Environmental factors associated with increased cholera cases in low-income districts in Zambia, 2017-2018

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ABSTRACT

Introduction: Zambia is a cholera-endemic country and the epidemic in the capital, Lusaka, 2017-2018, caused more than 5,900 cases and 110 deaths. Low-income resident districts in Lusaka are known as hotspots for cholera outbreaks. Among these districts, Kanyama sub-district has been the origin of the outbreaks in Lusaka, 2005-2006, 2016, and 2017-2018. However, spatial factors are associated with the increased number of cholera cases in the Kanyama sub-district; the origin place is still not fully understood. We determined the environmental factors associated with the increased cholera cases in the Kanyama sub-district by using geocoordinate data collected during the outbreak in 2017-2018. **Methods:** We conducted a retrospective data analysis on geocoordinate data of houses of cholera cases identified in Kanyama sub-district during the outbreak in 2017-2018. Associations between the number of cases in each of the 218 generated zones within Kanyama sub-district and the distribution of environmental factors (e.g., water sources, toilets) were analyzed. **Results:** A total of 405 cholera cases were identified in 136 zones (62%, 136/218). Zones with cases had significantly larger numbers (median, interquartile range; IQR) of toilets outside houses (56.5, 0-256; vs 35.5, 0-151; $p<0.001$) and pit latrines (51, 0-194; vs 28; 0-117; $p<0.001$), while significantly smaller number of water tanks than zones without cases (0, 0-21; vs 0.5, 0-19; $p=0.021$). The number of cases showed a positive correlation with the number of toilets outside houses (rho=0.307, $p<0.001$) and pit latrines (rho=0.354, $p=0.001$). **Conclusion:** Lack of access to sanitary toilet facilities was associated with the increased number of cholera cases in Kanyama sub-district; the origin place of the recent cholera outbreaks in Lusaka, Zambia. Our study highlighted the importance of targeted public health interventions to the sanitation systems in those areas.

KEYWORDS: Evaluation, Surveillance Tuberculosis, system attributes

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Introduction

Cholera is an acute diarrheal infection caused by the bacterium toxigenic *Vibrio cholerae (V.cholerae)*, which remains a major public health issue in Africa [1]. Zambia has been affected by repeated epidemics of cholera since 1977, and the nationwide epidemic in 2017-2018 caused more than 5,900 cases and 110 deaths [2,3]. The capital city Lusaka was reported as one of the hot spots for cholera outbreaks, and residents in some of the low-income resident districts in the city were suggested as being at high risk for cholera infections [2,4]. Notably, one of those districts in a peri-urban area of Lusaka (i.e., Kanyama sub-district) was reported as the origin of the recent major outbreaks in 2005-2006, 2016, and 2017-2018 [4,5]. A case-control study for cholera cases and their neighbours in Lusaka during the 2017-2018 outbreak has revealed poor sanitation and hygiene practices as potential risk factors for acquiring cholera infections at individual levels [6]. Conversely, despite the significant roles of the Kanyama sub-district for the onset and spread of cholera outbreaks in Lusaka, environmental factors associated with the increased number of cholera outbreaks in the area have not been clarified. In the study, we determined the environmental factors associated with the increased number of cholera cases in the Kanyama sub-district by using geocoordinate data collected during the outbreak in 2017-2018.

Methods

Study setting

The study was conducted using data collected during the cholera outbreak response which was implemented by the Zambia National Public Health Institute (ZNPHI) and the Zambia Ministry of Health (MoH) in 2017 and 2018.

Case definition and study population

During the cholera outbreak, patients presenting three or more events of acute "rice water" diarrhoea within 24 hours were defined as suspected cholera cases, and those who tested positive for V. cholerae O1 by culture using Thiosulfate-citrate-bile salts-sucrose (TCBS) agar and serotyping was defined as confirmed cholera cases [7]. In the study, suspected cholera cases identified in Kanyama sub-district, which is located on the west outskirts of Lusaka, Zambia, between 1 October 2017 and 31 May 2018 were categorized as cholera cases.

