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A Case-Control Study to Identify Risk Factors Related to Cholera Outbreak in Kasai Oriental Province, Democratic Republic of Congo, 2018

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Abstract

Cholera remains the major public health problem in the world. Democratic Republic of Congo is frequently affected by cholera since the introduction of 7th pandemic in the country in 1974. The 2018 cholera outbreak which was the second major one affecting the Kasai oriental (KOR) province started on the week7 and was still persistent on the week40, when it was decided to conduct a matched cases-controls study to identify its risk factors so that to readjust responses activities on going on the field. 80 cases were randomly selected in the line-listing among patients investigated in the treatment centres or units during cholera response activities and 80 controls were selected according to matching criteria. Bivariate and multivariate analyses were performed using Epi-info 7 software. The study identified as risk factors: Living in a household with more than five persons (Adjusted Odds Ratio (AOR):2.99; 95%CI[1.88-6.22]); drinking water sold along the street (AOR: 4.29; 95%CI[1.85-10.30]); Had been in contact with persons suffering of diarrhoea (AOR: 7.15; 95%CI[2.10-17.21]); Participated in funerals (5.16; 95%CI[3.02-29.95]); peoples ignoring how to contract cholera (5.78; 95%CI[2.38-18.10] and participants ignoring how to protect themselves from contracting cholera (2.49; 95%CI[1.73-5.20]). Cholera vaccination was not tested as risk factors during this study.

Keywords: *Risk factors, cholera, Kasai Oriental, Democratic Republic of Congo.*

Introduction

Cholera a very contagious infectious enteric disease caused by a gram-negative curved bacterium named Vibrio cholera usually transmitted through water or food contaminated (Juan et al., 1995). The major sign of the cholera disease is watery diarrhea with or without vomiting which could lead to loss of important quantity of fluids with electrolytes and then to deaths within hours if there is not appropriate treatment; but with appropriate one, which consist of largely hinges on fluid replacement, case fatality rate of the disease is less than 1 % (WHO, 2004; MSF, 2018). The disease remains a major public health concern worldwide more than 200 years after the first cholera pandemic which started from its reservoir in the Ganges delta of India on the 19th century (1817) and then spread all over the world, (Sigsworth, 1991). The world is currently facing its 7th cholera pandemic characterized by an almost absence of the disease in countries with a good level of socio-economic development while in some countries of South East Asia and sub-

Saharan Africa, the disease is rampant endemic more occasional very devastating outbreak like the one of 1994 in Goma, DRC with estimated 50,000 deaths (Nkoko et al., 2011; Echenberg, 2011)even that of Yemen in 2017 (WHO, 2019).The annually notified cholera cases estimation worldwide is between 1.3 to 4.0 million of which 21,000 to 143,000 deaths. However public health experts estimated that these WHO data represented approximately 5% to 10% of real cases and this can widely justify that cholera cases are worldwide underestimated despite the reasons mentioned above (Ali et al, 2015; WHO, 2019).The cholera was introduced in DRC in 1974, just three years after reaching Guinea, the first African country to be affected. Since then, DRC which cholera endemic in its east part has become one of the major cholera providers in Africa an even in the world (Ali et al, 2015). The occurrence and spread of cholera in a locality are not dependent on an isolated risk factor. The triad of pathogen-host-environment factors is therefore essential in this process (Janny, 2004; Carneal-Frazer, 2019). Since Kasai Oriental (KOR) Province is not an area where cholera is endemic (Nkoko et al., 2011), vibrio cholerae is probably not permanently resident there. However, the living conditions prevailing there, in particular the many rive, potential but never proven reservoir of vibrio, the problems of poverty and overcrowding of the populations and especially the problems related to water, sanitation and hygiene make this part of the DRC an environment conducive to the deadly outbreaks in case a vibrio strain with epidemic potential were to be introduced there as is often the case through the movements of people and foodstuff (Maheshwari et al., 2011). In 2002-2004, the first major cholera outbreak probably entered the KOR province through funeral rites. The index case was coming from Haut Katanga province, before the disease settled in the crowded and unsanitary mines of Mbuji-Mayi city, causing in two years around 10,000 suspected cases including about 600 deaths, with a CFR: 6% (Bompangue, 2009). A single case-control study conducted in that moment identified the consumption of peanuts and donuts sold outside households, the non-use of latrines, and having contact with diarrhea patient as risk factors (Mbuyi, 2003). Identification of the risk factors during cholera outbreak is very important to reinforce outbreak response and to readapt communication messages focusing on the study's findings. On the February, 12 of 2018(Week7), 35 years women, resident of Mbuji-Mayi city, started with an acute watery diarrhea, after attending funeral a day ago in the neighboring province of Lomami. This was a beginning of the second major cholera outbreak in the province about 14 years after the previous one. Despite the deployment of Cholera response team including public experts of the ministry of health on the national, provincial and local level as well as all traditional partners (WHO, Unicef, OCHA, MSF….) under the leadership of the provincial Governor of the province, the outbreak continued to spread with more Health Zones (HZ) or Health Districts affected. So, as on Week40th, when we started collecting data to carry out a cases-controls study to identify cholera risk factors as recommended by the provincial crisis comity (PCC), the number of suspected cases registered was 4780 including 249 deaths (CFR: 5.2%). Conducting this study was mainly motivated by the persistence of the outbreak in a very crucial context of poor socio-demographic and hydrographic conditions prevailing in the province as well as the situation of water supplied, sanitation and hygiene (WASH) in the KOR province that was said to be catastrophic (shomba and Olela, 2015).

