INTEGRATED APPROACH TO UNDERSTAND THE DYNAMICS OF CHOLERA EPIDEMICS IN GHANA, TOGO AND BENIN

Photo: Sandy Moore

FINAL REPORT

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2. Summary

Since cholera was first imported into West Africa, cholera cases have been reported in the sub-region each year, and outbreaks have especially intensified in Ghana since 2011. In contrast, cholera trends have remained stable in Benin and slightly diminished in Togo. Based on an analysis of the cholera case databases of 2011 to 2014, Greater Accra Region was identified as the main hotspot of cholera in Ghana as well as the sub-region of Ghana, Togo and Benin. Once, the toxigenic bacterium *V. cholerae* O1 is imported into the city, cholera outbreaks appear to rapidly diffuse throughout Accra Metro early during epidemic onset, as observed during each epidemic of the last four years. The current epidemic in Ghana occurred following a one-year lull; no lab-confirmed cholera cases were reported in Ghana during 2013 despite typical rainfall. Following the importation of cholera in Accra during the summer of 2014, a shift in case profile was observed during the first 7 weeks. Early on, younger women were exposed, and children below the age of 6 and adults over the age of 60 were not affected until week 4. These results suggest that the epidemic quickly reached the heart of the households and subsequently affected children and elderly. Investigations are ongoing to understand why epidemics spread so quickly in Accra. Field investigations also revealed that outbreaks subsequently occurring in other regions of Ghana (such as Ho and Ketu South) as well as neighboring countries were linked to the epidemic in Accra.

Togo appears to have regular importation of cholera cases that originate from neighboring countries experiencing outbreaks. Indeed, the high volume of travel between Lomé and Ghana as well as Lacs with other countries, such as Benin, Ghana, and Nigeria, renders the country vulnerable to cholera imported from abroad. Based on the field investigations, we found that outbreaks in Togo in 2014, especially in Lomé, were epidemiologically linked to the outbreak in Ghana. Furthermore, most outbreaks in Lomé occurred in flood zones as well as areas linked with fishing activity. Meanwhile, outbreaks in Lacs were associated with travelers coming from Benin or Nigeria for traditional animist ceremonies. However, when cases arrive they seem to only produce a few secondary cases or small outbreaks. Cholera epidemics in Togo are controlled quickly before they significantly expand.

Benin shares a border with the country of Nigeria, one of the largest cholera foci in Africa. As there is a high level of daily exchange between Nigeria and Benin, via road and boat (lake Yewa into lake Nokoué), Benin is vulnerable to the importation of cholera cases from Nigeria. Many of the communities affected along the lakes are indeed communities where limited access to potable water and poor sanitary conditions render the people vulnerable to cholera outbreaks. However, as these locales are relatively isolated from each other (especially in So-Ava), cholera outbreaks often fail to expand. Cotonou is also vulnerable to importation of cases from Nigeria due to the massive influx of people traveling by road and boat. However, the populations residing in the most affected zones of Cotonou do have ample access to potable water, and therefore outbreaks rarely expand in the city.

Finally, a total of 412 *V. cholerae* isolates from recent cholera epidemics in Ghana, the Democratic Republic of the Congo (DRC), Zambia, Guinea and Togo were subjected to Multiple-Locus Variable number tandem repeat Analysis (MLVA). We found that the Ghanaian isolates grouped into the West Africa cluster together with isolates from Togo and Guinea. In contrast, the isolates from Ghana were unrelated to isolates from Central Africa (the DRC and Zambia). Interestingly, that 2011 isolates from Ghana were closely related to and likely gave rise to the 2012 Guinean epidemic.

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3. Figures and Tables

4. Abbreviations

CI	Confidence Interval
DRC	Democratic Republic of the Congo
DSD	Disease Surveillance Department
MLVA	Multilocus Variable-number tandem repeat Analysis
MST	Minimum Spanning Tree
OR	Odds Ratio
PCR	Polymerase Chain Reaction
V. cholerae	*Vibrio cholerae*
VNTR	Variable-Number Tandem Repeat

5. Introduction

Seven cholera pandemics have affected mankind; however, the disease has only recently affected the African continent during the current pandemic, when *V. cholerae* was imported by travelers arriving in Conakry in 1970 (LeViguelloux and Causse, 1971). Since this time, West Africa has remained one of the most severely cholera-affected areas worldwide. Furthermore, the countries of Ghana, Togo and Benin appear to function as a gateway of transmission to other West African countries. Since 2000, the three countries have regularly been affected by cholera epidemics, with Ghana often reporting the greatest number of cases (**Figure 1**).

Since the introduction of cholera in Ghana in 1970, epidemics have been reported in the country nearly every year. From 1991 through 2012, 79,591 suspected cholera cases and 1,794 cholera-related deaths were reported in Ghana. Togo has experienced endemic cholera for at least the past 40 years, primarily in the coastal region. From 1996 through 2010, Togo reported 12,676 cholera cases and 554 deaths. During 2008–2010, 85% of 26 district-level outbreaks occurred in the capital Lomé or the coastal Maritime Region (Landoh et al., 2013). Since 2000, cholera outbreaks have been reported every year in Benin (with the exception of 2007), with the largest recent epidemic occurring in 2001 (3,943 reported cases) (CDCP, 2001-2013). However, a clear understanding of cholera dynamics in each country, which is essential for targeted public health strategies, remains to be elucidated.

Therefore, the UNICEF office in Dakar in collaboration with the three national offices in Ghana, Togo, and Benin launched a mission to improve the understanding of epidemics raging in this sub-region and establish sustainable WASH recommendations, based on the epidemiological findings, to protect the populations from future epidemics. The investigation team included Paul Cottavoz (WASH specialist), Sandy Moore (epidemiologist/biologist) and Renaud Piarroux (cholera expert/pediatrician/epidemiologist).

6. Objectives

The objective of the assignment is to better understand the underlying dynamics of the disease in Ghana, Togo and Benin through an integrated approach including field investigations combined with an analysis of molecular biological and epidemiological aspects of cholera outbreaks over the past several years.

6.1. Improve understanding of cholera epidemiology for effective public health strategies

With the proposed comprehensive analysis, the study aims to identify cholera hotspots, vulnerable populations and diffusion mechanisms of cholera in the region. These findings will serve as a solid and essential foundation for the design of effective public health strategies to control and prevent future cholera epidemics in the region.

Molecular analysis of *V. cholerae* isolates via MLVA will enable us to determine whether old epidemic strains remain in circulation in the region or rather new epidemics are caused by the importation of new *V. cholerae* strains (compare strains responsible for each epidemic). MLVA also highlights the connection between outbreaks.

6.2. Identification of cholera hotspots to conduct WASH assessments

The field investigation will be carried out jointly with an independent WASH consultant who will perform a WASH assessment in cholera hotspots based on the information provided by the epidemiology team.

6.3. Strengthen Ministry of Health capacity in cholera outbreak analysis, control and prevention

The objective of the assignment is also to strengthen Ministry of Health capacity in cholera outbreak analysis, control and prevention in Ghana, Togo and Benin. The results of this integrated study will culminate in scientific publications jointly composed with the Ministry of Health of the corresponding country as well as all actors significantly involved in the study.

7. Funding of the consultancy

This consultancy was established via a partnership between UNICEF-Senegal and Aix-Marseille University, where the research team of Prof Renaud Piarroux is based. The funding covered the mission fees of Sandy Moore and Renaud Piarroux as well as fees associated with cartography and epidemiological assessments, genetic analyses and redaction of the final report.

8. Materials and methods of the consultancy

8.1. Cholera case/death and rainfall data

Databases of all suspected cholera cases (based on the WHO definition of the disease) were collected from the epidemiological unit of each country. The records also include data on age, sex and place of residence. The National Public Health Reference Laboratory confirmed certain cases, and the laboratory results are also listed in the databases.

Daily-accumulated rainfall data for Accra were obtained from satellite estimates (TMPA-RT 3B42RT derived) provided by the National Aeronautics and Space Administration (available at: http://disc2.nascom.nasa.gov/Giovanni/tovas/realtime.3B42RT_daily.2.shtml).

8.2. WASH methodology

The methodology consisted of the following three steps: (1) identify and select communities that play a key role in the spread of cholera, (2) conduct detailed WASH diagnoses, and (3) propose sustainable improvements. In Ghana, the line lists (case location and date) established by the health services during epidemics were used to select affected districts.

In Togo, the selection of prefectures was performed at an introductory meeting at the Ministry of Health in the presence of the Deputy Director General of the Ministry, the Director of Disease Surveillance, the Director of Hygiene and Sanitation, Focal Points for cholera in Lomé and the head of cholera for the WHO. The prefectures and communities recurrently affected were identified and field visits were organized in priority sites. This ranking was subsequently redefined based on the line lists of the previous five years.

In Benin, under the "regional project for profiles of countries regarding cholera" initiated by UNICEF WCARO, a ranking of priority communes for WASH studies was established. This data was confirmed based on the provided line lists. During this mission, the health services of the first three communes concerned were contacted to refine the selection of the most affected areas and field visits were organized.

To select locales that play a key role in the spread of cholera, the spatiotemporal dynamics of each epidemic (including the location of index cases, the spatiotemporal characteristics of outbreaks, and the duration of outbreaks) and the total cumulative number of cases were taken into account. Using this method, we aimed to characterize sites as: 1) a cholera entry point (e.g., via fishermen or trader movements), 2) an area directly affected by the entry point (e.g., a market or community adjacent to an entry point), 3) an indirectly and/or randomly affected area near an entry point or a directly affected area, or 4) a distribution point contaminated by zones that spreads cholera into other regions. The value of this approach is to highlight the entry points and regularly affected communities to target actions on these sites and prevent the deployment of the epidemic on the other areas.

8.3. Cartography

The maps were generated using QGIS version 2.4.0-Chugiak with shapefiles obtained from DIVA-GIS (http://www.diva-gis.org/gdata).

8.4. Multilocus variable-number tandem repeat analysis (MLVA)

MLVA is a highly discriminatory technique that allows for the differentiation between various *V. cholerae* strains isolated during an epidemic. MLVA data can be applied to infer genetic relatedness and therefore provide insight into the mechanism by which strains evolve and the bacterial diffusion pattern over the course of a single epidemic. MLVA of *V. cholerae* strains was performed on isolates from Ghana to understand the relationship between outbreaks, and thereby reinforce epidemiological findings.

