



Recurrent cholera epidemics in Africa: which way forward? A literature review

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Abstract

Background Outbreaks of cholera in Africa seem to be unrelenting which has been continuous and recurrent leading to high morbidity and mortality in some quarters.

Objective The objective of this narrative review is to investigate and identify factors responsible for the recurrent outbreaks of cholera in Africa and response strategies that have been employed in curbing the problem, with the view of aggregating otherwise sparing data needed for policy formulation geared towards control and eradication of the disease.

Methods Search of literatures indexed in Google Scholar, PubMed and AJOL databases was carried out. Sixty-five eligible articles with reports on the risk factors that drive recurrent outbreaks, endemicity and response strategies were analyzed.

Results Our findings indicate that continuous and recurrent outbreaks of cholera in Africa are fueled by cross-border migration, environmental reservoirs, socioeconomic factors, climate change and political instability. The review also identified specific response strategies and modelling approaches that have helped in containing and reducing the impact of these outbreaks.

Conclusion Paying attention and tackling these identified factors that are dependent and independent can help put an end to this running battle.

Keywords Africa · Cholera · Endemic · Risk factors · *Vibrio cholerae*

Introduction

The global burden of cholera is estimated to be between 1.4 and 4.3 million cases with about 21,000–143,000 deaths per year [1]. Cholera is a gastrointestinal infection caused by *Vibrio cholerae* a Gram-negative comma-shaped rod bacterium. Over 200 serotypes have been identified with two, the O1 and O139, playing a major and active role in outbreaks [2]. *V. cholerae* O1 is classified as classical or El Tor biotypes considering phenotypic characteristics. However, on the basis of antigenic determinants of its O antigen *V. cholerae* can be serogrouped into Inaba and Ogawa. The El Tor strains tend to spread easily, cause severe infection and is suspected to be linked with increased frequency of asymptomatic infections [3, 4]. *V. cholerae* is primarily

domicile in estuaries and salty coast waters with the potential of assuming a viable but non-culturable state within biofilm when nutrients are depleted and in response to adverse environmental conditions [5]. Beside these pathogens' ability to survive in hostile environments, it has acquired and developed antibiotic resistance through superintegron (SI) in its genome to various classes of antibiotics including sulfonamides (sulfamethoxazole–trimethoprim), quinolones (ciprofloxacin), aminoglycoside (streptomycin), chloramphenicol and azithromycin [3]. With an infectious dose of 10³–10⁸ *V. cholerae* cells, a cholera infection could ensue within an incubation period of less than 24 h–5 days [6, 7]. Cholera infection is characterized by profuse diarrhea, dehydration and eventual death if there is no prompt intervention. The mode of transmission of cholera is through the fecal–oral route which is most of the time tied to consumption of contaminated water especially in developing countries [8]. The origin of this disease has been traced to the Ganges Delta of India and has since been disseminated worldwide leading to seven identified pandemics and varied epidemics across several regions of the world [9]. Africa has not been spared from these as cholera epidemics is a

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recurrent public health challenge among poor communities with little or no access to clean drinking water and waste disposal systems. In some cases, sporadic outbreaks have been recorded while there have been major epidemics in recent times. Prompt detection, rapid response, provision of portable water, sanitation and administration of oral rehydration solution (ORS) or intravenous fluid are some of the basics in the control and management of cholera outbreaks that cannot be overlooked [10]. Vaccination has also been employed in the control and prevention of cholera. Two major vaccines, Dukoral (WC-rBS killed whole monovalent O1 vaccine) and Shanchol (WC, killed modified whole cell bivalent O1 and O139 vaccine), have been made available in endemic countries [7]. Mengel et al. [11] reported cholera in Africa and pointed out factors that amplify persistent outbreak and discussed control and management approach. However, in this review of factors that encourage recurrent outbreaks and endemicity, specific response/management approaches have been adapted by various countries in response to outbreak. This is important because geographical, cultural, socioeconomic variations and level of literacy are different, hence modelling approaches in tackling cholera to suit regional or traditional settings could be the way forward. This is not to say that the WHO guideline on ending cholera should not be followed. With the running battle of African states against cholera, it is imperative to highlight the causes of the recurrent epidemics, appraise control measures and possible eradication strategies. Hence, this review seeks to breach the knowledge gap, and identify effective applicable response, control and eradication strategies by conducting a review of the literature on available reports of cholera epidemics in Africa to provide data that will inform policy in the area of prevention, control and possible eradication.

