



Impact of water and sanitation services on cholera outbreaks in sub-Saharan Africa

Cristiane D. Girotto^{1,4}, Kouros Behzadian¹, Anwar Musah², Albert S. Chen³, Aniq Ali¹, Luiza C. Campos⁴

¹ School of Computing and Engineering, University of West London St Mary's Road, Ealing, London, W5 5RF, UK

² Centre for Digital Public Health in Emergencies, Institute for Risk and Disaster Reduction, University College London, Gower St, London, WC1E 6BT, UK

³ College of Engineering, Mathematics and Physical Sciences, University of Exeter, Harrison Building, Streatham Campus, N Park Rd, Exeter EX4 4QF, UK

⁴ Dept of Civil, Environmental and Geomatic Engineering, University College London, Gower St, London WC1E 6BT
¹cristiane.girotto.19@ucl.ac.uk

Keywords: cholera outbreak; correlation; risk factors; sub-Saharan Africa; WASH;

Introduction

While most parts of the world seem to have controlled cholera, the sub-Saharan African region is still suffering with the cholera outbreaks and struggling to restrain its incidence. Recent research attributes eighty three percent of cholera deaths between 2000 and 2015 to the sub-Saharan region [1]. Poor water, sanitation and hygiene (WASH) services can be among the main risk factors contributing to the public health burden of cholera. Humans living in close proximity to one another in environments with poor hygiene conditions and little access to clean water is an explanation for how cholera takes root in non-coastal areas [2]. The combination of these factors with the vulnerability of surface and groundwater resources to faecal contamination can favour onset and propagation of outbreaks [3]. This study investigated the correlation between cholera rates per population and lack of basic services of drinking water and sanitation in the sub-Saharan African countries, where incident cases of cholera have been regularly reported to the World Health Organization (WHO) since 1991 [4].

Methodology

In this study, we aimed to inspect the relationships between cholera outbreaks and WASH services in sub-Saharan Africa in order to identify the pathways for further reducing human health risk to cholera. The availability of cholera data was a major challenge in our analysis to understand health surveillance in different countries. After an detailed analysis of available data between 1990 and 2019, we selected 13 countries shown in Figure 1 (Benin, Burundi, Democratic Republic of Congo, Ghana, Ivory Coast, Kenya, Malawi, Mozambique, Niger, Nigeria, Somalia, Tanzania and Togo) for our analysis due to consistent cholera data compared to other sub-Saharan countries. Data on WASH provision were gathered from the WHO/UNICEF Joint Monitoring Programme (JMP) [5]. The relationship between variables was analysed using Spearman's rho via the SPSS software. Spearman's rho is the best approach for the analysis due to the continuous non-parametric properties of variables.

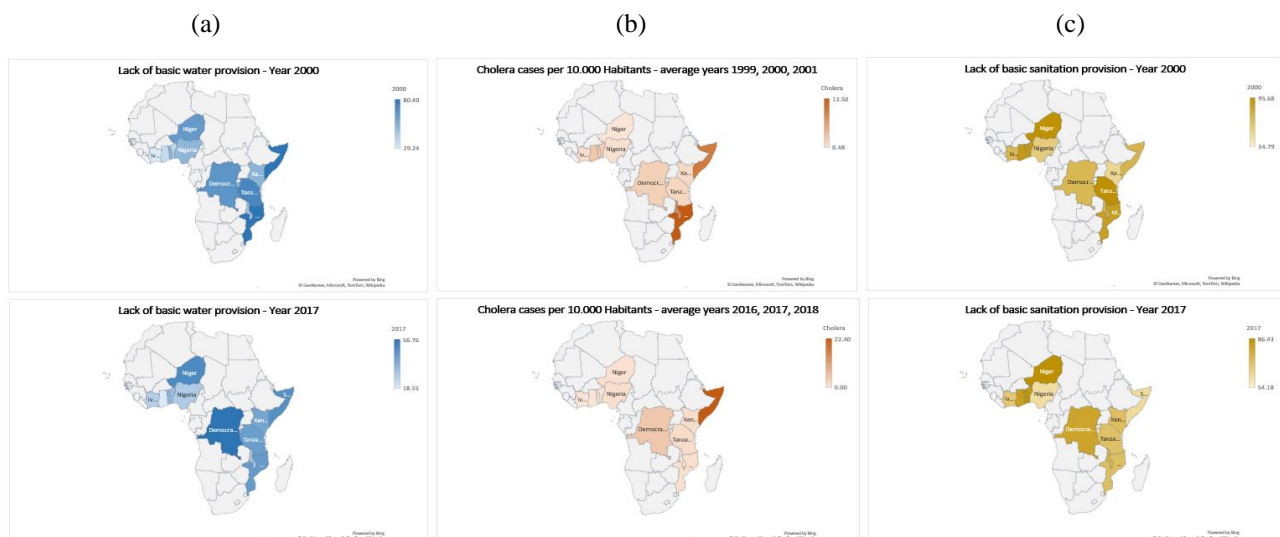


Figure 1 Comparison of (a) lack of basic water provision, (b) cholera cases and (c) lack of basic sanitation provision between 2000 and 2017 for the 13 selected sub-Saharan African countries.