Isolate selection and culture

A total of *V. cholerae* isolates were provided by the National Public Health and Reference Laboratory, Accra, Ghana. Clinical isolates from epidemics in 2010 (9 isolates), 2011 (37 isolates), 2012 (28 isolates) and 2014 (13 isolates) were selected for genotyping in a manner in which the samples are temporally and spatially representative of outbreak diffusion for each epidemic. The isolates were subcultured and subsequently transported at 4°C to L'Hôpital d'Instruction des Armées Laveran in Marseilles, France. In Marseilles, the strains were recultivated on non-selective trypticase soy agar medium (Difco Laboratories/BD) for 24 hours at 37°C. Suspected *V. cholerae* colonies were identified via oxidase reaction and, when necessary, Gram-staining.

The Ghanaian isolate results were compared with the results of previously analyzed *V. cholerae* isolates from the DRC, Guinea, Togo and Zambia. The DRC isolates were provided by the INRB (French acronym for the National Institute of Biomedical Research), Kinshasa, DRC. The Guinean reference laboratory of the Public Health National Institute (INSP – Institut National de Santé Publique), with support from the AFRICHOL Consortium (http://www.africhol.org/), provided the 2012 Guinea isolates. The bacteriology laboratory of the National Institute of Hygiene in Lomé, Togo provided *V. cholerae* isolates from Togo, which corresponded to epidemics occurring in 2010 and 2011. The Zambian 2012 epidemic isolates were collected during the CHOLTIC project together with the Institute of Tropical Medicine in Antwerp, Belgium.

DNA extraction

For DNA extraction, an aliquot of cultured cells (approximately 50 colonies) was suspended in 500 µL NucliSENS easyMAG lysis buffer (bioMérieux). Concerning isolates that failed to grow upon re-culture, an aliquot of the transport media was suspended directly in lysis buffer. Total nucleic acid is extracted from *V. cholerae* cultures/transport tubes using a NucliSENS easyMAG platform (bioMérieux) according to the manufacturer's instructions. The supernatants (100 µL) were then stored at -80°C for downstream applications.

MLVA

Genotyping of the *V. cholerae* isolates was performed via MLVA of 6 VNTRs, including 5 previously described assays and a novel VNTR assay, VCMS12, specifically designed to improve the discriminative power of the analysis (**Table 1**) (Olsen et al., 2009; Kendall et al., 2010; Rebaudet et al., 2014). The VCMS12 assay was designed based on the reference strain El Tor

N16961 (GenBank accession numbers AE003852.1 and AE003853.1) using Perfect Microsatellite Repeat Finder (currently unavailable). Specific primer pairs were subsequently designed using Primer3 (http://simgene.com/Primer3). The fluorescent-labeled primers (**Table 1**) were purchased from Applied Biosystems.

Locus name	Repeated pattern	Chr.[1]	Position[2]	Primer sequence (5'→3')	Ref
VC1	AACAGA	1	137106	fw: CGGATACTCAAACGCAGGAT	(Olsen, 2009; Kendall, 2010)
				rv: 6FAM*-CTTTCGGTCGGTTTCTCTTG	
VC4	TGCTGT	2	187759	fw: TGTTTGAGAGCTCGCCTCTT	(Olsen, 2009; Kendall, 2010)
				rv: PET*-TCATCAAGATGCACGACACA	
VC5	GATAATCCA	1	1915539	fw: AGTGGGCACAGAGTGTCAAA	(Olsen, 2009; Kendall, 2010)
				rv: VIC*-AATTGGCCGCTAACTGAGTG	
VC9	GACCCTA	1	467111	fw: CGTTAGCATCGAAACTGCTG	(Olsen, 2009; Kendall, 2010)
				rv: NED*-AGAAAACAATCGCCTGCTTG	
LAV6	ACCAGA	2	303939	fw: NED*-GCCTCCTCAGAAGTTGAGAATC	(Rebaudet, 2014)
				rv: CCGATGAACTCTCTGAACTGG	
VCMS12	TTTTGAT	1	1568189	fw: VIC*-GAGGTCTAGAATCTGCCCGA	Novel VNTR assay designed in Parasitology-Mycology lab, Aix-Marseille University
				rv: AAGCGCTGTGGGTAGAAGTG	

Table 1. Characteristics and primer sequences of the 6 tested *V. cholerae* VNTRs. [1] Chr.: chromosome. [2] Based on the reference strain El Tor N16961 (GenBank accession numbers: AE003852.1 and AE003853.1).

Each VNTR locus was amplified separately. DNA amplification was carried out by preparing a PCR mix containing the following components: 0.375 µL of each primer (20 µM), 1 X LightCycler® 480 Probes Master (Roche Diagnostics) and approximately 100 ng of template DNA. The PCR mix was brought to a total volume of 30 µL with H2O. PCR was performed using a LightCycler® 480 System (Roche Diagnostics). All PCRs were performed using the thermal cycling conditions as follows: 95°C for 5 min; followed by 30 cycles of 95°C for 30 sec, 58°C for 30 sec and 72°C for 45 sec; 72°C for 5 min.

Aliquots of the PCR products were first diluted 1:30 in sterile water. Next, 1 µL of the diluted PCR reaction was aliquoted into a solution containing 25 µL Hi-DiTM Formamide 3500 Dx Series (Applied Biosystems) and 0.5 µL GeneScanTM 500 LIZ® Size Standard (Applied Biosystems).

The fluorescent end-labeled PCR amplicons were separated via capillary electrophoresis using an ABI PRISM® 310 Genetic Analyzer (Applied Biosystems) with POP-7TM Polymer (Applied Biosystems). Finally, amplicon size was determined using GeneMapper® v.3.0 software (Applied Biosystems).

Data analysis

The MLVA results were exported to Microsoft Excel 2008 v. 12.2.0. Allele numbers were derived directly from the fragment sizes, and MLVA types were determined from the combined profile of alleles (i.e., each unique combination of 6 allele numbers was assigned a novel MLVA type number). To perform the Minimum Spanning Tree (MST) analysis, the isolates were further assigned into four epidemic populations as follows: Ghana 2010, Ghana 2011, Ghana 2012 and Ghana 2014. Finally, the Ghanaian isolates were compared with a panel of previously analyzed *V. cholerae* isolates from other African epidemics as follows: DRC 2008 -2013, Guinea 2012, Zambia 2012, Togo 2010 and Togo 2011.

Minimum Spanning Tree

Based on allelic profiles the evolutionary relationship between all 412 isolates was assessed with the MST algorithm in BioNumerics (Applied Maths, Sint-Martens-Latem, Belgium) using the default settings according to the manufacturer's recommendations. The MST was constructed using a categorical coefficient. Standard MSTs generated in BioNumerics using the single and double locus variance priority rules were used to visualize the relationships between strains. The MLVA types with the highest number of single-locus variants were set as a root node, and other MLVA types were then derived from the root nodes. The following default priority rules were applied: Priority rule 1, maximum number of N-locus variants (N=1), weight: 10000; priority rule 2, maximum number of N-locus variants (N=2), weight: 10.

9. Country overview

9.1. Ghana

The countries of Ghana, Togo and Benin appear to function as a gateway of transmission to other West African countries, with Ghana often reporting the greatest number of cases (Figure 1). In Ghana, epidemics have been reported nearly every year since 1970 (Osei & Duker, 2008b). From 1991 through 2012, 79,591 suspected cholera cases and 1,794 cholera-related deaths were reported in the country (CDCP, 1992-2013). In 2014, Ghana experienced the largest cholera epidemic to hit the country since 1991, when 13,172 cases were reported (UNICEF 2014; CDCP 1992-2014). The 2014 epidemic, which has spilled over into 2015, started in early June in the Accra Metropolis with 6 cases. Most of the cases were reported in the Greater Accra Region in Accra metro district followed by La-Dade Kotopon district. The epidemic then spread to many districts, mostly along the coastal districts and main roads. Major transmission factors have been identified as follows: street water and food vendors, unsafe drinking water and poor access to water, person-to-person transmission in households and in treatment centers, inadequate isolation procedures in case management sites, and relatives visiting patients in households and treatment centers (UNICEF, 2014).

A significant portion of Accra, the hardest hit area in Ghana, is congested and constitutes a favorable environment for the spread of cholera. In Accra Metro alone, there are 78 slums and/or squats where 1.6 million people reside. The slums are characterized by high population density (650 people/hectare), an unhealthy environment due to the presence of sewage and solid waste accumulation. Furthermore, these precarious neighborhoods lack sufficient access to safe drinking water, as the network is rationed and many households have running water only once or twice a week. Some neighborhoods are in rupture with the society, which can be likened to lawless areas that reveal a failed integration of migrant populations (mainly from the northern regions of Ghana) during the past 15 years. Each of these factors likely plays a role in cholera diffusion and persistence in Accra.

9.2. Togo

The country of Togo has experienced endemic cholera for at least the past 40 years, primarily in the coastal region. From 1996 through 2010, Togo reported 12,676 cholera cases and 554 deaths. During 2008–2010, 85% of 26 district-level outbreaks occurred in the capital Lomé or the coastal Maritime Region (Landoh et al., 2013).

The city of Lomé is divided into five districts and has a port area. The population exceeds one million inhabitants, and the agglomeration continues to expand towards the northwest and northeast. The city is bordered to the east by the Zio River, and a lagoon that formed in the old river bed crosses the city from east to west. The city was originally installed on the seafront with a relatively flat topography, although there is a plateau area in the north and slight depressions (of at least 30 meters) towards the lagoons. Urban pollution concentrates in these depressions,

which subsequently contaminates water from surrounding aquifers that feed many traditional water structures such as wells and boreholes. In contrast, the harbor area residents have water access via boreholes and an internal network. The boreholes do not exploit the superficial water layer, but instead extend deeper to 400 meters in depth. The city hall of Lomé is responsible for sewage and waste. The sewerage system covers only a small part of the city, and Lomé is not equipped with wastewater treatment plant; discharges go directly to the sea. Solid waste collection is outsourced to the private sector.

9.3. Benin

Since 2000, cholera outbreaks have been reported every year in the West African country of Benin (with the exception of 2007), with the largest recent epidemic occurring in 2001 (3,943 reported cases) (CDCP, 2001-2013). Gbary et al. have reported that the attack rates of the 2008 epidemic, which started in Cotonou on 26 July 2008 and lasted for 21 weeks, in Agbodjèdo, Hlacomey and Enagnon districts were significantly higher ($p<10^{-4}$) than in other districts. The city of Cotonou has nearly one million inhabitants. It is situated between the Atlantic Ocean and Lake Nokoué. The most precarious populations in the city are settled along the banks of the lake. The original populations are mainly Toffin fishermen, but more recently Ghanaian fishermen, who fish in the sea, have settled along the beach. Crowded living conditions along the banks of the lake along with poor sanitation and inadequate drinking water supply have been proposed to be at the root of the cholera burden in Cotonou (Gbary, Dossou, Sossou, Mongbo, & Massougbodji, 2011).

