 2011; Belghiti et *al*. 2013; Kahoul M. and Touhami M. 2014; Ndenge 2016). This seem to be the case in the study area where single water sources that have bacteria loads far above the acceptable levels is used by multiple households for drinking and other household needs. Thus, the study areas constitute a potential ground for cholera outbreaks or resurgence of an outbreak given that they had recorded episodes in the past. The results also reveal some weaknesses in the level of awareness of communities in the study who constitute both drivers and agents to creating favourable grounds for the recurrence or not of cholera. The level of awareness on both the causes and methods of preventing cholera infections amongst communities is also important. Unfortunately, the level of awareness is poor in the study area. This is exacerbated by the poor level of education of the population and an understanding of the modes of transmission, modes of prevention and household hygiene measures in the event of an outbreak. This situation in the project area also seem to be supported by poor socio-economic status of the residents. The study reveals that the public water network has broken down or has not been extended in the last decade to meet the needs of a growing population. While some residents have developed private water supply schemes, the quality of these schemes remain doubtful. More so these people are unable to pay the fees required by the private water suppliers to access the basic need.

The bacteriological analysis of the boreholes and open well samples revealed the presence of numerous faecal pollutant bacteria above the 110UFC/100mL limit recommended by WHO. From the assessment of data collected from this study, more than 88% of indices ranged between 2.5 and 4.5 with the average vulnerability range for the neighbourhoods between 2.74 to 3.11. The poor access to water and by extension sanitation services such as public and household toilet facilities attest to this high faecal bacteria load in the water samples collected from the neighbourhood and therefore the high level of vulnerability to ccholera. A similar approach has been used in a study carried out in Abidjan city of Cote D'Ivoire by Kouame et al. (2016) which showed that all surveyed households were highly vulnerable to cholera, with vulnerability indices between 2.5 and 3.5. Based on the overall findings of this study a cholera vulnerability map drawn for the city of Yaounde indicate that though there are slightly variable degrees of vulnerability to cholera amongst the neighbourhoods, the neighbourhoods are globally vulnerable to cholera outbreaks. In addition, it reveals that households in the vulnerable communities are the main agents creating a favourable environment for potential cholera outbreaks. This overall threat to the health and wellbeing of residents of the neighbourhoods calls for harmonised approaches to ensure an effective cholera preparedness, prevention, and case management.

This study was focused on analysing data collected from households. It did not collect data on health facilities' awareness and preparedness which are complementary to that of households. However, the above findings are informative including the map of the global vulnerability generated. These and all the other outputs of this research could be used by health facilities and other health stakeholders to engage in effective and efficient cholera preparedness and response planning.

5. Conclusion

The households in slum neighbourhoods in the 7 Subdivisions in the City of Yaounde have weaknesses in their capacity to cope with a cholera epidemic. Their current access to WASH and their level of awareness exposes them to potential health dangers especially to cholera outbreaks. While examination of the situation in health facilities was not within the scope of this studies the high level of vulnerability of communities is a pointer to the level of preparedness of the health facilities in and around this study area to the threat of a cholera epidemic.

To improve on the readiness of these Subdivisions to prevent a cholera outbreak the following recommendations are made:

To Ministry of Public Health, the heads of health facilities (public and private), district health services, regional delegation of public health and local councils

- Engage in a rigorous process to develop education packages tailored to suit vulnerable actors taking note of their level of education and socio-economic status. Such packages should involve both households in communities and health facilities if possible, through co-production and co-training.
- Designate the right personnel to train and raise awareness of the vulnerable communities using the well-developed education packages and plans.
- Provide material and financial subsidies in fighting against faecal peril and diarrhoea diseases.
- Improvement of public health communication system and importantly regarding WASH related diseases.
- Make use of the vulnerability indices and the mappings generated from this study to develop actions to address the challenges especially the faecal pollution levels in the water sources currently used by communities.

Communities, households, local groups, and NGOs

- Actively take part in the awareness campaigns.
- Actively implement measures to address vulnerabilities alongside communities who are major agents and drivers for an enabling environment for the outbreak and spread of cholera.
- Mainstream and streamline issues of disease prevention and management in existing interventions at community level.

References

[1]. ACF (2012). Rapport de l'enquête sur la vulnérabilité au choléra des ménages et quartiers précaires d'Abidjan (Côte d'Ivoire) 120p,

[2]. Akoachere, J, Omam, L, Massalla, TN (2013). Assessment of the relationship between bacteriological quality of dug-wells, hygiene behaviour and well characteristics in two cholera endemic localities in Douala, Cameroon. BMC Public Health 13:692.

[3]. Andersson, K, Dickin, S, Rosemarin, A (2016). "Towards "Sustainable" Sanitation: Challenges and Opportunities in Urban Areas". Sustainability. 8 (12): 1289

[4]. Ateudjieu, J., Yakum, M.N., Goura, A.P. et al. (2019). Health facility preparedness for cholera outbreak response in four cholera-prone districts in Cameroon: a cross sectional study. BMC Health Serv Res 19, 458

[5]. Belghiti.M.L., Chahlaoui.A., Bengoumi.D., El.M.R (2013). Étude de la qualité physico-chimique et bactériologique des eaux souterraines de la nappe plio-quaternaire dans la région de Meknès (Maroc). Larhyss Journal, pp. 21-36.