Cholera cases with available geocoordinate data of their houses were included for analysis. Geo-coordinate data of houses of cholera cases, water sources, toilets, waste collection sites, and flooded wetlands (i.e., areas covered by water after heavy rainfall) were collected by using global positioning system (GPS) during the physical visits of public health workers, which was implemented by the ZNPHI and the MoH [3].

Data analysis

A digital map of the Kanyama sub-district was developed using QGIS version 3.10 A Coruna (**https://qgis.org/en/site/**). Boundaries were drawn along the streets to divide the Kanyama sub-district into small zones with 1-10 small blocks, by which a total of 218 zones were generated (**Figure 1A**). The number of cholera cases, water sources, toilets, and waste collection sites, as well as the area of flooded wetlands per zone, were plotted using QGIS.

Statistical analysis was carried out by using R version 3.5.0 (R Foundation for Statistical Computing, Vienna, Austria). A Wilcoxon rank sum test was used to explore the distribution of environmental factors between zones with at least one cholera case (i.e., zones with cases) and those without any cases (i.e., zones without cases). Spearman´s rank correlation coefficient was calculated to explore the relationship between the number of cholera cases and the independent factors (number of water sources, toilets, waste collection sites, and the area of flooded wetlands per zone). The correlation coefficient which was higher than +0.3 or lower than -0.3 was regarded as being correlated [8]. A p-value less than 0.05 was considered statistically significant.

Ethical Consideration

Ethical clearance for the use of patients´ data collected as part of the public health response of ZNPHI and MoH for scientific analysis and publication was obtained from the National Health Research Authority, Zambia (reference number NHRA000054/30/03/2022). Geo-coordinate data of the household was handled carefully as it was private information of the cases. Data was deidentified and data analysis was conducted on password-protected computers.

Results

A total of 405 cholera cases with geocoordinate data of their houses were identified in the Kanyama sub-district between October 2017 and May 2018. One or more cholera cases were identified in 136 zones (62%, 136/218) (**Figure 1B**). The median number (interquartile range; IQR) of water tanks were significantly smaller in zones with cases than those without cases (0, 0-21; vs 0.5, 0-19; p=0.021) (**Table 1**). Among the 6 types of toilets, the number (median, IQR) of toilets outside houses (56.5, 0-256; vs 35.5, 0-151; p=0.0001) and pit latrines (51, 0-194; vs 28; 0-117; p<0.001) were significantly larger in zones with cases than those without cases (**Table 1**). Among the 4 types of waste collection sites, none of them showed

significant differences in the distribution of cholera cases (Table 1). The area of the flooded wetlands per zone was not significantly different between zones with cases and those without them (Table 1).

In addition, we explored the associations between the increased number of cholera cases and the distribution of environmental factors (i.e., the number of water sources, toilets, and waste collection sites, and the area of flooded wetlands per zone). Among the 6 types of toilets, the number of toilets outside houses (rho=0.307, p<0.001) and pit latrines (rho=0.354, p<0.001) were positively correlated with the number of cases per zone (Table 2). The number of any types of water sources and waste collection sites, and the area of flooded wetlands did not show significant correlations with the number of cases per zone (Table 2).

Discussion

We explored the environmental factors for the increased number of cholera cases in the Kanyama sub-district; a low-income resident district, which has been the origin of the recent cholera outbreaks in Lusaka, Zambia. Distributions of toilets outside houses and pit latrines were significantly correlated with the identification of cases and the increased number of cases in each zone. It suggested that a lack of access to sanitary toilet facilities was associated with an increased risk for transmission of cholera in the Kanyama sub-district. Our results were in line with a previous study which reported that households without latrines were at higher risk for cholera infections in Lusaka [9]. Our study further demonstrated that a lack of access to sanitary toilet facilities was also associated with the increased number of cholera cases in the origin place of the whole outbreaks in Lusaka.