However, the commune most affected by cholerae in Benin during recent years is So-Ava, which is located north of Lake Nokoué. So-Ava is divided into seven districts comprised of official 69 villages. The resident population is 104,690 inhabitants. In So-Ava, water occupies 65% of the surface; most villages are only accessible via boat/canoe. The average rate of access to potable water in rural areas is 51%. Residents of So-Ava use of latrines on stilts or practice open defecation; family latrines are rare. The main occupation of the population was historically fishing-related activities. However, now that the lake has been over-fished, the people have resorted to finding a variety of alternative means to make a living. Several alternative activities include sand mining and smuggling fuel from Nigeria, which has become the major pillar of the local economy.

10. Field investigation observations and epidemiological results

Since cholera was first imported into West Africa, cholera cases have been reported in the sub-region each year, and outbreaks have especially intensified in Ghana since 2011. In contrast, cholera trends have remained stable in Benin and slightly diminished in Togo (**Figure 1**). Based on an analysis of the cholera case databases of 2011 to 2014, Greater Accra Region was identified as the main hotspot of cholera in Ghana as well as the sub-region of Ghana, Togo and Benin. The cumulative suspected cholera cases in the region, from 2011 to 2014 (until week 49), are illustrated in **Figure 2**. In 2011 and 2012, 10,178 and 10,292 suspected cases, respectively, were reported in the sub-region. In 2014, the sub-region reported the largest to-date epidemic with 29,740 suspected cases reported until week 49. During the four-year period, 68.2% of cholera cases in the tri-country region were reported in Greater Accra Region. Strikingly, 80.2% of regional cholera cases were reported in Greater Accra Region in 2011.

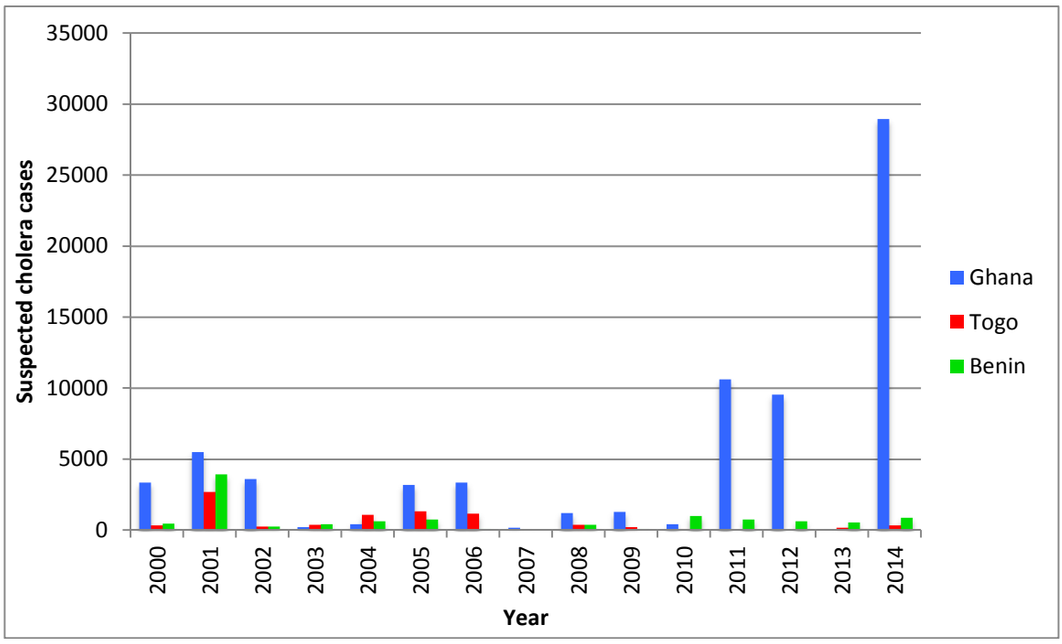

Figure 1. Total annual cases reported in Ghana, Togo and Benin from 2000 to 2014.

Interestingly, no lab-confirmed cholera cases were reported in Ghana in 2013 and only 579 suspected cases were reported in the entire tri-country region, which represents a near 95% drop in cholera cases compared with the previous year. The temporal evolution of the epidemics in each country is displayed in **Figures 3-6**. Total suspected cholera cases, weeks of notification, and cholera-related deaths in 2011-2014 reported by region (Ghana) or district (Togo) are listed in **Table 2**.

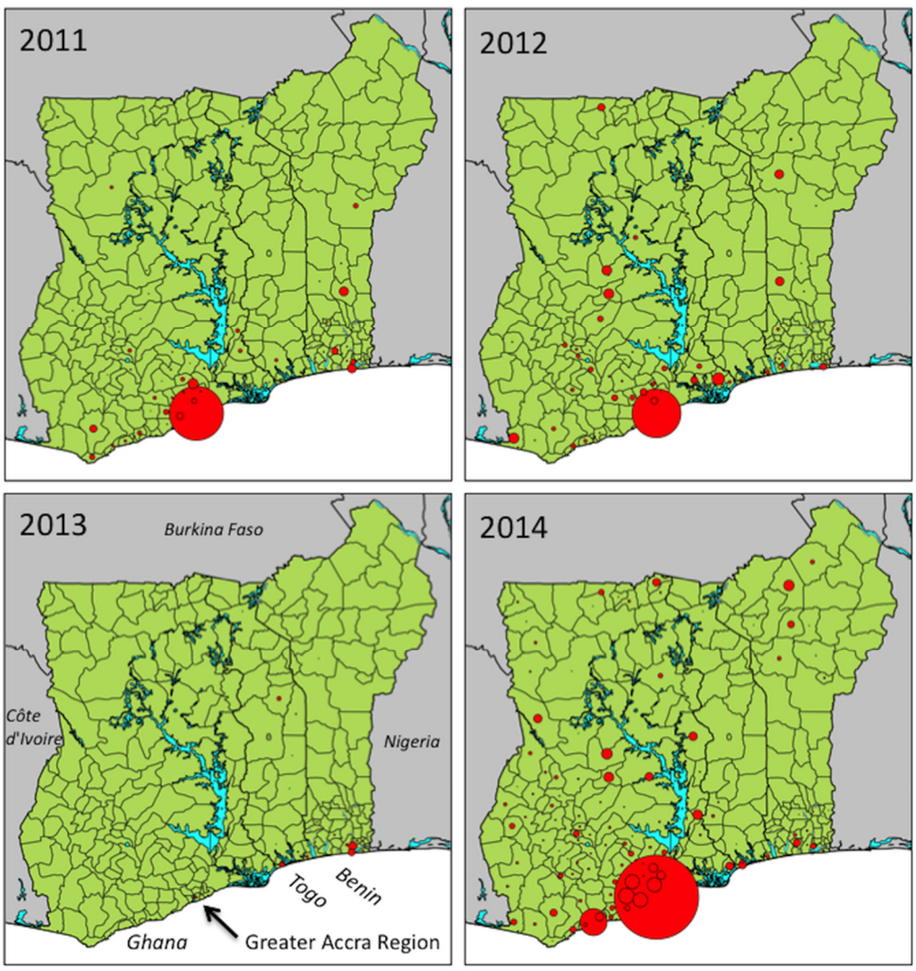

Figure 2. Cumulative suspected cholera cases per year in the sub-region of Ghana, Togo and Benin from 2011 to week 49 of 2014. Suspected cholera cases reported in each district (Ghana and Togo) or commune (Benin) are indicated by red circles; the circle area indicates relative case numbers. The large red circle shown in 2011, 2012 and 2014 represents the total cases in the Greater Accra Region. Each country and the Greater Accra Region are labeled in the 2013 map (lower left).

Ghana	Total cases	Total weeks	Total deaths
Region			
Ashanti	871	42	11
Brong-Ahafo	1608	49	38
Central	4175	45	61
Eastern	2959	59	21
Greater Accra	35972	137	237
Northern	368	21	5
Upper East	438	19	14
Upper West	45	13	2
Volta	1390	33	20
Western	1066	54	16
Total	**48892**	**472**	**425**
Togo	**Total cases**	**Total weeks**	**Total deaths**
District			
Anié	1	1	0
Bas-Mono	1	1	0
Blitta	1	1	0
D1	9	7	0
D2	131	31	1
D3	110	30	2
D4	38	20	0
D5	9	8	0
Golfe	70	22	3
Lacs	113	16	8
Tchamba	4	2	0
Tchaoudjo	49	9	1
Vo	6	4	1
Zio	36	6	1
Ave	15	3	0
Agou	6	1	0
Kloto	26	9	3
Kpélé	0	0	0
Total	**625**	**171**	**20**

Table 2. Total suspected cholera cases, weeks of notification, and cholera-related deaths in 2011-2014 reported by region (Ghana) or district (Togo).

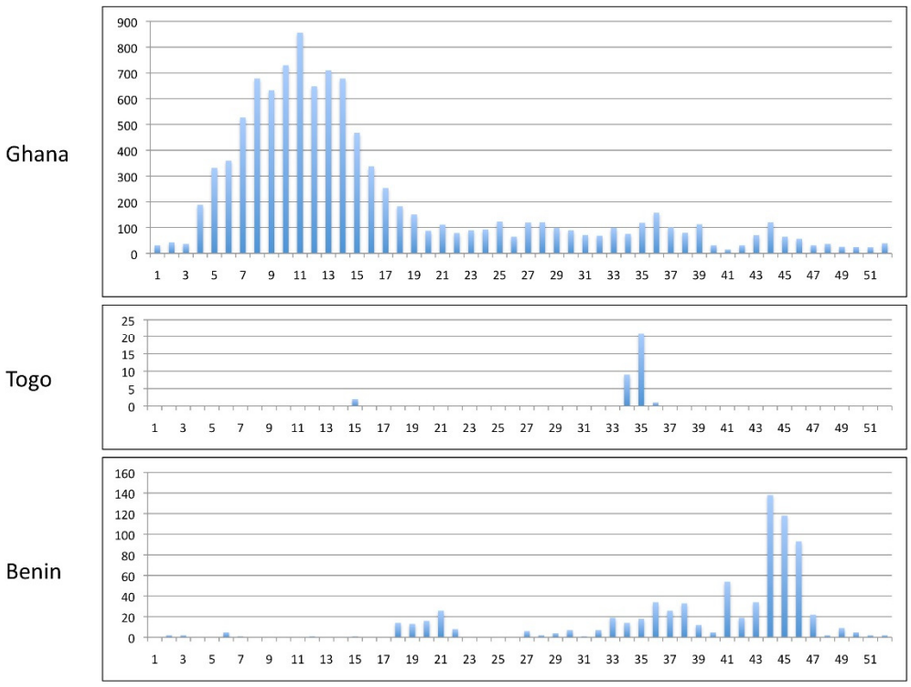

Figure 3. Histogram of the 2011 epidemics in Ghana, Togo and Benin. Suspected cholera cases are listed on the y-axis, and the corresponding week is listed along the x-axis.