Objectives of the study

To identify the risks factors of cholera in the Kasai oriental Province in 2018

Methods

Study design

It was a matched case-control study. We matched each case with one control with same gender, the same age group (±5years) and in the same area (neighborhood).

Study area

The KOR province is one of the 26 Provinces of the DRC. It has a population estimated at 5,030,071 inhabitants for an area of 9,699 Km2, a density of 504 inhabitants / Km2. 62% of this population lives in one of the 10 HZ of its main city Mbuji-Mayi and the remaining population are located in the other 9 HZ of the rural area of the province. The rainfall pattern in the KOR includes a 9-month rain season (September to

May) and a 3-month dry season (June to August). The average annual temperature varies from 25°C in the North to 22.5°C in the South of the Province with important annual variations (1.5 to 2°C) according to the seasons. The province is bounded on the north by the provinces of Kasai Central and Sankuru, on the east and south by the province of Lomami and on the west by the province of Kasai Central (Figure 1). It is irrigated by a dense network of rivers used most of the time by populations as a priority source of water, in a context of scarcity of drinking water. Besides, Mbuji-Mayi is the name of one of these rivers. In addition, its subsoil is very rich in diamond, nickel, lead and hydrocarbon. With such a basement rich in such minerals there is a flowering of the diamond mines in the city of Mbuji-May and its surrounding area, which attracts many poor people living in deplorable conditions of hygiene and this make this province a high-risk locality of developing water born epidemic such as cholera. The artisanal diamond mining occupies most of the active unemployed population in KOR Province (UNDP, 2009).

Study population and sampling

Our target population includes all cholera cases that meet the Ministry of Public Health standard case definition of the suspected cholera case and confirmed case as adapted from MSF (2018) and GTFCC (2017) case definition; reported in the line listing of cholera case available in the DPS and all control that was defined as persons living in the same province as a case but who had not suffered from any diarrhea cholera.

Inclusion and exclusion of cases

Was included as case in our study, all persons targeted as cases during the period of study (October 1st – November 30, 2018). Were excluded, non-residents in the provinces, cases with no investigation done or completed, cases refusing to take phone call or refusing to give their verbal consent.

Inclusion and exclusion of controls: Was included as controls all persons residing KOR province during the period of cholera outbreak and who matched with a case (sex and age group). Where excluded all absent at home or refusing to take a phone call as well as those refusing to participate.

Suspected case (used during this cholera outbreak)

Any patient resident in one of the 19 HZ of the province at the moment of the disease unset, who develops watery acute watery diarrhea of sudden unset, with or without dehydration that mean at least three liquid stools per 24hours or a person who died for acute diarrhea.

Confirmed case

A suspected case in which Vibrio cholera O1 or O139 has been isolated from their stool

Sample size calculation: We calculated sample size using the Open-Epi software (Kelsey et al., nd). Taking into consideration an alpha risk of 5%, a power of 80%, we calculated our sample size by using an Odds Ratio (OR) of 2.6 (Dubois et al., 2016), assuming a prevalence of 40% exposure in control group and 01case for 01 control. Then, we selected Fleiss method with continuity correction factor (Kelsey et al., nd). We finally obtained a total of 160 subjects to be selected; therefore 80 cases and 80 controls.

Selection of cases

In the period concerned by a case-control study, 712 cholera cases where registered in the line-listing of the province with questionnaire investigation forms filled and entered in a data base of the investigations also available at the DPS. So, we need to select choosing stratify sampling method 80 controls among these 712 investigated cases, stratified by Heath Zone with regard to the number of cases registered in the line listing. Se in table 1 the number of cases and control randomly selected in each HZ.

Selection of controls

After having randomly selected our 80 suspected cholera cases among 712 already investigated and interviewed during cholera response activities, we called each of them through their phone numbers to identify their locations in their respective HZ, health area and once there, we selected the household in which we should chose its control. To process, we reached in the case's household and using a bottle thrown on the ground just outside its household, we chose the subsequent control's household to which the bottle pointed. Ones inside the household, we asked for people of the same gender, approximately the same age (± 5

years) to interview. If there were no specified controls, we got out and seek for control in the next household coming from the right till the completion of our target population getting in our mind that selected control should not be in a radius of more than 25 household of its linked case. In case, we found more than one subsequent control in the same household, we selected randomly one of them.