Search strategy

Available reports on cholera outbreaks in Africa were searched in PubMed, African Journals Online (AJOL) and Google Scholar using words and phrases such as “cholera in Africa”, “cholera epidemics in Africa”, “cholera outbreaks in Africa”, “control of cholera in Africa”, and “risk factors associated with cholera outbreaks in Africa”. Also a sub-regional search based on the United Nations sub-regional division of Africa (North Africa, Southern Africa, East Africa, West Africa and Central Africa) using the above-mentioned search strings was done. Search results were restricted to publications from January, 1970 to August, 2017 based on the fact that major large and initial outbreaks of cholera in most African countries occurred around the early 1970s. Articles were included in the study based on the following inclusion and exclusion criteria:

Inclusion criteria

1. Articles published between January, 1970 and August, 2017
2. Articles that reported outbreaks, case fatality, emergency response and control strategies
3. Articles that captured all members of the affected population.

Exclusion criteria

1. Articles published before 1970
2. Articles that were not Africa centric
3. Articles that reported cholera outbreaks with other diarrheal diseases
4. Articles that focused on specific groups of the population.

Retrieved articles were sorted and double entries were eliminated; after which data were extracted from included articles and analyzed. One thousand seven hundred and sixty-three articles were retrieved, and after elimination of duplicate studies and screening of other articles 65 eligible articles were included in the review.

Central Africa

Recurrent and continuous outbreak of cholera in countries of the Central Africa sub-region is widespread. In Angola, cholera outbreak of 1987 recorded 16,222 cases with 1460 deaths. This outbreak occurred after several years of absence [12, 13]. After a recurrent outbreak till 1988, there seemed to be a break between 1997 and 2005, before another outbreak emerged in 2006 which was the most severe outbreak ever. In Cameroon like most other African countries, initial report of cholera outbreak was in 1971 with recurrent outbreaks till now. The most severe outbreak was recorded during the 2010 and 2011 outbreak [14, 15]. The outbreak recorded 23,152 cases with 843 deaths. Identified risk factors responsible for the recurrent outbreaks include coastal areas open to the ocean that are subject to regular flooding and trans-border migration. Most outbreaks in Cameroon started from Bepanda, a suburban overcrowded neighborhood in Douala, also identified was the presence of *V. cholerae* in wells and streams during and after the rainy season which could be linked to the perpetual endemicity of cholera in this region [16]. In the far northern region of Cameroon, a reported epidemic of 2009 had a case fatality rate of 12% and this was attributed to lack of, or inability to access health care facilities [17]. Nsagha et al. [15] in a similar study in Buea health district also identified poor food preservation methods, lack of portable water and irregular water supply as independent risk factors of cholera epidemic. However, the lack of concrete understanding of the epidemiology of the disease coupled with the diversity of Cameroon's climate

subzone, recurrent nature of outbreaks tends to be an enigma [18]. Iterative cholera outbreaks with seasonal peaks are also a common phenomenon in the Democratic Republic of Congo (DRC). Several outbreaks have been recorded since the 1970s with the great lake region and most especially the eastern DRC being a consistent reservoir for transmission [19]. However, a 10-year hiatus was observed in Kinshasa between mid-2001 and 2011 when cholera reemerged [20]. The endemicity of cholera in the DRC has been linked to a potential *V. cholerae* reservoir in the Rift Valley Lake with concomitant dissemination by the fishing industry [21] based on migratory patterns of local fishermen. Also interruptions in water supply exacerbated the cases of cholera as observed by Jeandron et al. [19]. They observed that in south Kivu province following a day without tap water supply, suspected cholera incidence rate increased by an average of 155% in 12 days. Bompangue et al. [22] analyzed a link between complex emergencies (war and volcanic eruption) and cholera epidemics. It was revealed that even with the persistence of cholera in Kivu there was systematic cholera epidemics post-complex emergency event; however, some aided in the spread of cholera.