The effectiveness of improving sanitation systems in reduction of the cholera incidence has been demonstrated in previous studies in different parts of the world [10]. Despite the intensive public health interventions to improve the sanitation systems that have been made in Lusaka, a lack of access to those systems was reported as one of the potential risk factors for cholera outbreaks in the study, which was suggestive of the difficulties in maintaining those systems and eliminating the risks of cholera outbreaks in those areas. Regular monitoring and improvement of the sanitation systems might be necessary especially for those low-income resident districts to prevent the onset and spread of cholera outbreaks.

Meanwhile, the distribution of water tanks, which were built as part of the public health response during the outbreaks in 2017-2018, was negatively associated with the number of cholera cases in the area. Our results highlighted the importance of safe water supplies to prevent the transmission of cholera in low-income resident districts.

Limitations of our study include the study design being an ecological study with a limited number of cholera cases with their household locations available. Analysis with an increased number of cases with geo coordinates might help understand the overall geographical distribution patterns of cases and spatial risk factors in the Kanyama sub-district. In addition, the effect of the methodology of manually creating boundaries on the analysis output cannot be fully ruled out. However, it was assumed to be minimal as we obtained similar results using multiple types of boundaries generated through the same methodologies.

Conclusion

A lack of access to sanitary toilet facilities was shown to be associated with the increased number of cholera cases in a low-income resident district (i.e., Kanyama sub-district), which has been the origin place of the recent cholera outbreaks in Lusaka, Zambia. Further studies using additional data (e.g., an increased number of cases with geocoordinates, and water source test results) are required to fully define the risk factors for the spread of cholera outbreaks in those low-income resident districts to suppress future cholera outbreaks.

What is known about this topic

- Poor sanitation and hygiene practices were reported as potential risk factors for acquiring cholera infections at individual levels during the cholera outbreak in Lusaka, Zambia, 2017-2018
- One of the low-income districts in a peri-urban area of Lusaka (i.e., Kanyama sub-district) was reported as the origin of the recent major outbreaks in 2005-2006, 2016, and 2017-2018

What this study adds

- Environmental factors including a lack of access to sanitary toilet facilities were shown to be associated with the increased cholera cases in Kanyama sub-district; the origin place of the recent cholera outbreaks in Lusaka, Zambia
- The distribution of water tanks was negatively associated with the number of cholera cases in Kanyama sub-district, which highlighted the importance of safe water supplies to prevent the transmission of cholera in low-income districts

Competing interests

The authors declare no competing interest.

Authors' contributions

N.S. and T.I. were the principal investigators. N.S., O.C., P.Z., F.K., R.H., M.L., M.K., N.K., and V.M. designed the study. O.C. and F.K. collected the data. N.S., T.I., and E.S. analyzed the data. N.S. and T.I. wrote the manuscript.

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Tables and figures

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Table 2: The relationship between the number of cholera cases and associated environmental factors in Kanyama sub-district, Lusaka, Zambia
Figure 1: Distribution of cholera cases in Kanyama sub-district between October 2017 and May 2018

References

1. World Health Organization.Fact sheets: Cholera [Internet]. Geneva (Switzerland): World Health Organization; 2023 Dec 11 [cited 2024 Mar 20]. Google Scholar

2. The Ministry of Health, Zambia, Zambia National Public Health Institute, World Health Organization, Global Task Force on Cholera Control. Risk Assessment and Mapping of Cholera Hotspots in Zambia: Review of Epidemiological Data from 2016 to 2019. Lusaka (Zambia): Ministry of Health; 2020 Nov. 38 p. Google Scholar

3. Sinyange N, Brunkard JM, Kapata N, Mazaba ML, Musonda KG, Hamoonga R, Kapina M, Kapaya F, Mutale L, Kateule E, Nanzaluka F, Zulu J, Musyani CL, Winstead AV, Davis WW, N´cho HS, Mulambya NL, Sakubita P, Chewe O, Nyimbili S, Onwuekwe EVC, Adrien N, Blackstock AJ, Brown TW, Derado G, Garrett N, Kim S, Hubbard S, Kahler AM, Malambo W, Mintz E, Murphy J, Narra R, Rao GG, Riggs MA, Weber N, Yard E, Zyambo KD, Bakyaita N, Monze N, Malama K, Mulwanda J, Mukonka VM.Cholera epidemic — Lusaka, Zambia, October 2017-May 2018 . MMWR Morb Mortal Wkly Rep [Internet]. 2018 May 18 [cited 2024 Mar 20];67(19):556-9. https://doi.org/10.15585/mmwr.mm6719a5 PubMed | Google Scholar