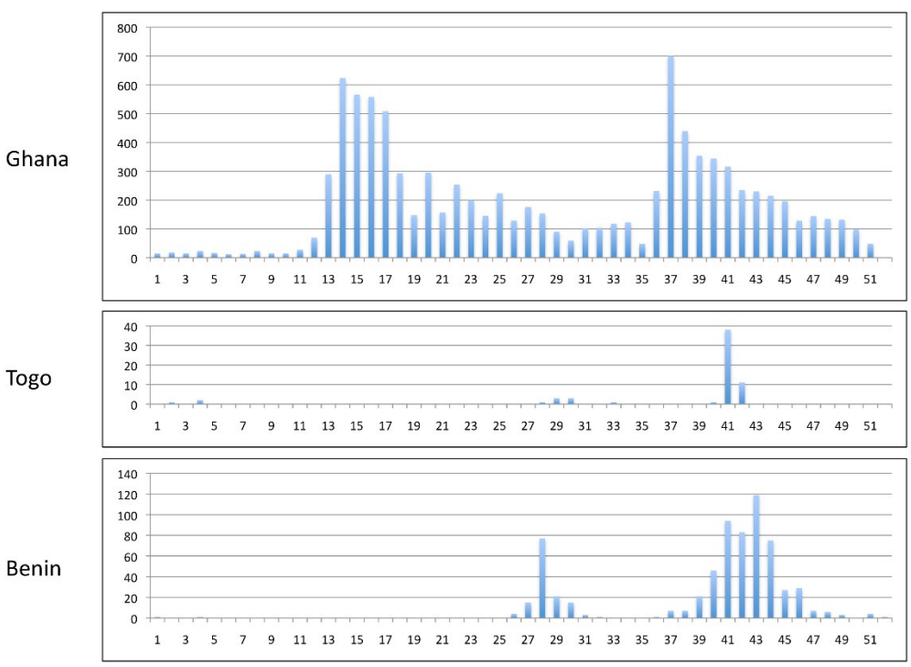

Figure 4. Histogram of the 2012 epidemics in Ghana, Togo and Benin. Suspected cholera cases are listed on the y-axis, and the corresponding week is listed along the x-axis.

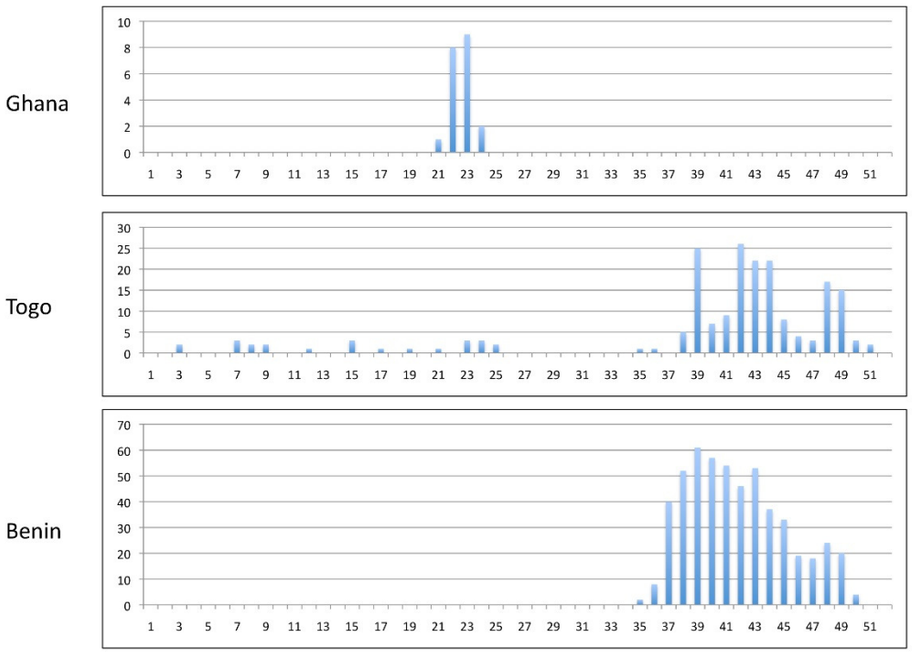

Figure 5. Histogram of the 2013 epidemics in Ghana, Togo and Benin. Suspected cholera cases are listed on the y-axis, and the corresponding week is listed along the x-axis.

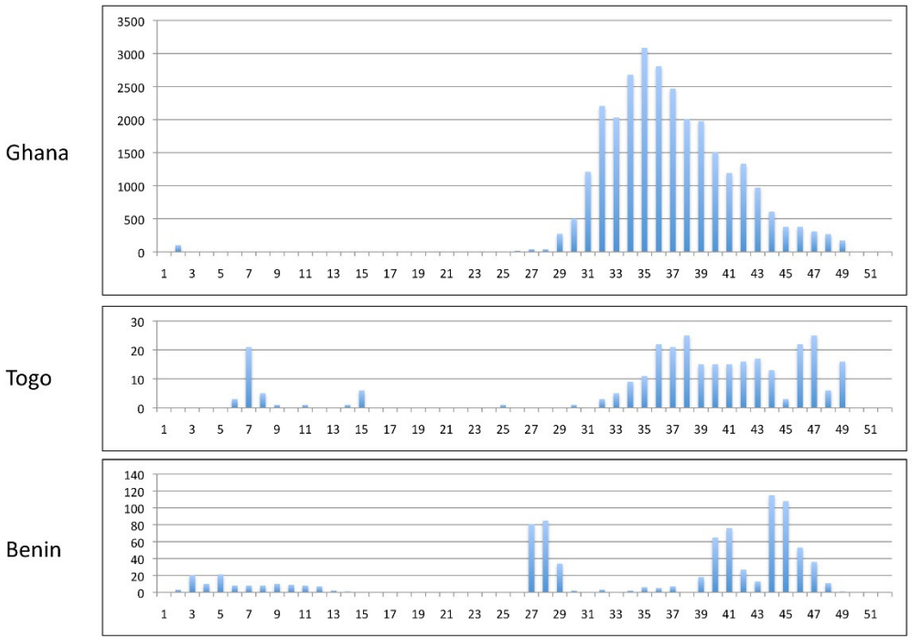

Figure 6. Histogram of the 2014 epidemics in Ghana, Togo and Benin. Suspected cholera cases are listed on the y-axis, and the corresponding week is listed along the x-axis.

10.1. Epidemiology: Ghana

In 2014, Ghana experienced the largest cholera epidemic in the country's history; a total of 28,944 suspected cholera cases were reported in 2014 (UNICEF, 2014). For the past four years, Accra has been the epicenter of cholera in the country. In 2012, cholera cases were first reported in Accra in early January and other districts were not affected until 12 weeks later. Likewise, the cholera epidemic of 2014 started in Accra Metro on June 10, before spreading to other districts in Ghana four weeks later. Furthermore, field investigations conducted in Ho and Ketu South revealed that cholera cases were associated with people traveling from Accra (see specific reports in the Annex).

Accra

The epidemic histogram of weekly cases over the past four years in Accra displayed an unusually sharp increase in cases at the beginning of each epidemic peak, indicating a rapid early expansion within the city (**Figure 7**). To identify localities playing a key role early in the spread of cholera in the Greater Accra, we assessed the early diffusion of cases. During the 2014 epidemic, cholera quickly diffused throughout the majority of Accra Metro and into adjacent districts during the first seven weeks (**Figure 8**). A similar phenomenon was observed in 2011 (data not shown).

Notably, the 2014 epidemic in Ghana occurred following a one-year lull; no lab-confirmed cholera cases were reported in Ghana during 2013 despite typical rainfall (**Figure 7**).

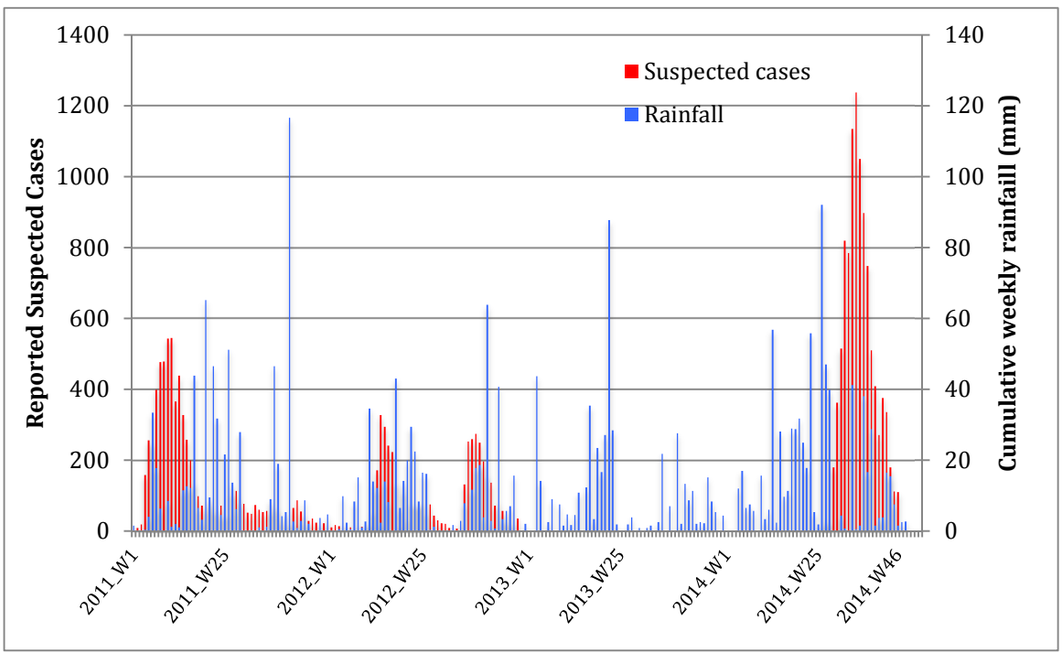

Figure 7. Evolution of cholera epidemics in Accra Metro 2011, 2012 and 2014 (until week 46) and weekly rainfall levels. Suspected cholera cases are indicated in red, and rainfall is indicated in blue.