East Africa and Southern Africa

The pattern and parameter that drives cholera outbreak in Uganda is nothing different from those identified in DRC (Central Africa sub-region). There has been periodic outbreak of cholera in Uganda since 1971. In Uganda, the highest risk areas identified include slums of Kampala and areas that share border with DRC, Sudan and Kenya. Tracking and containing of sporadic and recurrent cholera outbreaks could be an uphill task because the movement of humans and animals in identified endemic and epidemic areas is high. An estimated 11,000 cholera cases occur in Uganda yearly, with 61–182 deaths [23]. This is conversely in relation to the cholera surveillance in Uganda between 2007 and 2011 reported by Bwire et al. [24]. The 5-year review showed a decline in cases reported. This could be a direct reflection of the effect of the Uganda government's effort in education and proper sanitization of communities. Cummings et al. [25] reported a cholera outbreak among semi-nomadic pastoralists in northern Uganda. A multi-variate analysis revealed factors including residing in the same household as another cholera case, eating road side food, not disposing of children's feces in a latrine and not treating drinking water with chlorine. The outbreak was presumably linked to drinking water obtained from Lake that was contaminated by feces [26]. Contaminated drinking water source does not only result in cholera outbreak but also fester persistence and prolonged outbreaks. Kwesiga et al. [27] reported a cholera outbreak that lasted for 3 months with over 100 confirmed infections. This long-span outbreak was

linked to drinking water source contaminated by fecal matter and cross-border trading. Apart from community outbreaks, in 2008 a unique cholera outbreak was confirmed at a national mental referral hospital in Uganda with a case fatality rate (CFR) of 28% compared to 2.4% national average for cholera outbreak in communities. This report suggests that nosocomial-related outbreak has a profound consequence than community outbreaks. Another factor that has been fingered in the endemicity of cholera in East Africa is the El Niño phenomenon, which increases rainfall and flooding that inadvertently results in outbreaks. Implication of El Niños in cholera outbreaks has been reported in Uganda; Alajo et al. [28]; Nkoko et al. [29], Tanzania; Reyburn et al. [30]. The El Niño phenomenon has practically resulted in a shift of cholera burden to East Africa, with a threefold increase in El Niño-sensitive regions [31]. Apart from increasing levels of rainfall in the East African region, El Niño has also induced drought which has triggered a severe outbreak of cholera in Somalia. The drought-hit Somalia has recorded 51,000 infected cases and 782 deaths since the start of 2017. An outbreak that is considered as unprecedented as 75% of the country has been affected [32, 33].

Traerup et al. [34] evaluated the cost of climate change as it relates to the burden of cholera outbreak in Tanzania. Results showed a significant relationship between temperature and cholera outbreak. Thus noting that for a degree centigrade elevation in temperature, there is the initial relative risk of cholera increasing by 15–29% and the total costs of cholera attributed to climate change were estimated at about 0.32–1.4% of Tanzania's gross domestic product (GDP) by the year 2030. Tanzania has been reporting cholera outbreak since 1977 with *V. cholerae* O1, Ogawa strains being the major culprit [35, 36]. Penrose et al. [37] reported informal urban settlements in Dar es Salaam, Tanzania, as a risk factor that encouraged outbreaks. It was observed that cholera incidence was mostly closely associated with population density, informal housing and income levels of informal residents. This brings to bare the huge housing deficit in Africa which promotes disease outbreaks. However, Kachwamba et al. [38] reported distinct strains of *V. cholerae* O1 causing outbreaks in two separate outbreaks 4 months apart thus establishing the fact that genetically related *V. cholerae* cluster in outbreaks could be distinct strains which circulate simultaneously. Water bodies were once again identified by Hounmanou et al. [39] as an important reservoir and source of transmission of *V. cholerae* O1 in Tanzania when they determined the presence of toxigenic *V. cholerae* O1 in vegetables and fish raised in wastewater during a non-cholera outbreak period.