Data collections tools and technic

A standardized investigation form used was adapted to include information on local behaviours. Then original of the questionnaire was provided by the health officers of the DPS of KOR province, provided by a partner Doctors Without Borders (2018). This investigation questionnaire of two pages was divided 4 sections. Section I: General information concerning the entire respondent (Cases and Controls) such as: Sex, age, main occupation, disease status, health area or HZ of notification, number of persons in the household, confirmation to the lab or not.

Section II: Clinical features of the cases (only to be filled by the suspected cases). Characteristics of the disease. Section III: Risk factors section with subsection A: consumption of certain local foods and drinking water and subsection B: Environmental and behavioural risk factors. Section IV: Some basic knowledge about cholera. The same questionnaire was also used for all 80 selected controls around households of the 80 primary selected and interviewed cases. All the information collected during investigations of suspected cases was done using this structured case-control questionnaire of investigation and were regularly entered in an Excel 2010 file, by the data manager of the DPS of KOR province. Data from a total 712 investigated suspected cases were entered in Excel file among these, 80 were selected as cases for studies purpose. The interviews of control were done by the same team in selected area with regard of the case household

Data analysis

Data of 80 selected suspected cases in one file and 80 subsequent controls in another file were merged in a single database (cases and controls) which was imported in Epi-Info, Version 7 of the CDC, Atlanta, USA. From tables 2x2 generated after crossing each potential risk factor with the outcome, Crud Odds Ratio (COR) with their 95% Confidence Intervals and the value p were calculated. Then for all table's association with p-values <0.1, the exposition variable was retained for multivariate analysis and integrated in the logistic regression model to control confounding factors. The risk factor or protective factor or determinant of any dependent variable under study was identified for an Adjusted OR (AOR)≠1, with its 95% Confidence Interval not containing 1 and at the same time a p-value<0.05 (WHO, 2003; Bonita et al., 2010).

Ethical consideration

The interview of selected case was part of response activities and at that time, no informs consent was asked to them. But, when a case was randomly selected in the line-listing to participate in the case-control study, they were contacted trough their phone number, the purpose of the study was explained to them and their verbal consent where asked. If they agree, they were asked to describe the location of their household so that we could reach there and select in their neighboring the matching control. When the correct control was selected, the purpose of the study was also explained to him and then we ask for their verbal consent and if agree, we started the interview. Consent for children under the aged 5 years was obtained from their parents or guardians. Verbal assent was also obtained for children under 15 years. Our protocol was submitted to the approval of the only ethics committee of the city of Mbuji-Mayi namely the Ethics Committee of the Faculty of Medicine of Mbuji-Mayi University and we obtained the Ethical clearance (N/Ref:52/MREC/UM/NKB/GDT/2019, dated on August 20, 2019. Also, the authorization of the DPS's authorities in the KOR province to use line listing data for research purposes as well as the investigations database of suspected cases notified during this outbreak.

Dissemination of findings

The findings of the study will be shared with the DPS of Kasai oriental province and national authorities as well as to different partners involved in cholera control as our contribution eliminating cholera in DRC.

Further studies

To complete this risk factors study, additional epidemiological and microbiological investigations should be done in the many rivers in the KOR province to see if these are possible vibrio reservoirs. Also survey on knowledge, Attitudes and practices of populations should be done as well as the evaluation of the two rounds oral cholera vaccination campaigns that was executed in the KOR province with the aims to have this disease under control in the KOR province.

Results

Socio-demographic characteristics of study population

A total of 160 (80 cases /80 controls) subjects participated in this study. The age, sex and area of notification of the cases and controls were comparable with no surprise as participant selections was matches with regard to these three variables. 27(33.7%) cases and 26(32.9%) controls were aged 40years and above. Out of 80 cases, 40(50.0%) were aged (5-36) years old and among 80 selected controls, 40(50.0%) were aged (3-35) years old. 42(52.0%) selected cases were men as well as 42(52.0%) controls. 55(68.9%) cases and 55(68.9%) were selected in Mbuji-Mayi city. More ever, occupation and education of cases and controls were slide different but these were not statistically significant ($p<0.05$). The only difference noticed between cases and control in our study population was the number of persons in the household. 54(68.2%) cases lived in household with five persons and above while 34(42.3%) of controls lived in the household with five persons or more (Table 2)

Clinical characteristics of cases

During cases, investigation in one of the treatment units, 78(99.0%) were with acute watery diarrhea, 53(66.7%) with vomiting, 22(27.0%) with severe dehydration. See others detailed signs in Table 3.

Food eating and water drinking exposure

Twenty particular food consumption or water drinking within five days before the diarrhea unset, were tested in bivariate analyses model and four was retained for multivariate as p-value<0.1. That was: Eating cooked or grilled corn on the street (p=0.027), eating cool cooked food on the street (p=0.071), Drinking poorly conserved water (p=0.048) and Drinking water sold on the street (p=0.002); See details in table 4.