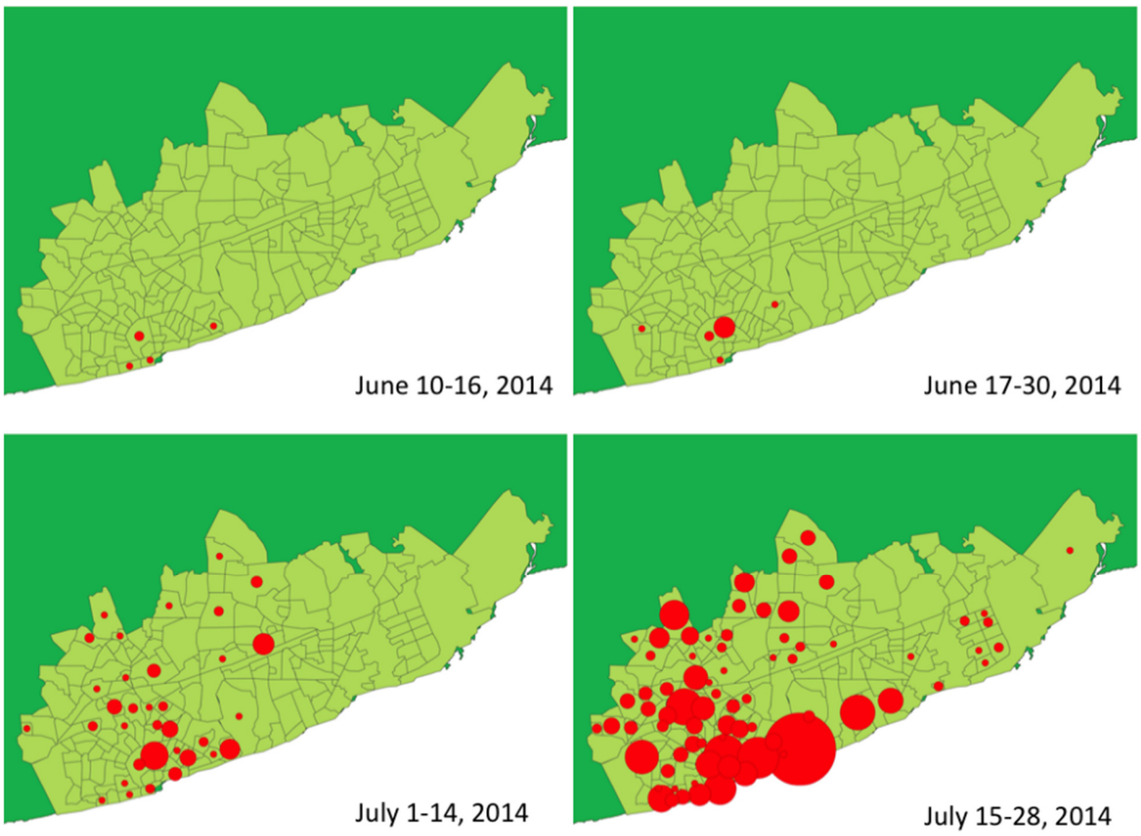

Figure 8. Evolution of cholera cases during the first seven weeks of the 2014 epidemic (from June 10 to July 28, 2014) in Accra Metro Assembly. Accra Metro Assembly and the bordering regions of the adjacent districts of Greater Accra Region are indicated. The size of the circles represents the relative number of cases reported in each neighborhood/locality.

In 2014, the first lab-confirmed cases were reported in Agbado (Ashiedu Keteke), Circle (Osu Klottey), and Maamobi (Ayawaso). The most severely affected districts in Greater Accra were Ablekuma, Okai Koi, Ayawaso, Ga East, Osu Klottey, and Ashiedu Keteke. Preliminary assessment of the 2014 line lists (until mid-September) revealed that the most affected neighborhoods included La, Dome, Osu, Nungua and Dansoman. As many cases occurred in unplanned areas, a certain margin of error must be taken into account concerning exact localization of cases.

Field investigations were carried out in the early and heavily affected neighborhoods to assess access to potable water, latrines, and other factors associated with cholera. Briefly, in many locations, residents reported that the water network only runs once or twice per week, some people even stated that the network water flows only once every two weeks. Many people are forced to collect water in very unsanitary conditions to met to their household needs (**Figure 9**). Furthermore, once network water is collected, it is then stored for several days, often under conditions that are not always appropriate to prevent further contamination. Although, many people consume sachet water, residents also reported using the network water for cleaning,

cooking and direct consumption. According to the MICS report, 55% of the population reports drinking only sachet water or bottle water. The use of Aquatabs varied greatly depending on the neighborhood. Many people stated using Aquatabs just after a local outbreak, but that once the supply was exhausted, they continued using the untreated water.

Figure 9. Children in La Municipality, Accra Metro, collecting groundwater running along pipes. The children stated that the water would be used for household use, which highlights the extreme water shortages that many Accra residents experience. The collection buckets were also resting in the gutter water flowing just below the pipe, thereby further contaminating the water collected. Photo: Sandy Moore.

Likewise, we found that access to personal latrines is limited; in the Greater Accra Metro Area, only 34% of households have access to a latrine in the home (MICS, 2014) and that most people either use private/public latrines, pan latrines (buckets that are then dumped into the roadside gutters) or “flying toilets”/open defecation.

Drains running along streets and throughout neighborhoods are partially or completely clogged with trash and solid waste and therefore would easily overflow during heavy rains. Water network pipes, which are often of poor quality, are often running through these drains or along the ground (**Figure 10**). As open defecation is rampant and the water network is often cut off, the water pipes could likely become contaminated with ground water (including human waste),

especially during the rainy season. Strikingly, a study conducted during the dry season has revealed unsuitable residual chlorine levels and the regular presence of fecal coliform in the network water (Karikari and Ampofo, 2013). Davies-Teye et al. have conducted a descriptive and unmatched 1:2 case-control study in Osu-Klottey including cases reported from March 1st to November 30th 2012. Accordingly, eating unheated food (OR=3.11) and drinking community pipe-borne water (OR=2.15) were associated with contracting cholera in Osu-Klottey. The researchers also found that consuming home-prepared food (OR=0.083) and household exclusive access to home toilet facility (OR=0.289) were protective factors against the disease (Davies-Teye, et al, 2014). Further investigations are required to confirm whether community pipe-borne water actually plays an active role in rapid cholera diffusion throughout the city.

Figure 10. Self-installed water network pipes running along ground near drainage flow in Agbogbloshie. This situation is representative of many neighborhoods in Accra Metro. Photo: Paul Cottavoz.

Demographic profiles of cases and factors of cholera transmission in Accra

To understand the dynamics of early cholera spread, we assessed the demographics of suspected cases at each week of the first seven weeks of the 2014 epidemic. We found that, except for the first two weeks (June 10-23, 7 females/9 total cases), males were more often affected (59.8% during June 24-July 28) (**Figure 11**). As the risk factors are likely to change during the course of

the epidemic, it is important to continue the analysis to identify drivers of the epidemic at each phase.

Interestingly, after visiting four fishing villages in the city (i.e., Jamestown, Chorkor, La, and Osu-Alata), we found that fishermen living in Accra, who were present during our visit, were largely unaffected by cholera. However, fishermen who travel longer distances, often reaching Cote d'Ivoire in the West and Togo in the East, were absent and could therefore not be interviewed.

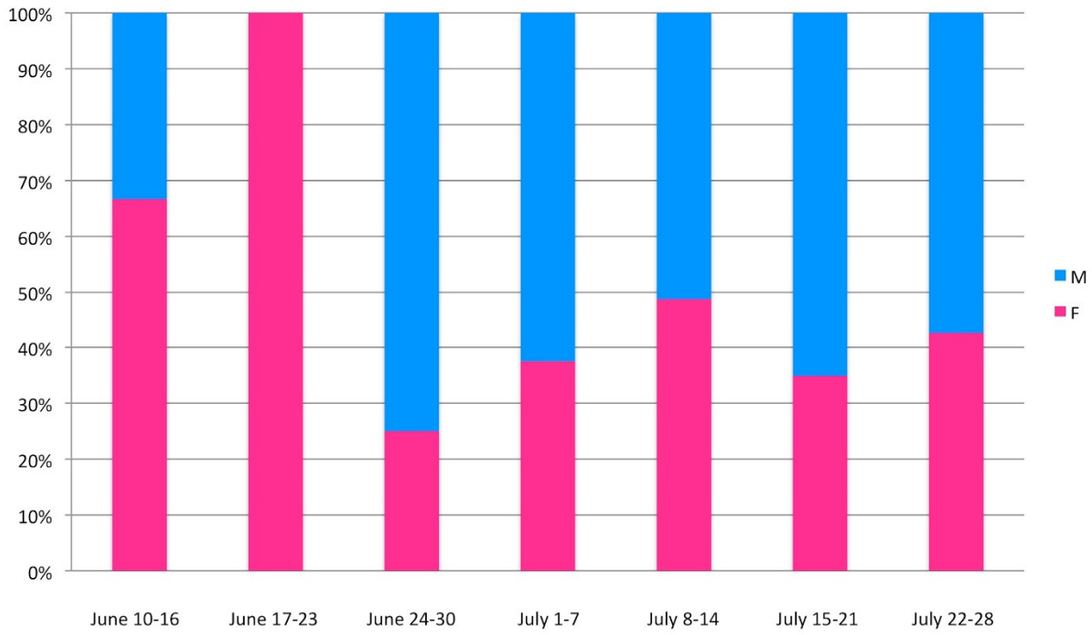

Figure 11. Sex distribution percentage of cholera cases during the first seven weeks of the 2014 cholera epidemic (from June 10 to July 28, 2014) in Greater Accra Region. The time periods of the first seven weeks of the 2014 epidemic are indicated on the x-axis.

Likewise, we assessed the age distribution percentage of suspected cases each week, during the first seven weeks. The average age of cases during week 1 (June 10-16) and week 2 (June 17-23) was 25.33 yrs and 24 yrs, respectively. However, the cases affected during weeks 3-7 included a broader age spectrum, with the average case age of 36.19 yrs (week 3, June 24-30), 32.36 yrs (week 4, July 1-7), 31.68 yrs (week 5, July 8-14), 30.62 yrs (week 6, July 15-21) and 30.85 yrs (week 7, July 22-28). Children below the age of six and adults over the age of 60 were not affected until week 4 (**Figure 12**). These results suggest that the epidemic very rapidly reached the heart of the households, infecting children and elderly, starting on the fourth week. A similar profile was observed for the 2011 epidemic (data not shown).