Another East African country that has also suffered from recurrent outbreaks of cholera since it was first reported in 1977/1978 and a more recent outbreak reported in 2016 is Zambia [40, 41]. The epidemiology of cholera in Zambia is

not ambiguous; however, it is associated with identified risk factors such as poverty, rural–urban migration, poor sanitation and lack of portable water. Chirambo et al. [40] reported a 62-year-old woman that migrated from a cholera outbreak zone in Lusaka to Chibombo district in Central Zambia which resulted in an outbreak in the district. As observed in Tanzania, the influence of varied climatic condition evaluated by Fernandez et al. [42] revealed the influence of temperature and rainfall on the evolution of cholera epidemics in Lusaka Zambia. A 1 °C rise in temperature prior to an outbreak increased the number of cholera cases. From 2003, the region has had a progressive increase in annual cholera outbreak incidence. As in 2010, 6794 cases with a CFR of 1.6% was reported in Lusaka [41]. Phiri et al. [43] identified factors that were associated with recurring cholera outbreak in Sinazongwe district of southern Zambia. It was revealed that most households access water from surface sources such as rivers, lakes and streams with increased rainfall being perceived as contributing factors to outbreaks.

Mozambique is another cholera endemic zone which is plagued yearly by outbreaks occurring with a seasonal pattern (December–June) with 2009 outbreak accounting for one-third to one-fifth of all cases reported in Africa, 19,679 cases were reported with 155 deaths [13, 44]. Gujral et al. [45] evaluated epidemiologic patterns of cholera outbreaks in Mozambique and reported a wide-spread cholera outbreak of short courses involving distinct spatial clusters which comprised inland, coastal, rural and urban populations. The rainy season was a factor which was identified as coinciding with the outbreaks. Also an average of 0.96 CFR was recorded in the years 2000 and 2009. The two-decade study by Langa et al. [44] showed two different genetic profiles of epidemic strains of 1997–1999 and a strain with genetic background related to the pandemic strains currently active around the world. Zimbabwe recorded an unprecedented cholera outbreak with over 4000 deaths with more than 60% deaths occurring at community level between August 2008 and July 2009. Majority of deaths occurred in communities outside areas with health facilities [46]. Most hit communities were Chipinge and Chiredzi in the South-East of the country close to the Mozambique border [47]. The Massive death toll steamed from failure in urban environmental health and planning which comprised inadequate safe and clean water in most suburbs, collapse of waste management system and poor performance of the health care sector [48]. As reported by Mutonga et al. [49], cholera is among a list of major diseases of public health concern in Kenya, with multiple cholera outbreaks recorded since 1971. The 14-year (1997–2010) surveillance report gave suspected clinical cases to be 68,522 and 2641 deaths with a CFR of 3.9%. The disease is endemic in some areas in Kenya which can explain the recurrent outbreaks experienced. Saidi et al. [50] characterized 81 *V. cholerae* isolates and found that *V.*

cholerae O1 El Tor variants carrying the classical *ctxB* gene sequence was dominant which displayed intermediate resistance to nalidixic acid, chloramphenicol and imipenem in the Nyanza (cholera endemic grate lake region) cholera outbreak of 2007–2008; though the reported predominant circulating strain from the national surveillance data from 2007 to 2010 was *V. cholerae* O1 serotype inaba [49]. Stoltz et al. [51] investigated the interaction between climatic, environmental and demographic factors on cholera outbreaks in Kenya. Results revealed that in Kenya there was an increased risk of cholera outbreaks when a greater proportion of the population lived more than 5 km from a health facility, proximity to a water body, high volume of rainfall between April and June. However, unlike other East African countries, there was no perceivable association between cholera and poverty, waste disposal methods, population density and rainfall between the first quarter of the year and from July to September. Feikin et al. [52] identified water hyacinth (a floating aquatic plant) as a key factor that might be the driving force behind persistent and recurrent outbreak of cholera in Kenya and East Africa at large. Determining statistical associations between annual variables such as cholera cases, temperature, water hyacinth coverage and rainfall, it was revealed that there was a correlation between peak cholera years and greatest hyacinth coverage while there was no hyacinth observed at all during a period (from early 2002 through late 2005) without cholera.