4. Mwaba J, Debes AK, Shea P, Mukonka V, Chewe O, Chisenga C, Simuyandi M, Kwenda G, Sack D, Chilengi R, Ali M.Identification of cholera hotspots in Zambia: A spatiotemporal analysis of cholera data from 2008 to 2017 . Akullian A, editor. PLoS Negl Trop Dis [Internet]. 2020 Apr 15 [cited 2024 Mar 20];14(4):e0008227. https://doi.org/10.1371/journal.pntd.0008227 PubMed | Google Scholar

5. Sasaki S, Suzuki H, Fujino Y, Kimura Y, Cheelo M.Impact of drainage networks on cholera outbreaks in Lusaka, Zambia . Am J Public Health [Internet]. 2011 Sep 20 [cited 2024 Mar 20];99(11):1982-7. https://doi.org/10.2105/AJPH.2008.151076 PubMed | Google Scholar

6. Nanzaluka FH, Davis WW, Mutale L, Kapaya F, Sakubita P, Langa N, Gama A, N´cho HS, Malambo W, Murphy J, Blackstock A, Mintz E, Riggs M, Mukonka V, Sinyange N, Yard E, Brunkard J.Risk factors for epidemic cholera in Lusaka, Zambia-2017 . The American Journal of Tropical Medicine and Hygiene [Internet]. 2020 May 26 [cited 2024 Mar 20];103(2):646-51. https://doi.org/10.4269/ajtmh.20-0089 PubMed | Google Scholar

7. World Health Organization.Cholera Outbreak Toolbox [Internet]. Geneva (Switzerland): WHO; 2022 July [updated 2023 Dec: cited 2024 Mar 20]. 3 p. Page can be downloaded as pdf using a link at the bottom of the page. Google Scholar

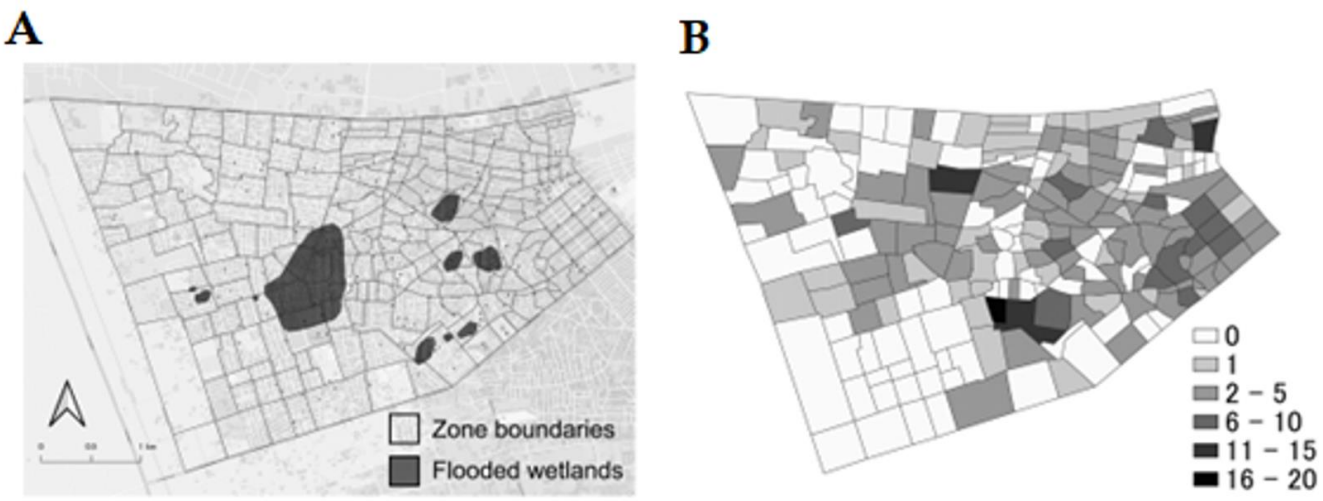
8. Akoglu H.User´s guide to correlation coefficients . Turkish Journal of Emergency Medicine [Internet]. 2018 Aug 7 [version of record 2018 Aug 23; cited 2024 Mar 20];18(3):91-3. https://doi.org/10.1016/j.tjem.2018.08.001 PubMed | Google Scholar