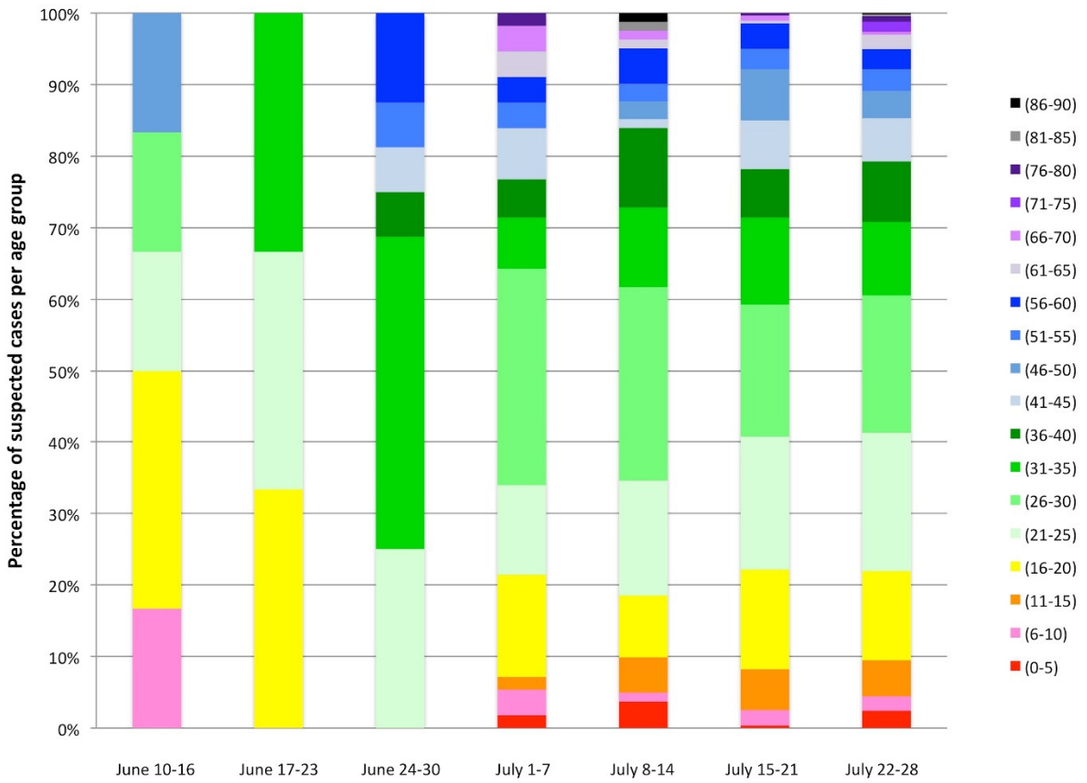

Figure 12. Percentage of suspected case per age group during the first seven weeks of 2014 outbreak (from June 10 to July 28, 2014) in Greater Accra Region. The time periods of the first seven weeks of the 2014 epidemic are indicated on the x-axis. The colors indicate the different age groups, labeled on the right.

Ketu South

Ketu South Municipality is located in the Volta Region, in the southeastern corner of Ghana. The district shares common boundary with Republic of Togo to the East. Due to its location, there is a high level of population movement associated with business activities. The municipality does have an effective surveillance system, proper health education and screening of food vendors.

An episode of severe diarrhea and vomiting was reported in Ketu South municipal hospital and Central Aflao Hospital on the 11th of August 2014 where eight and two diarrhea cases were recorded by Ketu South Municipal Hospital and Central Aflao hospital, respectively. The three tested samples were positive for *V. cholerae*. The index case was a 26-year-old female trader from Gbugbla-Aflao. The index case had just returned from Accra and developed the condition on that same day. A brother's wife of the patient, who had eaten rice and beans with the patient, also became sick. The rice and beans had been purchased from a food vender in Ketu South. No other person in the area has developed the disease (Ketu South Cholera Report, 2014).

As of September 16, Ketu South recoded 175 cases including two deaths. Overall, 66% of cases were female (116/175 total cases). Most of the cases came from Gbugbla, Teshie, Rainbow and Timber Market all suburb of Aflao where environmental sanitation is very poor (Ketu South Report Cholera, 2014). The average age of cases was 31.9 years.

Ho

Ho is located further north in the Volta region, approximately 158 km from Accra. Cholera cases were first reported in Ho during week 32 of 2014. During the week 32-39 period, females were predominantly affected, accounting for 54% (n=20) of cases. The age group 20-29 years was the most affected, followed by the 30-39 year group. The elderly were the least affected.

Over the weekend of August 22-24, 2014, three *V. cholera*-positive cases reported in Ho. The first confirmed case from Ho municipal was a local hospital orderly who attended a female patient from Ho West while she was on admission. The second was a pastor from Ashaiman in the Greater Accra region, who developed symptoms just prior to visiting his family in Ho. Four people in his household in Ashaiman had also developed the disease after he left for Ho. The third confirmed case took care of her daughter from Ho West while she was on admission with suspected cholera. Following discussion with local health authorities, it was found that the majority of outbreaks had direct links to Accra, due to the high population movement between Ho and the capital.

10.2. WASH: Ghana

Accra: A chaotic urbanization that is a breeding ground for cholera

- A significant part of the city is congested and constitutes a favorable environment for cholera; however, a few hotspots within Accra were identified (**Table 3**). In Accra Metro alone there are 78 slums and/or squats where 1.6 million people reside. The slums are characterized by high population density (650 people/hectare), unhealthy conditions due to the presence of sewage and solid waste accumulation. Some neighborhoods are in rupture with the society. They can be likened to lawless areas that reveal a failed integration of migrant populations (mainly from the north of Ghana) during the past 15 years.
- Risk of contamination at the household level is especially important via the storage of water in poor conditions. Food and water consumption practices in the street are very common, which also pose a risk for cholera transmission.
- The water networks, electricity, roads are undersized and cannot meet the needs of the city. In the slums, possibilities of progress have already been explored, with water kiosks, public toilets, family toilet, and cleaning programs. However, a significant change can only come from true structural projects in urban planning and public service.

Locality	Status	Neighborhoods
Osu Klottey	Entry point, secondary area, diffusion site	Odona “Sahara “, Mensah Guinea, Osu Mandela Park
Okaikoi	Entry point, secondary area, diffusion site	
Ashiedu Keteke	Entry point, secondary area, diffusion site	Agbogbloshie Market
Old Fadama	Entry point, secondary area, diffusion site	Sodom and Gomorra slum
Ayawaso East	Secondary area and diffusion site	Maamobi and Nima (in the vicinity of the market)
Chorkor	Secondary area and diffusion site	
Dansoman	Secondary area and diffusion site	Two slums
La municipality	Secondary area and diffusion site	Apapa, La Main Township, Agema, Wireless, and Olympia
Dome	Indirectly or randomly affected area, diffusion site	Dome Agbetown, Groshe town
Teshie-Nungua	Indirectly or randomly affected area, diffusion site	Miami, Sangonaa (fishermen)

Table 3. Hotspots located within the Greater Accra Region. Localities that appear to be the most affected and respective epidemic status.

Response

- Despite a good field presence and little cholera-related mortality, the management quality remains average, with delay problems during mobilization and inadequacy of some treatment center in term of isolation, which may become distribution sites.
- Difficulties are particularly noticeable at the end of an epidemic when case tracing, which should facilitate to stop the epidemic, is not properly performed.
- A cholera action plan exists, but it is too general and lacks relevant and differentiated targets (e.g., response/prevention, urban/rural, and short/medium term).

The role of the water network is underestimated vis-à-vis cholera

- The water network fulfills only 60% of the needs, and the distribution is rationed, this imposes scarcity of water. Water collect is a daily concern, and many households spend a significant amount of money on water. Overall, 75% of neighborhoods suffer from water rationing with some of them supplied only once or twice per week; many families only use 10 to 20 liters of water per person per day.
- During the rainy season, the mobility of pollution rises sharply. The combination of poor network conditions (leaks), the unhealthy environment, and floods cause contamination of the water system.
- Although the sachet water covers most (55%) of the needs for drinking water, the network feeds many people directly or indirectly (89%). Piped water is used for preparation of street food, water tankers, and the family-unit production of sachet water.
- Poor water quality of the network has been addressed in independent studies. Ghana Water Company Limited performs water quality tests, but they do not communicate the results. Nevertheless, they favor improving the chlorination of the network to ensure the presence of residual chlorine at the consumer level.

10.3. Epidemiology: Togo

Togo has experienced cholera epidemics every year since 2000 (**Figure 1**). However, the country has displayed a significant reduction in suspected cholera cases since the early 2000s. During the seven-year period from 2000 to 2006, a total of 7234 suspected cases were reported. Meanwhile, during the following seven-year period, only 983 cases were report in the country, yielding an average of approximately 140 cases each year. As of week 48 of 2014, a total of 281 suspected cases were reported in Togo.

To understand the dynamics of cholera in the country we performed a detailed assessment of the 2014 epidemic. We found that an initial epidemic struck the Lacs district during weeks 6-8 (indicated in dark blue in **Figure 13**), during which three deaths were reported. Of note, the first cases reported at the same period in Lomé during week 6 proved to be negative for *V. cholerae*. During week 9 and 11, one lab-confirmed case was reported in the districts of Golfe and Lomé, respectively, although these cases failed to give rise to epidemic expansion. Five suspected cases and two-cholera related deaths were again reported in Lacs during weeks 14-16.

The epidemic did not explode in Lomé until later in the year following a confirmed case on week 30. The epidemic peaked in the country on week 38. During this epidemic, a few suspected cases were also reported in Zio (1 case), Kloto (26 cases), Ave (9 cases) and Agou (6 cases). The epidemic then gradually subsided until week 45, when a second peak of cases occurred in Golfe during weeks 46-47 (**Figure 13**).