The first report of cholera in South Africa was in the early 1970s. From 1980 to 1987, South Africa recorded a cholera outbreak with 25,251 cases and CFR of 1.4% [53]. However, the case fatality rate (0.5%) of the 2008–2009 cholera outbreak that affected all nine provinces of South Africa showed a drastic reduction in CFR in contrast to that previously documented. Majority of strains implicated in this outbreak were characterized as serotype Ogawa [54]. In Malawi, the first reported cholera case was in 1973, with a major outbreak in 1989 and 1990 with 21,808 cases, 497 death and CFR of 2.3%. Malawi experienced recurrent yearly outbreaks with the highest outbreak recorded in 2001/2002. However, there was a drop in CFR of 2.3% recorded in 2001/2002 outbreak compared to the 2011/2012 outbreak that had a CFR of 2.1% [55, 56]. As noted from other regions in Africa living around water bodies is a major risk factor. This was evident in the 2009–2010 outbreak in Malawi where people living around Lake Chilwa had the highest attack rate. It was observed that the number of cholera cases decreased with increasing distance from the lake [57]. Unlike other countries in Africa that recorded the presence of cholera in the early 1970s, Namibia reported her first outbreak in 2006/2007 with over 250 cases which occurred in the northwestern part of the country that borders Angola. This brings to bear the role that cross-border migration play in the dissemination of the pathogen [58].

West Africa

West Africa has also been plagued by cholera since the 1970s. Both coastal and inland areas of West African states have suffered the recurrent bout of cholera outbreaks since the first confirmed report of cholera in Ghana in 1970. It has become endemic with regular epidemics with a large number of reported cases as evident in the 26,924 cases and 620 deaths reported to the WHO between 1999 and 2005 with an annual average of 3066 cases since 2000 [59, 60]. Eibach et al. [60] reported one of the largest outbreak in Ghana in recent times with over 20,000 cases. Results of findings revealed the environment as an endemic reservoir with *V. cholerae* strains with different genetic background and selective pressure favoring the evolution and emergence of strains in each outbreak period. Like in other African settings, lack of proper waste disposal is connected to outbreaks in Ghana. This was substantiated by Osei and Duker, [59] in their report of the spatial dependency of *V. cholerae* prevalence on open space refuse dumps in Kumasi. Acquah et al. [61] reported a cholera outbreak with case fatality of 5.9% following a marriage ceremony in Mediya, Western Ghana. The outbreak was pinned to the consumption of fufu and groundnut soup. It was observed that in the environment there was open defecation and poor personal hygiene. Cote d'Ivoire has reported cases of cholera each year ranging from 37 to 4993. During the largest outbreak in the country, a CFR of 5.44% was reported [62]. Traore et al. [63] linked the risk of *Vibrio* transmission to the consumption of crustaceans. In Nigeria, both the coastal areas and Northern Savanna have had recurrent cholera outbreaks since it was first recorded late 1970. These outbreaks have been of sporadic, endemic and epidemic proportions with CFR of 12.8% (1971), 12.9% (1991) and 4.1% (2010). A 2014 outbreak of cholera in Kaduna state in northwest Nigeria recorded 1468 case patients and 54 deaths with a CFR of 3.68% and lasted for over 33 weeks. Though the CFR of 2010 was lower than that of previous outbreaks, it was one of the largest outbreak in Africa and the circulating strains mostly in the north-eastern part of the country was Ogawa serotype and classical biotype [64]. Circulating serovars in recent outbreaks are the atypical El Tor and Non-O1/non-O139 *V. cholerae* [65–68]. The emergence of CT genotype 7 (Haitian type of ctxB allele) and CT genotype1 (classical ctxB allele) was, however, recorded by Adewale et al. [69] as predominant among Ogawa serotype and Inaba serotype, respectively. Sometimes, outbreaks are confined to rural areas as recorded by Udonwa et al. [70], where an intra-family transmission of *V. cholerae* was observed during an epidemic in rural South-Southern Nigeria or spreading from the epicenter to towns and even urban settlements. This was evident in the 2010 cholera outbreak that grew in magnitude to a scale that transversed the entire northern part of