Environmental and behavioral exposure

Over 14 exposures tested in bivariate analysis, five potentials risks factors were retained (p-value<0.1) for multivariate analysis: Participation in a mass gatherings (p=0.078); Washing cooking tools in the lac or river (p=0.08); Having contact with person suffering of diarrhea (p=<0.001); Participation in funerals (p=<0.001) and Used common latrine for defecation with p-value of 0.083 (See details on table 5).

Knowledge on cholera as exposure

Five questions were asked to cases and control to seek for cholera related risk factors. Two of them were retained as potential risk factors (p<0.1) to be introduced in logistical model: Don't know how to contract cholera disease (p=<0.001) and Don't know how to protect from contracting cholera (p=<0.001). See details in table 6.

Identification of independents predictors or risk factors of cholera

At all, 12 potentials risk factors (11 selected above alongside the "number of persons in the household") were put in logistical regression model to control potential risk-factors and finally, the following six one was identified as cholera risk factors taking into account AOR, 95%CI and p-value. Indeed, participants who live in a household with more than five persons were 2.99 times more likely to develop cholera symptoms than those living with less than five persons (95%CI [1.88-6.22]; p=0.015); participants who drink water sold along the street were 4.29 times susceptible to develop cholera disease than those who didn't (95%CI[1.85-10.30]; p<0.001); Participants who was in contact with persons suffering of diarrhea were 7.15 times more likely to develop cholera diarrhea than those who didn't (95%CI[2.10-17.21]; p<0.001); subjects who participated in funerals were 5.16 times susceptible to develop cholera than those who didn't (95%CI[3.02-29.95]; p<0.001); participants who ignored how to contract cholera where 5.78 times more likely

to develop the disease than those who known how (95%CI[2.38-18.10]; p=0.003) and finally participants who ignored how to protect themselves from contracting cholera were 2.49 times more susceptible to develop cholera than those who known how (95%CI[1.73-5.20]; p=0.014). See all details in table 7.

Discussions

We chose a matched cases-controls study instead of the classical one because we wanted to control confounding factors such as age, sex and area during data collection as it is sometimes recommended in such studies (Rothman et al., 2008; Bonita, 2010; CDC, 2012). This design method is commonly used to identify outbreak's risk factors in a few studies conducted especially in African countries such as those conducted in Mozambican refugee camp by Moren et al, (1991) and in Tanzania by Acosta et al (2001). We do not think, given the relatively short incubation period of cholera, that the memory biases inherent in case-control studies could have influenced the subjects' responses. Among the potential cholera risk factors identified and tested in the current study, living with more than 5 persons in the household, Drinking water sold on the street, Having contact with persons suffering of diarrhoea, participating in funerals 5 days before unset, how to contract cholera, How to protect from cholera were all the independents predictors of this cholera outbreak after applying a multi-logistical regression model and making interpretations using AOR instead of use COR (WHO, 2003; Bonita et al., 2010). In this study, a wide range of food items were tested to see if they were associated with the risk of contracting cholera infection but as part of a few one which statistically significant association in bivariate analyses, none of these was found as independent predictors of the disease in logistical regression model. It is well known that water consumption plays important role cholera transmission during outbreaks. The cholera response team found empirically that in the KOR province, especially in Mbuji-Mayi, populations carried water for their domestic activities mainly in one of the many rivers irrigating the province as well as in the wells and when seeing the low proportion of the household without any toilet, it was evident that water should have been contaminated. So, there were systematic, massive and intensive chlorination of water in many points of these rivers as well as in the wells used in the households.

Promiscuity and overcrowding in precarious hygienic and environmental conditions are known factors in the spread of cholera (Nkoko et al., 2011). The province of KOR is relatively overcrowded and in a context of generalized poverty, it is not uncommon to find households of more than 5 people. This is compounded by the fact that the city is scoured by numerous diamond mines. These have the effect of attracting people to the surrounding dwellings. The epicentre of the cholera outbreak at the moment we conducted this study was in Luamuela, a locality in the Tshillenge HZ. This area is home to important artisanal diamond mining sites. Around these sites, mostly idle populations built small makeshift dwellings in which they could find themselves in the evening at bedtime, sometimes more than a dozen per dwelling. All this explains why we found that living more than 5 people in a household was a risk factor for cholera in the province. Similar results have been found in other cholera epidemics in Haiti (Grandesso et al., 2014), Vietnam (Nguyen et al., 2017) and Mali (Halidou et al., 2018)

The consumption of water sold along the street has also been identified as a cholera risk factor. Indeed, in a context where the water needs of the populations were not sufficiently covered in a province which had already spent almost 8 months in epidemics with significant chlorination activities, it is understandable that certain people resistant to the smell of chlorine abandon chlorinated water to buy water sold in the streets, often without worrying about their origin. This situation where populations became infected with cholera by consuming water sold on the street has also been observed in Nigeria (Hutin, 2003; Adagbada et al., 2012); in Kenya (Mwenda et al., 2017); in Niger (Halidou et al., 2018) and in Ethiopia (Abduilhafiz et al., 2019)

One of the first things to avoid or at least to reduce during cholera outbreaks is contact with people, especially people with diarrhoea. This is very important to know since even if the diarrhoea is not really watery one, it can still be a cholera case knowing that more than 80 people infected with cholera remain asymptomatic or mildly-symptomatic (Adagbada et al, 2012;

Moore, 2016). The identification of contact with people suffering from diarrhoea as one of the cholera risk factors in the current study had already been done 14 years ago in Mbuji-Mayi during the previous cholera outbreak of 2002-2004 (Mbuyi, 2003). This risk factor has also been identified in other countries such as India (Sur et al., 2005); in Papua New Guinea (Rosewell et al., 2011); in Haiti (Grandesso et al., 2014); in Benin (Senoumantin et al., 2017) and in Ethiopia (Abduilhafiz et al., 2019).