9. Tambatamba B, Mulenga P, Sasaki S, Suzuki H, Igarashi K.Spatial analysis of risk factor of cholera outbreak for 2003-2004 in a peri-urban area of Lusaka, Zambia . The American Journal of Tropical Medicine and Hygiene [Internet]. 2008 Sep 1 [cited 2024 Mar 20];79(3):414-21. https://doi.org/10.4269/ajtmh.2008.79.414 Subscription or purchase required to view full article. PubMed | Google Scholar

10. Pun SB.Understanding the cholera epidemic, Haiti . Emerg Infect Dis [Internet]. 2011 Aug 18 [cited 2024 Mar 20];17(11):2178-80. https://doi.org/10.3201/eid1711.110981 PubMed | Google Scholar

Table 1: Characteristics of zones with cases of *Vibrio cholerae* O1 in Kanyama sub-district			
Variables	**Zones with cholera cases**		
	Yes (n=136) *	No (n=82) *	*p*-value
Water sources			
Water tanks	0 (0-21)	0.5 (0-19)	0.021
Wells	0 (0-17)	0 (0-12)	0.825
Toilets			
Inside toilets	3 (0-82)	4.5 (0-75)	0.078
Outside toilets	56.5 (0-256)	35.5 (0-151)	0.001
Flush toilets	1.5 (0-23)	1 (0-124)	0.669
Pour flush toilets	1 (0-49)	1 (0-24)	0.458
Pit latrines	51 (0-194)	28 (0-117)	<0.001
Buckets	0 (0-18)	0 (0-9)	0.234
Waste collection sites			
Authorized waste collection sites	0 (0-12)	0 (0-19)	0.893
Unauthorized dumping holes	0 (0-3)	0 (0-4)	0.996
Unauthorized dumping sites without holes	0 (0-8)	0 (0-14)	0.372
Flooded waste dumping sites	0 (0-4)	0 (0-1)	0.676
Flooded wetlands			
Area of flooded wetlands [km^2]	0 (0-67)	0 (0-84)	0.504
* Median (interquartile range; IQR) was indicated.			

Table 2: The relationship between the number of cholera cases and associated environmental factors in Kanyama sub-district, Lusaka, Zambia		
Variables/factors	**Spearman's rank correlation coefficient**	***p*-value**
Water source		
Number of water tanks	-0.161	0.017
Number of wells	-0.050	0.456
Toilets		
Number of toilets inside houses	-0.078	0.254
Number of toilets outside houses	0.307	<0.001
Number of flush toilets	-0.014	0.836
Number of pour flush toilets	0.115	0.090
Number of pit latrines	0.354	<0.001
Number of bucket toilets	0.086	0.207
Waste collection sites		
Number of authorized waste collection sites	0.075	0.268
Unauthorized dumping holes	0.035	0.605
Unauthorized dumping sites without holes	0.109	0.110
Number of flooded waste dumping sites	-0.010	0.892
Flooded wetlands		
Area of flooded wetlands	-0.020	0.774



A: A digital map of Kanyama sub-district was developed using QGIS version 3.10 A Coruna (https://qgis.org/en/site/). Boundaries were drawn along the streets to divide Kanyama sub-district into small zones with 1-10 small blocks, by which a total of 218 zones were generated.

B: Numbers of Vibrio Cholera cases was counted for each of 218 zones in Kanyama sub-district. Numbers of Vibrio Cholera cases per zone were indicated with gradient gray scales.

Figure 1: Distribution of cholera cases in Kanyama sub-district between October 2017 and May 2018