Nigeria [71]. Ishaku et al. [72] identified fecal pollution of Rafin Kumin Tagway River a main water source of an urban community in Akwanga, north central Nigeria, as the main cause of 2013 cholera outbreak. The role of environmental reservoirs in cholera outbreaks cannot be overemphasized. Smith et al. [73] demonstrated using ERIC-PCR analysis that toxigenic *V. cholerae* strains responsible for the 2013 cholera epidemic in Nigeria was linked to environmental strains. Cholera being an important climate-sensitive disease, Leckebusch and Abdussalam [74] investigated the influence of meteorological and socioeconomic factors on the spatiotemporal variability of cholera morbidity and mortality in Nigeria. It was revealed that population density, poverty, adult literacy, access to pipe-borne water, seasonal maximum and minimum temperatures and annual rainfall totals influenced the spatial and temporal variability of the disease incidence and mortality. Conflict was also identified as a factor that increased the risk of cholera in Liberia and Sierra Leone [11] and this is also evident with the continuous outbreak of cholera in north-eastern Nigeria.

The emergence of cholera in Senegal is of the same trend with other West African countries. Senegal has experienced several outbreaks since 1971 [75]. Sambe-Ba et al. [76] identified an El Tor *V. cholerae* O1 Ogawa strain hosting SXT element implicated in the 2004–2005 outbreak, a major cholera epidemic in Senegal indicating the emergence of hybrids of classical and el Tor strains in West Africa. de Magny et al. [77] evaluated the effect of climate in cholera outbreaks in Senegal. Results showed a specific pattern of rainfall throughout Dakar region which was observed to have exacerbated the cholera epidemic. Togo has also had series of cholera outbreaks. A national surveillance data revealed that between 1996 and 2010 Togo had 12,676 reported cholera cases and 554 deaths [78].

Control strategies

It is obvious that cholera is an endemic disease in Africa with several risk factors driving recurrent outbreaks (Fig. 1). Coastal areas being open to the ocean which are subject to regular flooding and trans-border migration, and retention of *V. cholerae* in sources of water supply such as wells, streams, rivers, fishing activities and so on have an interplay which may be dependent or independent in the continuous outbreak of cholera in Africa.

Amaah [79] evaluated knowledge, attitude and social representation in the extreme north of Cameroon with a bid to identifying key elements that can serve as footholds to an effective fight against cholera. Results revealed that representations of cholera, cultural and social-cultural values were not adequately considered in the fight against cholera. This reflects the review of Ujah et al. [80] that identified

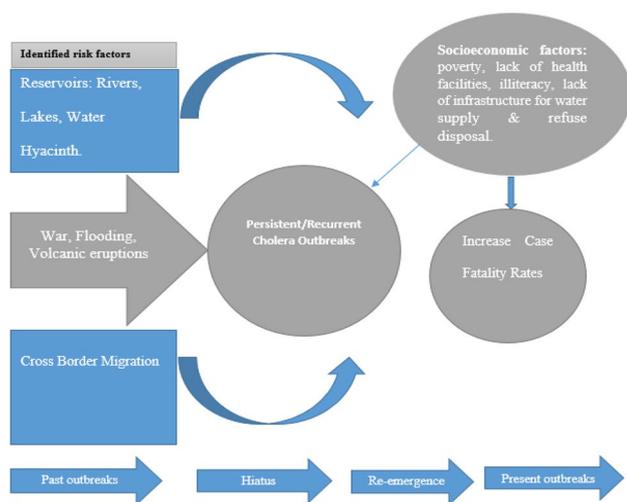


Fig. 1 Persistent/recurrent cholera outbreaks in Africa triggered by a complex of various factors. Some countries experience a period of hiatus followed by re-emergence of the disease possibly re-introduced from reservoirs, cross-border migration, flooding, etc.