Attendance at a funeral was also among identified cholera risk factors in this study, thus confirming information available in the literature. Indeed, participating in funerals in Africa is often an opportunity for affected relatives to manipulate the bodies of the deceased during certain traditional rites. However, the bodies of people who have died from cholera are known to be highly contaminating for those who handle them (Lamond & Kinyanjui, 2012). Moreover, the first major cholera outbrek of 2002-2004 in the KOR province had already spread during funeral rites (Bompangué, 2009) following the death of a person who contracted the disease from Katanga province. In addition, the current cholera outbreak (2018) in the KOR province had also index case, a woman who went to attend the funeral of a relative in the neighboring province of Lomami. The rites are so ingrained in cultural mentalities in some communities that even when the securing of bodies is carried out systematically by response team's members, some families manage to circumvent the rule. In addition, it can happen that certain clothes of the deceased, contaminated with stools and vomit are discreetly kept for ritual needs while the body is handed over to the teams in charge of secure burials.

In an environment as favorable to the transmission of cholera as the KOR province and mainly the city of Mbuji-Mayi, one of the best ways to avoid the disease and limit its spread lies in knowledge, attitudes and practices of populations on the cholera prevention. And in this register, knowledge allows populations to demystify the disease and therefore to develop positive attitudes such as the correct and systematic hands washing before any meal and after leaving the toilet, defecation in appropriate latrines and exclusive consumption food that has been properly washed (if raw food) or cooked/reheated so as to no forget the exclusive consumption of potable water. This study also identified two additional risk factors, namely: not knowing how cholera is transmitted and not knowing how to prevent cholera. Similar studies conducted in Vietnam by Nguyen et al. (2017) and in Zambia by Phiri et al. (2018) also found that the absence or the inadequacy of people's knowledge of cholera during the epidemic was risk factors.

Limitation of the study

Excepted the potential exposures related to food and water consumption, environmental factors and knowledge was not assessed taking into account the spatiotemporal sequence. Since about 80% of people infected with V. cholerae are asymptomatic or mildly symptomatic (Moore, 2016) many cholera cases might have been selected as controls in the absence of a systematic laboratory confirmation.

We did not test other important individual factors identified in previous studies such as the immune system, the production of gastric acid, the nutritional status, the blood group because these data were not easy to collect. We focused on identifying the major transmission factors for cholera, mainly, the possibility of contact with water and food contaminated by vibrio (consumption of the possibly contaminated water and meals), behaviours exposing populations to the disease through unsuitable practices such as non-compliance with both personal hygiene (hand washing, treatment of drinking water) and environmental hygiene or sanitation (defecation conditions) as well as knowledge populations on cholera disease. Another risk factor that would have been of interest in this study is the non-vaccination of populations against cholera. But that was not possible because the people of KOR province have never had such a vaccine. This case-control study was launched almost 8 months after the epidemic and throughout this period, numerous communication and awareness-raising messages were sent out to the populations during response activities. These would have positively influenced certain behaviours and practices of the populations.

Conclusion

This case-controls study identified 6 independent predictors of cholera during the

2018 cholera epidemic in KOR province. The results of this study having been fully available only after the response activities in the field, their useful exploitation should make it possible to readjust the communication messages to the populations even in the post-outbreak period as the cholera control must be an ongoing activity. The two cholera vaccination campaigns that took place in this province in late 2018 and early 2019 completed the intervention package and now give the possibility for future studies on the look for cholera vaccination as potential risk factors.

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Abbreviations list

AOR	:	Adjusted Odds Ratio
CFR	:	Case Fatality Rate
CI	:	Confidence interval
COR	:	Crude Odds Ratio
DPS	:	Provincial Division of Health
FETP	:	Field Epidemiology Training Programme
GTFCC	:	Global Task Force of Cholera Control
KOR	:	Kasai Oriental
MSF	:	Medecins Sans Frontières (Doctors Without Borders)
NGOs	:	Non-Governmental Organization
OCHA	:	United nation Office for the Coordination of Humanitarian Affairs
PCC	:	Provincial Crisis committee
UNDP	:	United Nations Development Programme.
UN	:	United Nations