[6]. Cohen B (2006). Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. Technol Soc 2006;28:63-80.

[7]. Dieudonne.N.G (2016). Évaluation de la mise en oeuvre du concept WASH (Water Sanitation and Hygiene) en milieu scolaire : Cas de quelques lycées de la ville de Yaoundé, 2016, Pp.8.

[8]. Djomassi LD, Gessner BD, Andze GO, Mballa GAE (2013). National surveillance data on the epidemiology of cholera in Cameroon. J Infect Dis.;208 (Suppl 1):S92–7

[9]. Dutertre .J., Huet .M., Gateff.C., Durand.B (1972). Le choléra au Cameroun. Med Trop, 32 : 607-24.

[10]. EU (2020) UNICEF Cholera Epidemiology and Response Factsheet Cameroon https://www.unicef.org/cholera/files/UNICEF-Factsheet-Cameroon-EN-FINAL.pdf (Accessed 02/07/2020)

[11]. Feumba.D.R., Kana.S.M., Ngono.N.A., Ebelle.E.R.(2011) Influence des méthodes de traitement sur la qualité microbiologique des eaux consommées au quartier Bonangang (Douala- Cameroun). Sciences, Technologie&Développement ISSN.n°1, 8 – 13. 12: 1029 – 2225.

[12]. Guévart.E., Noeske.J., Solle.J., Essomba.J.M., Mbonji.E., Bita.A., Mouangue.A., Manga. B (2006). Déterminants du choléra à douala. Med Trop ;66 : 283-291.

[13]. Kahoul.M., Touhami.M (2014). Évaluation de la qualité physico-chimique des eaux de consommation de la ville d'Annaba (Algérie). Larhyss Journal, ISSN, 15:1112-3680,pp. 129-138.

[14]. Mahvi AH, Karyab H (2007) Risk assessment for microbial pollution in drinking water in small community and relation to diarrhea disease. American-Eurasian J Agric Environ Sci 2:404-6.

[15]. Minsante (2018). Plan National de reponse a l'epidemie de cholera au CAMEROUN, 51P.

[16]. Munier A, Njanpop-Lafourcade B-M, Sauvageot D, Mhlanga RB, Heyerdahl L, Nadri J, et al. (2017). The African cholera surveillance network (Africhol) consortium meeting, 10–11 June 2015, Lomé, Togo. BMC Proc [Internet] [Access 2 July 2020;11

[17]. National Research Council (US) (1977). Safe Drinking Water Committee. Drinking Water and Health: Volume 1. Washington (DC): National Academies Press (US); III, Microbiology of Drinking Water. Available from: https://www.ncbi.nlm.nih.gov/books/NBK234164/ (accessed 20 June 2020)

[18]. Ndengue Germain D (2016). Évaluation de la mise en oeuvre du concept WASH (Water Sanitation and Hygiene) en milieu scolaire : Cas de quelques lycées de la ville de Yaoundé, Pp.8.

[19]. Ngang et al. (2015). Community Water Management Schemes: An option for sustainable water-for-all in North West region of Cameroon amidst climate change and population growth, Journal of Advanced Studies in Agricultural, Biological and Environmental Sciences (JABE), Vol.2.Issue.4.2015 (Oct-Dec), ISSN:2394-2606,

[20]. Ngwa MC, Liang S, Kracalik IT, Morris L, Blackburn JK, Mbam LM, et al. (2016). Cholera in Cameroon, 2000-2012: spatial and temporal analysis at the operational(Health District) and sub climate levels. PLoS Negl Trop Dis [Internet]. Accessed 28 June 2020 10(11). Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC5113893/

[21]. Rigby.R.A (2005). Stasinopoulos D.M. Generalized additive models for location, scale and shape, (with discussion).Appl Stat, 2005, 54: 507–554.

[22]. Tumwine JK, Thompson J, Katua-Katua M, Mujwajuzi M, Johnstone N, Porras I. (2002). Diarrhoea and effects of different water sources, sanitation and hygiene behavior in East Africa. Trop Med Int Health 7:750-6.

[23]. United Nations Children's Fund (2010). UNICEF Conakry Action Contre La Faim. Épidémiologie du choléra dans la ville de Conakry (République de Guinée) : Étude rétrospective des facteurs de risque dans la ville de Conakry, 57P.

[24]. UNDP (2015). Goal 6: Clean water and sanitation http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-6-clean-water-and-sanitation.html, Accessed 06/5/2020

[25]. Venables WN, Ripley BD (2002). Modern Applied Statistics with S. New York: Springer Science+Business Media.

[26]. WHO (1996). Guidelines for cholera control. Genova: WHO, Available, 1996, http:// whqlibdoc.who.int/publications/1993/924154449X.pdf. Accessed 12 April 2009.

[27]. WHO (2020). Prevention and control of cholera outbreaks: WHO policy and recommendations [internet]. (Access 1 July 2020]. Available from: http://www.who.int/cholera/technical/prevention/control/en/.

[28]. Yongsi H. B (2010). Suffering for water, suffering from water: access to drinking-water and associated health risks in Cameroon. Journal of health, population, and nutrition, 28(5), 424–435. https://doi.org/10.3329/jhpn.v28i5.6150