Results and discussion

Figure 1 shows the colour-coded maps for comparing lack of basic water and sanitation provision, i.e. WASH, between 2000 and 2017 with cholera cases by country. The three-year average was used in the maps for cholera rates to moderate the trend of cholera reported and discard any bias towards any specific year. Most of the countries with significant improvement in WASH provision, e.g. Mozambique, Malawi, Togo, Benin and Burundi show noticeable reduction in the cholera rates. However, some countries such as Democratic Republic of Congo, Ivory Coast and Kenya with little improvement on WASH provisions or even worse conditions by 2017 have also smaller reduction in cholera cases but with a lower rate in this period. The only exception is Somalia with significant improvement in WASH facilities but still poor performance in cholera rates. This can be linked to the fact that Somalia has been in war since 1991 and hence health surveillance systems have not improved properly. Other factors such as GDP may also be impactful that need to be investigated further as it can contribute to understanding cholera risk factors.

The Spearman's analysis results show a convincing correlation between the lack of basic water provision and cholera rates for the selected countries. More specifically, while Spearman's rho greater than 0.5 indicates a strong correlation, the study discovered the associated correlation coefficient of 0.424, indicating a medium to strong association that is highly significant. The correlation could improve if more accurate and higher temporal resolution, e.g. monthly cholera cases and WASH, became available for all sub-Saharan African countries. Other WASH factors that can potentially improve the correlation include access of communities to drinking water, water sources (surface, underground and piped), quality of the water provided and sources of contamination.

An expected association between cholera rates and lack of sanitation was not detected firmly. The correlation coefficient calculated for lack of basic sanitation and cholera rates is 0.055 which is an indicator of a very weak correlation. The failure to link poor sanitation with cholera rates could have been due to the lack of data or a misunderstanding of the mechanisms and interactions of sanitation-related factors influencing cholera rates. This needs to be further investigated with more countries and a larger data base in the future.

Other environmental factors can also be included in the analysis to identify a better correlation with cholera cases. For example, climatic hazards can directly influence disease outbreaks to some extent, but more importantly, affect WASH. As a potential common factor between WASH and cholera cases, climatic hazards can influence the relationship between the two, and indirectly affect the disease infection and transmission rates. The same is likely to happen with other common factors between cholera and WASH thus requiring further investigation.

Conclusions

Although a reasonable correlation was observed between cholera cases and lack of drinking water services, there is no strong correlation for lack of sanitation services. Nevertheless, several key factors influencing cholera outbreak were unavailable in this analysis due to lack of information or not being reported due to poor or inconsistent surveillance systems in relevant health departments. To strengthen the analysis and gain better understanding of the relationships between cholera outbreak and environmental factors, we urge the applications of digital innovations to enhance the data collection for health surveillance systems. With improved data availability and quality, insightful knowledge on critical factors influencing the cholera cases will be generated to develop adaptations to mitigate its negative impacts.

Acknowledgement

The study is a part of the OVERCOME (digital innOVation in climatE hazaRd early warning and related disease prevention for COMMunity capacity building and rEsilience) project, funded by the UKRI GCRF Digital Innovation for Development in Africa (DIDA) programme (EP/T030089/1).

REFERENCES

- [1]Lessler, J., Moore, S. M., Luquero, F. J., McKay, H. S., Grais, R., Henkens, M., Mengel, M., Dunoyer, J., M'bangombe, M., Lee, E. C., Djingarey, M. H., Sudre, B., Bompangue, D., Fraser, R., Abubakar, A., Perea, W., Legros, D., & Azman, A. S., 'Mapping the burden of cholera in sub-Saharan Africa and implications for control: an analysis of data across geographical scales'. *Lancet* (London, England), 391(10133), 1908–1915, 2018. Available at: [https://doi.org/10.1016/S0140-6736\(17\)33050-7](https://doi.org/10.1016/S0140-6736(17)33050-7)
- [2]Nkoko, D. B., Giraudoux, P., Plisnier, P., Tinda, A. M., Piarroux, M., Sudre, B....Piarroux, R., 'Dynamics of Cholera Outbreaks in Great Lakes Region of Africa, 1978–2008', *Emerging Infectious Diseases*, 17(11), 2026-2034, 2011. Available at: <https://dx.doi.org/10.3201/eid1711.110170>
- [3]Rebaudet, S., Súdre, B., Faucher, B., & Piarroux, R., 'Cholera in coastal Africa: a systematic review of its heterogeneous environmental determinants' *The Journal of infectious diseases*, 208 Suppl 1, S98-106, 2013.
- [4]World Health Organization, *Weekly Epidemiology Record*, 2020. Available at: <https://www.who.int/wer/2020/en/>
- [5]WHO/UNICEF, 'Progress on household drinking water, sanitation and hygiene 2000-2017', *Joint Monitoring Programme for WASH*, 2019. Available at: https://www.who.int/water_sanitation_health/publications/jmp-report-2019/en/