Figures and tables list

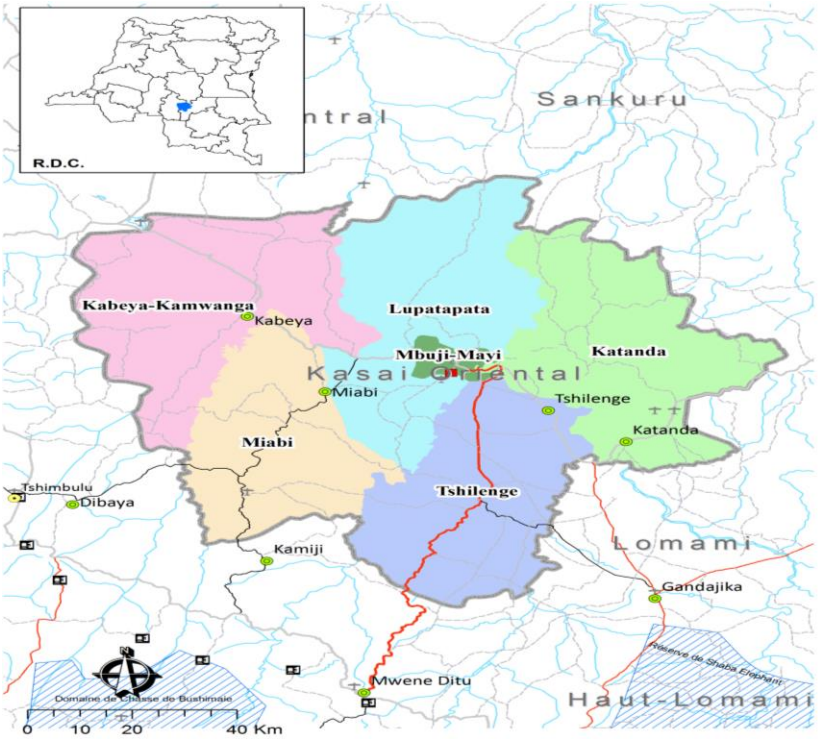

Figure 1. Map of KOR in DRC after 2015 administrative distribution (Congo Profond, 2018)

Table 1. Distribution of cases and controls to be selected randomly in each HZ, KOR province, DRC, 2018

Heath Zone of notification	Suspected cases	% cases	Number of Selected Cases	Number of Selected Controls
Kansele	2	0.3%	0	0
Lubilanji	1	0.1%	0	0
Lukelenge	7	1.0%	1	1
Mpokolo	10	1.3%	1	1
Muya	5	0.7%	1	1
Dibindi	18	2.5%	2	2
Diulu	16	2.3%	2	2
Bonzola	14	1.9%	2	2
Bipemba	25	3.5%	3	3
Nzaba	123	17.3%	13	13
Total Mbuji-Mayi City	220	30.9%	25	25
Cilundu	2	0.3%	0	0
Kabeya-Kamwanga	1	0.1%	0	0
Mukumbi	10	1.4%	2	2
Citenge	25	3.5%	3	3
Tshishimbi	52	7.3%	6	6
Bibanga	56	7.8%	6	6
Tshilenge	111	15.6%	12	12
Kasansa	236	33.1%	26	26
Total Rural HZ	492	69.1%	55	55
Total KOR province	712	100.0%	80	80

Table 2. Socio-demographic characteristics of cases and controls, cholera outbreak in KOR province, DRC, 2018

Variables	Cases	Controls	p-value
	n (%)	n (%)	(X2)
Age (years)			
<5	2(2.8)	3(3.7)	0.987
5-14	10(12.1)	9(11.8)	
15-24	25(31.2)	25(31.9)	
25-39	16(20.2)	16(19.7)	
≥40	27(33.7)	26(32.9)	
Median Age (years)	36 (Range 5-75)	35 (Range 4-77)	**0.86****
Sex			
Male	42(52.0)	42(52.0)	1.000
Female	38(48.0)	38(48.0)	
Area of Health Zone			
Mbuji-Mayi city	55(68.9)	55(68.9)	1.000
Rural area	25(31.1)	25(31.1)	
Occupation			
Mining worker	14(11.0)	11(13.7)	0.631
Farmers	20(25.2)	13(16.0)	
House workers	12(14.7)	14(17.7)	
Street vendor	7(8.3)	9(11.3)	
Student	9(10.9)	10(12.1)	
Others workers	19(23.9)	23(29.2)	
Education			
None	31(38.9)	26(33.1)	0.401

Primary	30(38.1)	26(33.1)	
Secondary	12(14.9)	18(21.9)	
Higher	6(8.1)	10(11.9)	
Number of persons in household			
Five persons and more	54(68.2)	34(42.3)	**0.001***
Less than five persons	26(31.8)	46(57.7)	

**t-test p-value

Table 3. Clinical characteristics of cases, case-controls study, cholera outbreak, OR province, DRC, 2018