various opinions and myths about cholera, which gave rise to varying methods of control thus influencing effective and holistic operational response to outbreaks. These perceptions also hamper control and prevention strategies such as use of vaccines. Merten et al. [81] evaluated local perceptions of cholera and anticipated vaccine acceptance in Katanga province (DRC). It was reported that 97% anticipated the vaccine to be supplied free, hence the need for governments and non-governmental organizations (NGOs) to invest in providing vaccines. Ngwa et al. [82] assessed the integrated disease surveillance and response (IDSR) strategy adapted in Cameroon in 2003. It was revealed that cholera surveillance was active during outbreaks but became passive when there was no outbreak. Valuable components of the hierarchical structure were defective in terms of laboratories lacking the capacity to confirm outbreaks and absence of structured data analysis. However, the strategy proved to be effective in early detection and rapid response of cholera outbreak. The IDSR strategy also adapted by Uganda proved to be effective but just like the case of Cameroon inadequate laboratories for confirmation of cases also hampers a holistic success that should have been achieved by applying this strategy [83]. Since infrastructure deficit in terms of water supply plays a key role in disease outbreaks such as cholera, a component of the Democratic Republic of Congo strategy on the elimination of cholera was a planned budget of nearly \$ 160 million US dollars with 60% expended on improvement of water and sanitation infrastructure [9]. As pointed out earlier, nosocomial cholera outbreak could have a devastating effect, thus effective response and prevention strategy is of esteemed value. Bwire et al. [84] documented procedures for prompt diagnosis, treatment, disinfection and

prophylaxis coupled with preemptive use of oral cholera vaccine as a key to forestalling high CFR in a nosocomial outbreak scenario. Furthermore, it is imperative to expand the current guidelines on cholera prevention and control to accommodate nosocomial (hospital/other institutions alike) outbreaks. The rampant and frequent cholera outbreaks in Tanzania tend to hinder existing control measures [39]. However, proper and adequate mapping provides the needed data that help in surveillance and strategic response in times of outbreak. Mayala et al. [85] evaluated the potential of geographic information system (GIS) in monitoring sources and spread of cholera in Ilala district Tanzania. From mapping, poor water, poor sanitation and high population density were identified as cholera spatial elements within the district. The efficiency of digital technology in control/prevention strategy was further substantiated by Ali et al. [86] that demonstrated the easy and seamless registration of subjects for mass oral cholera vaccination in Tanzania using personal digital assistants (PDAs). The use of oral cholera vaccine in mass vaccination campaign in response to an outbreak in Malawi proved to be an effective additional measure in controlling cholera in outbreak prone areas [87]. Oyedepo et al. [88] evaluated a GIS-supported post-epidemic assessment of cholera in parts of Abeokuta in southwestern Nigeria. Findings revealed that rapid epidemiological mapping gave an elaborate insight into the poor sanitary practices of the indigenes which included improper sewage and waste disposal systems, heaps of refuse dumps with human feces on old, rusty and leaking water pipes. Using generalized additive modelling (GAM) and multiple linear regression (MLR) approach, Leckebusch and Abdussalam [74] quantified the influence of climate and socioeconomic variables in explaining the spatial and temporal variability of cholera. This suggests a strong possibility of disease prediction which will help inform policies in effective response control and prevention of cholera outbreaks. In terms of response to cholera outbreaks, Ohene et al. [89] in Ghana assessed the quality and effect of response in control of cholera outbreak. Identified were multiple strengths in the prompt response in terms of timely notification of distinct health official, prompt investigation and coordinated response activities. From the foregoing, dealing with the determinants of recurrent cholera outbreak can see African countries get over what seems to be an enigma.

Conclusion

There seems to be no end in sight of the recurrent nature of cholera outbreak in Africa. However, if the identified factors that fuel it are addressed there would be recourse. Government should also intensify deployment of vaccines to areas prone to regular outbreaks. Though vaccination is a

short-medium term intervention, prevaccination before outbreak has been proven to reduce the number of cases and tend to delay epidemic peak. However, vaccination during outbreaks remain the main focus which is more effective if 50–70% of population at risk is covered [90] and this is done in tandem with provision of portable drinking water, adequate sanitation and hygiene practice. Vaxchora, a single-dose oral vaccine approved by the United States food and drug administration (FDA), is effective in the protection of adults travelling to cholera endemic areas. Although its safety has not been established in immunocompromised persons, pregnant and breast feeding mothers, children and people living in endemic zones [91]. This could serve as a potential means of control in cholera outbreaks associated with cross-border migration.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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