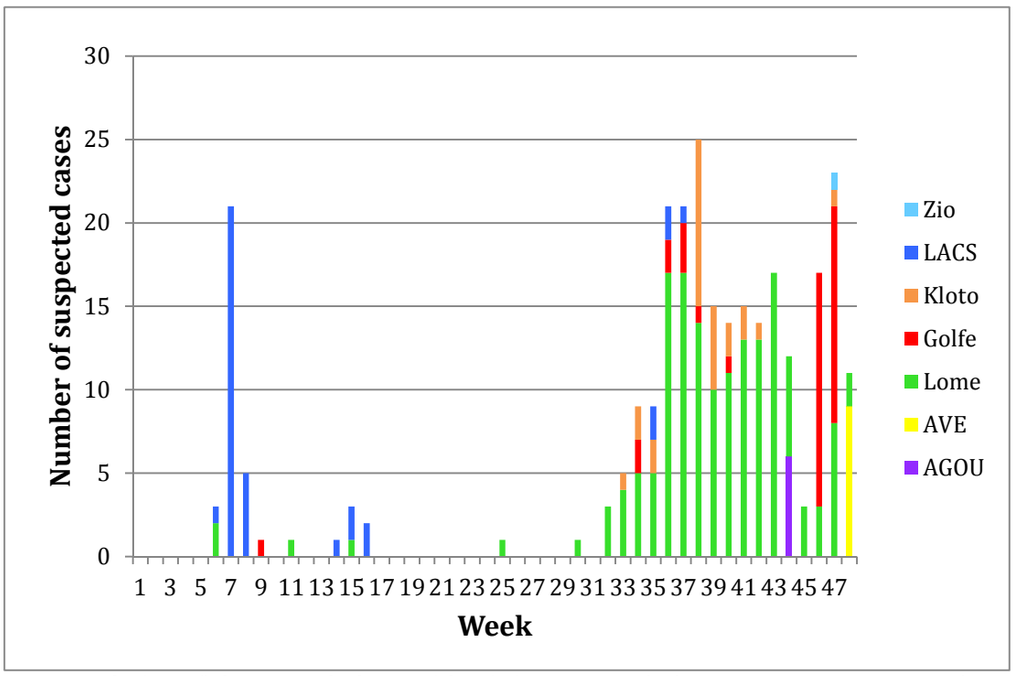

Figure 13. Evolution of the 2014 cholera epidemic in Togo. Each district reporting suspected cases is indicated in different colors.

In 2014, 55.8% of suspected cases were reported in Lomé. Furthermore, cases in Lomé were often residents of district D2 (59.9% of Lomé cases) or D3 (25.4% of Lomé cases) (**Figure 14**). We found that cases in Lomé were often associated with areas linked with fishing activity as well as flood zones, especially in Adakpamè, Bè Kpota, Anfamé, and Akodéssewa. In D2, cases appear to be associated with movement from Ghana and the large market close to the port.

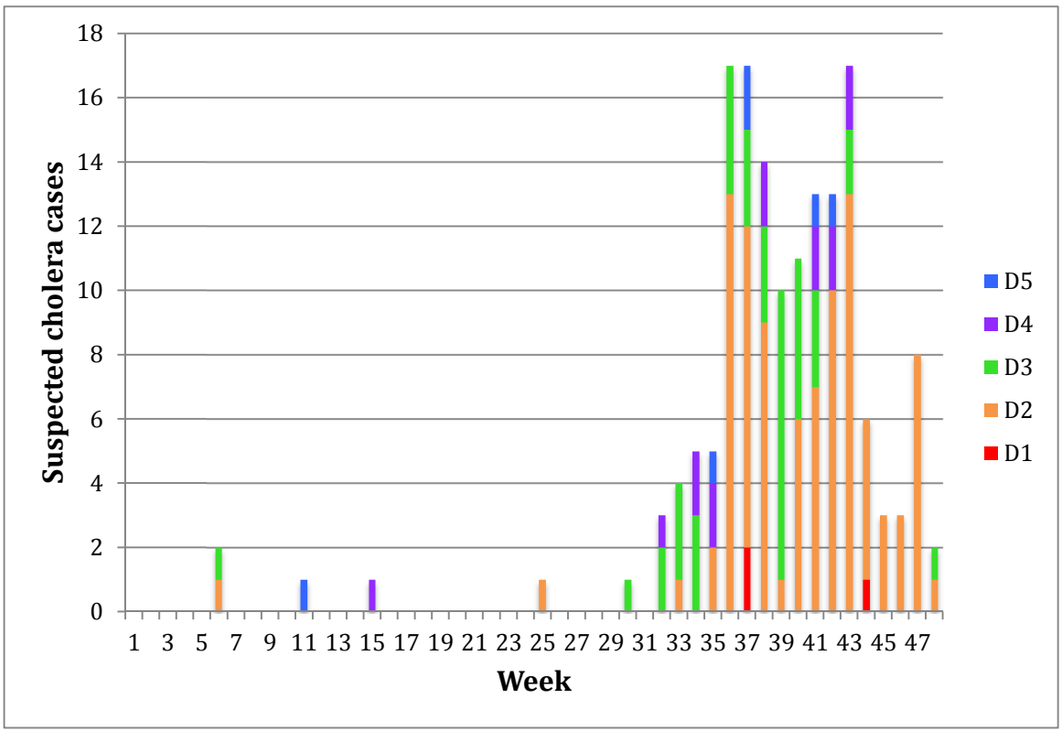

Figure 14. Evolution of the 2014 cholera epidemic in Lomé. Each district within Lomé reporting suspected cases is indicated in different colors.

Many of the cases in D3 were reported in Katanga. This site is primarily a fishing community with people of various ethnic origins. There is significant movement between Katanga and Ghana. Traditional wells are the primary source of water. The water is slightly brackish and the level varies with the tides. The wells (1 well per 5-10 households) provide access to a significant amount of water for domestic use. The exact number of fishermen affected by the disease is unknown, as this population is very mobile and may evade disease surveillance. For example, fishermen from Ghana that contract cholera in Lomé sometimes prefer to return to Ghana for treatment.

In Lacs, both epidemics from 2013 and 2014 were associated with people traveling from abroad (e.g., Nigeria and Benin) for large annual traditional animist ceremonies, which usually occur during the dry season. For 2014, the first cases where people who attended the ceremony in Séko and then a few secondary cases occurred before the outbreak came to a halt. In Séko, the

traditional animist ceremony was described to be rather "masculine", which likely explains why males were more affected (**Figure 15**). Furthermore, the attendants of such ceremonies tend to be older, which correlates with the older average age of cases in Lacs (37.5 years), compared with Golfe (26.1 years), Kloto (31.9 years), D2 (27.6 years) and D3 (31.6 years). During the ceremony of 2014, it was stated that open defecation occurred adjacent to the site where animals were slaughtered for the meals. Activities also took place along a riverbank where attendants drink untreated water directly from the river, which could be easily contaminated by the open defecation practice.

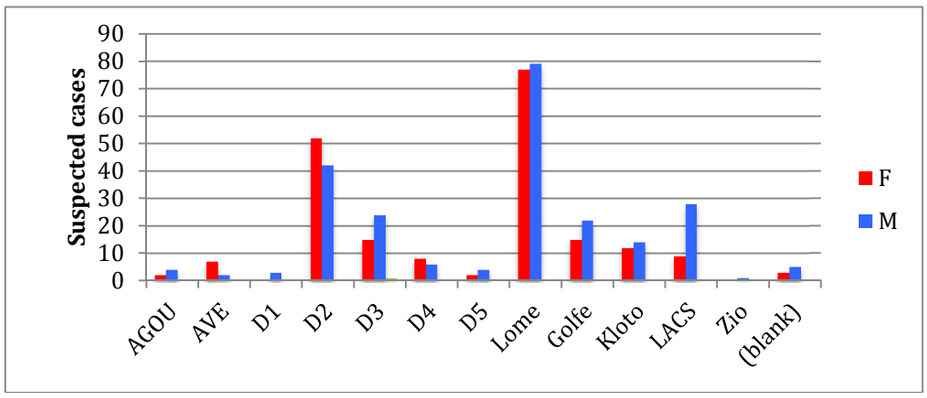

Figure 15. Cholera epidemic of 2014 in Togo: sex distribution by district.

An unusual two-week peak of 27 cases was reported in Golfe during week 46-47 (**Figure 13;** Golfe is indicated in red). The major of the cases (67%; 18 of 27 cases) were reported from Agoè zongo, in which many of the initial cases were a group of children aged and two teachers all living in close proximity. All of the six cases who were interrogated, except for a 8-year-old boy who died on Nov 15th (we spoke with his mother), obtain drinking water from the same borehole water station, although it is in very good condition.

The index case in Golfe during week 46-47 was likely a 17-year-old boy who first developed symptoms on Nov 13 at 2 AM. He stated that he had consumed water from the borehole water station and beans and cassava flour at home. He declared no history of travel or receiving visitors. Nobody in his immediate courtyard contracted the disease.

10.4. WASH: Togo

Selection and status of the local cholera hotspots

Commune level

1) The two coastal regions of Lomé and Maritime reported 85% of total cases of cholera in Togo between 2006 and 2013.

2) Sites where the cholera outbreaks often starts are primarily located in coastal districts, with a recurrence observed in the districts II, III, IV and V of Lomé as well as the Golfe and Lacs districts.
3) Overall, regularly affected communes with a duration and incidence ranked at "medium to high" are located: a) in the Lomé region: Districts II, III, IV and V; b) at the border with Benin (i.e., Lacs) and Ghana (i.e., Golfe); or c) at one crossroad point (i.e., Haho) (**Table 4**).

Districts	Quarters	Status	Cholera impact	Flood risk (Municipality of Lomé)	Quality of water supply by the network (TDE)
Lomé / District III	Katanga, Lomnava	Entry-point, directly affected, diffusion site			
Lomé / District II	Adakpamé (Danguipé, Akodessawa, Anfamé)	Entry-point, directly affected, diffusion site			
Lomé District IV	Nyekonakpoé Togbato, Aflao	Indirectly and randomly affected			
Lomé District V	Gbadago Togbato	Indirectly and randomly affected			
Golfe	Agoé Zongo	Indirectly and randomly affected			
Lacs	Seko, Anfoin	Directly affected and diffusion site			

Table 4. Communities affected by cholera and their status regarding cholera, flood risk and water quality. Red= high, yellow = medium, green = low. The two major local hotspots identified are located in Lomé (i.e., the village of Katanga and the sanitary district of Adakpamé). These areas have recurring outbreaks and report most of the cases. The patients reported that many of the inhabitants perform an activity linked with the port area, which seems to be the entry point and the major distribution site of cholera in Lomé.

Hotspots in Lomé:

Katanga

- **Localization, population and dwellings**
  The village is located on the beach near the port area. The population is estimated at 4,000 people. The area is home to very mobile fishing communities from Togo, Ghana and Benin. Fishermen migrate based on fishing opportunities. It is a spot of business where individual economic interests prevail over general and community interest. During the day, the site hosts many residents from neighboring districts (e.g., Akodessewa and Adakpamé) who exercise their professional activities (i.e., fishing, fish smoking, and trade) in Katanga. Dwellings are usually basic with shelters made of local materials (seko), planks and leaves; although some concrete houses are also present.