Clinical information	**Cases [n (%)]**
Watery diarrhoea	
Yes	78(99.0)
No	2(1.0)
Bloody diarrhoea	
Yes	3(4.2)
No	77(95.8)
Vomiting	
Yes	53(66.7)
No	27(33.3)
Abdominal pain	
Yes	29(35.9)
No	51(64.1)
Unconciousness	
Yes	4(4.9)
No	76(95.1)
Hyperthermia	
Yes	6(8.0)
No	74(92.0)
Clinical dehydration	
None or slide	12(14.9)
Moderate	46(58.1)
Severe	22(27.0)
Duration between onset of disease and attending health care centre	
Median (Min-max)	2(1-5)
Outcome Statue	
Alive	75(93.7)
Decease	5 (6.3)

Table 4. Food consumption and water drinking exposure, case-control study, cholera outbreak, KOR province, DRC, 2018

Exposure	**Category**	**Cases**	**Controls**	**COR [95% CI]**	**p-value**
		n (%)	**n (%)**		
Grilled fish/meat on the street	Yes	4(5.0)	1(0.5)	4.15 [0.45-38.04]	0.172
	No	76(95.0)	79 (99.5)		
Cooked or grilled corn on the street	Yes	21(26.9)	10(11.5)	2.49 [1.08-5.70]	0.027*
	No	59(73.1)	70(88.5)		
Hot cooked food on the street.	Yes	1(1.0)	1(0.5)	2.01 [0.12-32.48]	1.000
	No	79(99)	79(99.5)		
Cake/bread at home	Yes	33(41.0)	30(37.0)	1.17 [0.62-2.20]	0.627
	No	47(59.0)	50(63.0)		

Raw food at home.	Yes	38(48.0)	36(44.5)	1.10 [0.59-2.06]	0.751
	No	42(52.0)	44(55.5)		
Cold cooked food at home	Yes	53(66.0)	54(68.0)	1.10 [0.50-2.10]	0.570
	No	27(44.0)	26(32.0)		
Fresh milk on the street	Yes	16(20.2)	13(15.8)	1.28 [0.57-2.89]	0.538
	No	64(79.8)	67(84.2)		
Drinking water from a river	Yes	54(67.0)	46(58.0)	1.53 [0.80-2.92]	0.191
	No	26(33.0)	34(42.0)		
Hot cooked foot at home	Yes	50 (61.2)	47(58.9)	1.10 [0.54-2.27]	0.775
	No	30 (38.8)	33(41.1)		
Cake/bread on the street	Yes	39(49.0)	36(44.5)	1.17 [0.62-6.24]	0.634
	No	41(51.0)	44(55.5)		
Pineapple or other fruits at home	Yes	7(8.5)	3(4.0)	2.46 [0.61-9.88]	0.191
	No	73(91.5)	77(96.0)		
Cooked or grilled corn at home	Yes	1(1.0)	0	-	-
	No	79(99.0)	80(100)		
Cold cooked food on the street	Yes	35(44.1)	24(30.0)	1.81 [0.94-3.48]	0.071*
	No	45(55.9)	56(70.0)		
Drinking untreated water	Yes	12(15.0)	10(12.5)	1.23 [0.50-3.05]	0.646
	No	68(85.0)	70(87.5)		
Drinking water from the well	Yes	28(35.0)	21(25.5)	1.51 [076-2.98]	0.230
	No	52(65.0)	59(74.5)		
Drinking poorly conserved water	Yes	21(26.0)	11(14.0)	2.23 [0.99-5.93]	0.048*
	No	59(74.0)	69(86)		
Drinking water sold on the street	Yes	25(30.6)	9(11.3)	3.59 [1.55-8.30]	0.002*
	No	55(69.4)	71(88.7)		
Pineapple or other fruits on the street	Yes	26(32.5)	18(22.0)	1.65 [0.82-3.35]	0.156
	No	54(67.5)	62(78.0)		
Fresh milk at home	Yes	0(0.0)	1(1.0)	-	-
	No	80(100)	79(99.0)		
Chikwange (local cassava) on street	Yes	7(9.0)	6(7.5)	1.18 [0.38-3.69]	0.772
	No	73(91.0)	74(92.5)		

COR=Crude Odd ratio CI: Confidence interval *p<0.1

Table 5. Environmental and behavioural exposure, cases-controls study, cholera outbreak, KOR province, RDC, 2018

Exposure	**Category**	**Cases**	**Controls**	**COR [95% CI]**	**p-value**
		n (%)	**n (%)**		
Habitations in flood zones	Yes	2(3.0)	1(1.0)	2.03 [0.18-22.80]	0.560
	No	78(97.0)	79(99.0)		
Washing clothes in river/lake	Yes	6(8.0)	6(7.5)	1.07 [0.44-2.62]	0.918
	No	72(92.0)	72(92.5)		
Conserving water in bowl > 3 days	Yes	1(1.0)	1(0.5)	2.01 [0.12-32.48]	1.000
	No	79(99)	79(99.5)		
Systematic hand washing after toilet	Yes	30(37.0)	33(41.0)	0.85 [0.52-1.39]	0.505
	No	50(63.0)	47(59.0)		
Systematic hand washing before eat	Yes	38(48.0)	35(44.5)	0.77 [0.48-1.25]	0.288
	No	42(52.0)	45(55.5)		
Participated in mass gatherings	Yes	21(26.0)	12(14.5)	2.02 [0.91-4.44]	0.078
	No	68(74.0)	68(85.5)		

Washing cooking tools in lake/river	Yes	22(26.9)	18(22.5)	1.53 [0.65-5.04]	0.081*
	No	58(73.1)	62(78.5)		
Carried drinking water lac/river	Yes	26(33.4)	21(25.7)	1.35 [0.68-2.68]	0.385
	No	54 (66.6)	59(74.3)		
Correct hand washing with soap or chlorine	Yes	30(37.5)	32(40.0)	0.90 [0.48-1.70]	0.745
	No	50(62.5)	48 (60.0)		
Having contact with persons suffering of diarrhea	Yes	56 (70.0)	22 (26.7)	6.15 [3.10-12.21]	0.000*
	No	24(30.0)	58(73.3)		
Participating in funerals 5 days L.	Yes	46(58.4)	20(25.0)	4.06[2.07-27.95]	0.000*
	No	34(41.6)	60(75.0)		
Habitations close to mines sites	Yes	9(11.7)	6(8.4)	1.07 [0.74-1.56]	0.897
	No	71 (83.3)	72(91.6)		
Used home latrine for defecation	Yes	34(42.7)	27(32.7)	1.16 [0.56-28.75]	0.224
	No	46(57.3)	53(67.3)		
Used common latrine defecation	Yes	60(75.0)	44(54.3)	1.50 [1.03-2.20]	0.083*
	No	**20(25.0)**	**36(45.7)**		

COR=Crude Odd ratio CI: Confidence interval *p<0.1

Table 6. Knowledge exposure, cases-controls study, cholera outbreak, KOR province, RDC, 2018

Questions	**Category**	**Cases**	**Controls**	**COR [95% CI]**	**p-value**
		n (%)	**n (%)**		
How to contract cholera	Don't know	22(28.3)	6(6.7)	4.68 [1.78-12.29]	0.000*
	Know	58(71.7)	74(93.3)		
How to protect from cholera	Don't know	38(46.9)	22(27.9)	2.38 [1.23-4.60]	0.009*
	Know	42(53.1)	58(72.1)		
Can cite at least one method of water purification	No	47(58.5)	38(47.8)	1.53 [0.80-2.97]	0.283
	Yes	33 (41.5)	42(52.2)		
Ever have education on cholera 2 years ago	Don't know	42(60.0)	45(55.5)	1.17 [0.43 -3.50]	0.174
	Know	32(40.0)	35(44.5)		
Know how to do in if contracted cholera	Don't know	50(61.1)	38(47.4)	1.75 [0.90-3.27]	0.094
	Know	30 (38.9)	42(52.6)		

COR=Crude Odd ratio CI: Confidence interval *p<0.1

Table 7. Independent risk factors, cases-controls study, cholera outbreak, KOR province, RDC, 2018

Exposure	**Category**	**COR [95% CI]**	**p-value**	**AOR [95% CI]**	**p-value**
Number of persons in household	≥5	2.81 [1.47-5.35]	0.001	2.99 [1.88-6.22]	<0.001**
	<5				
Cooked or grilled corn on the street	Yes	2.49 [1.08-5.70]	0.027	2.22 [0.62-5.99]	0.418
	No				
Cold cooked food on the street	Yes	1.81 [0.94-3.48]	0.071	1.92 [0.84-3.48]	0.171
	No				
Drinking poorly conserved water	Yes	2.23 [0.99-5.93]	0.048	2.99 [0.89-5.93]	0.078
	No				
Participated in mass gatherings	Yes	2.02 [0.91-4.44]	0.078	2.52 [0.89-5.47]	0.083
	No				
Drinking water sold on the	Yes	3.59 [1.55-8.30]	0.002	4.29 [1.85-10.30]	<0.001**

street	No				
Washing cooking tools in lake/river	Yes	1.53 [0.65-5.04]	0.081	2.62 [0.45-5.17]	0.832
	No				
Having contact with persons suffering of diarrhea	Yes	6.15 [3.10-12.21]	0.000	7.15 [2.10-17.21]	<0.001**
	No				
Participating in funerals 5 days before unset	Yes	4.06 [2.07-27.95]	0.000	5.16[3.01-29.95]	<0.001**
	No				
Used common latrine for defecation	Yes	1.50 [1.03-2.20]	0.083	1.60 [0.53-2.80]	0.242
	No				
How to contract cholera	Don't know	4.68 [1.78-12.29]	0.000	5.78 [2.38-18.10]	0.003**
	Know				
How to protect from cholera	Don't know	2.38 [1.23-4.60]	0.009	2.49 [1.73-5.20]	0.014**
	Know				

COR: Crude Odds Ratio AOR: Adjusted Odds Ratio IC: Confidence Interval **p<0.05

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