  The village has a Primary Care Unit built in 2001 and, since last year, a mini Cholera Treatment Center with three beds. However, it is common that Ghanaian patients prefer

to travel to Ghana for medical assistance via boat or road. Therefore, they may contaminate the vehicle or boat and delay treatment.

The village of Katanga exhibits regular tension and disorganization. The village has an "informal" status, and the option to displace the community is often discussed among local public health leaders. Nevertheless, a village development committee is working to improve the living conditions, although this committee is challenged by another committee that was recently established by a local group of young men.

- **Access to water and sanitation**
  Traditional wells are the main source of water. The water is slightly brackish but wells allow access to a significant amount of water for domestic use. The village was equipped with nine kiosks connected to the network of the national water company (Togolaise des Eau). Unfortunately, six are out of service and only three are functioning since they were restored in 2013 by the village development committee with the support of Organisation Internationale de la Francophonie. However, the water supplied by the Togolaise des Eau is very erratic, and the volume of water delivered is insignificant. There are several boreholes; two of them were funded in 2011 by a subsidiary of Bolloré. The boreholes are equipped with hand pumps, and they are overused. The water is soft, constantly running and free of charge; however, in case of a malfunction, money must be collected for repairs. Sachet water is often mentioned as a source of drinking water. The quantity consumed by households varies depending on the available resources. Households have access to Aquatabs distributed by the Primary Care Unit to treat water before drinking. Overall, households in Katanga have access to a sufficient quantity water, but quality drinking water is rare.

  The site has six public latrines, which are heavily used. The number of family latrines is very low, with no more than a few units within the community. Open defecation is very common, especially among children. Regarding personal hygiene, hand-washing practices are good. Water, showers and soap are available. We observed a high level of domestic hygiene; the courtyards were rather clean and tidy. The premises are clean, and the tidy alleys allow for decent circulation. There is a site for garbage disposal near the beach at the entrance to the port. In 2013, due to the cholera outbreak, a major operation to disinfect the port area and the neighborhood was performed, in which the houses, latrines, and waste were disinfected with chlorine.

Adakpamé

- **General description**
  The population of the district is diverse with many families of Ghanaian origin; several Muslims from northern Togo and Niger also reside in the community. Danguipé is the sub-quarter most affected by cholera. The area is urbanized but suffers from regular flooding. The population of the sanitary district of Adakpamé (which includes the

neighborhoods of Akodessewa and Anfamé) is 126,000 people. The community has a Cholera Treatment Center with 11 beds.

- **Access to water and sanitation**
  The area is very poorly served by the water network. The Togolaise des Eau water network rehabilitation work currently underway, with the support of the Agence Française de Développement, will not improve the service delivered in this area. The main water source is shallow wells. There is a well in each courtyard, which provides a significant amount of water for domestic use. A portion of the population also uses this well water for drinking. There are many private boreholes, and some people sell borehole water. During the 2013 outbreak, these water vendors received Aquatabs to treat water in the customer jerricans; however, these vendors did not receive Aquatabs during the 2014 epidemic. Overall, households in Adakpamé - Danguipé have sufficient access to water, but drinking water is rare.

  Approximately 60% of households have a family latrine, which are mostly water latrines with a septic tank, although these latrines often overflow and leak sewage into the street or backyard. Public latrines built and managed privately are also present. Despite the presence of family and public latrines, open defecation persists and pollutes the immediate environment of many households.

  The personal hygiene and hand-washing practices are sub-optimal. The premises are not always very well kept. The solid waste management is disorganized, and a significant quantity of solid waste is dumped into the streets.

Akodessewa and the eastern part of Anfamé (District II)

Akodessewa is located southwest of Adakpamé towards the port area, and Anfamé is northwestern of Adakpamé. Many residents settled here to be near the port area and the village of Katanga. Some parts of these neighborhoods are underserved by the water network and experience flooding. There are also pockets of the population living under precarious shelters made of sekos, without toilets and with very limited access to water.

The Quarter Development Committee manages one public latrine, but they should administer two or three additional latrines to help prevent open defecation. Moreover, they would like to reopen some public fountains that were closed in 2004. Concerning the areas not covered by the network, they propose to drill some boreholes to establish public water kiosks.

Lacs

The Lacs prefecture is located in the east of Togo along the border with Benin; this site represents an entry point for cholera from Nigeria and Benin. Cholera outbreaks often occurred during traditional animist ceremonies. These events gather several hundred people for one to several weeks. During the ceremonies, the living conditions are precarious and the host villages cannot provide adequate sanitary conditions for all

visitors. In 2014, more than 20 cases of cholera were reported during two episodes linked to the ceremonies. During the second episode, the health district disinfected the village of Seko. Subsequently, the prefecture has contacted the association of traditional healers to request that preventive measures are taken during subsequent events.

The ability to stop cholera outbreaks

- Due to the monitoring system, management, and mobilization capacity (sword intervention), cases of cholera arriving regularly in Togo did not result in substantial epidemics. Note that the cholera-related mortality is low in Lomé and the maritime zone, although it is relatively elevated in Lacs, where the level of information and access to care is of lower quality.
- In the fight against cholera, Togo has an action plan (2013) in which cross-border meetings are organized. However, these exchanges are limited to the border districts, with more emphasis on Benin than Ghana.

Structuring projects and proximity action

- To cope with the continuous urban increase of Lomé, several projects (e.g., Agence Française de Développement, World Bank, and European Union) are on-going in the domains of water supply and the prevention/management of floods. The general situation should improve soon. However, the planned results will have little or no impact on areas of Katanga and Adakpamé. In the field, several actors (e.g., Organisation Internationale de la Francophonie, Red Cross, UNICEF, WHO, and Organisation de la Charité pour un Développement Intégral-Caritas) have projects to improve the living conditions of the population (e.g., chlorination at home, improved hygiene) and strengthen the capacity of Local Development Committees for self-development.

10.5. Epidemiology: Benin

Since 2000, the average number of suspected cases per year in Benin ranges from a few cases to several hundreds, with the exception of 2001, when 3943 cases were reported. No cases were reported in Benin in 2007 (**Figure 1**).

Over the course of the past four years, Cotonou was only affected by major cholera outbreaks in 2011 (226 cases) and 2013 (223 cases) (**Figures 16** and **18**). In contrast, the lakeside commune of So-Ava was affected every year since 2011, although only few cases were reported in 2012 (**Figures 16-19**). Furthermore, in 2011, 2013 and 2014 So-Ava was the first affected commune in the country (**Figures 16, 18** and **19**). The lakeside commune reported 40% of cases in 2013 and 30.4% of cases in 2014.

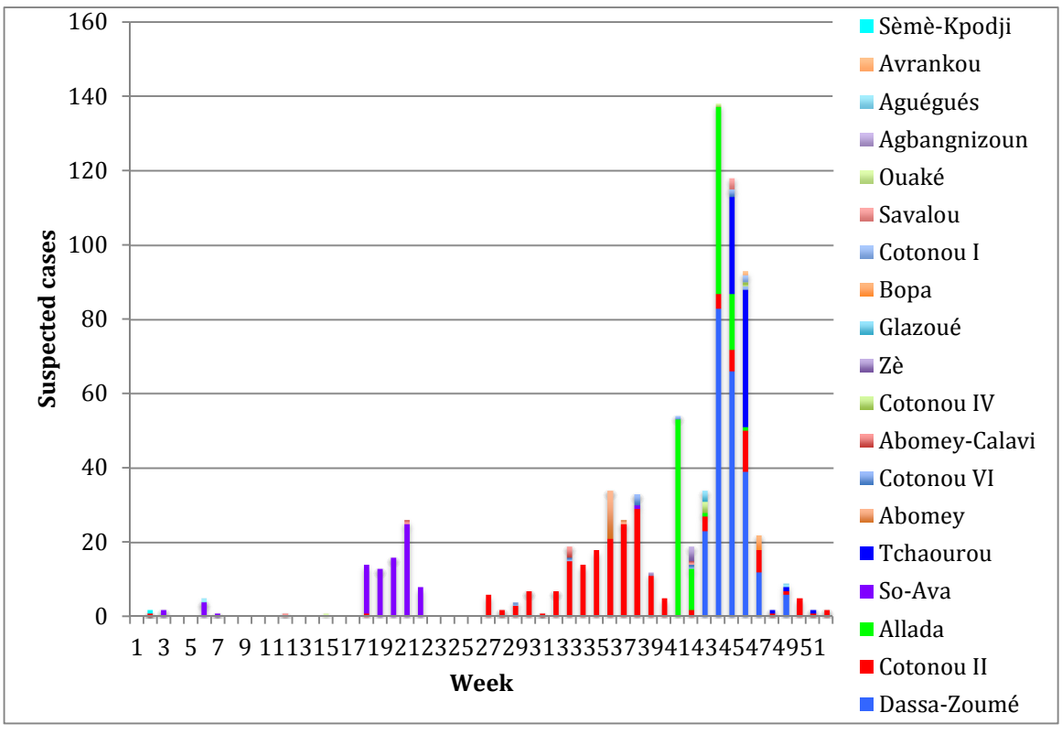

Figure 16. Evolution of the 2011 cholera epidemic in Benin. Each commune reporting suspected cases is indicated in different colors.

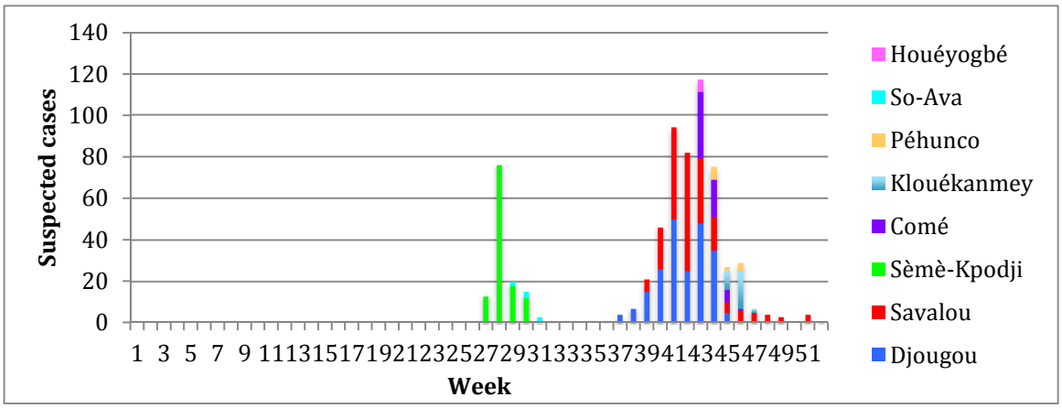

Figure 17. Evolution of the 2012 cholera epidemic in Benin. Each commune reporting suspected cases is indicated in different colors.

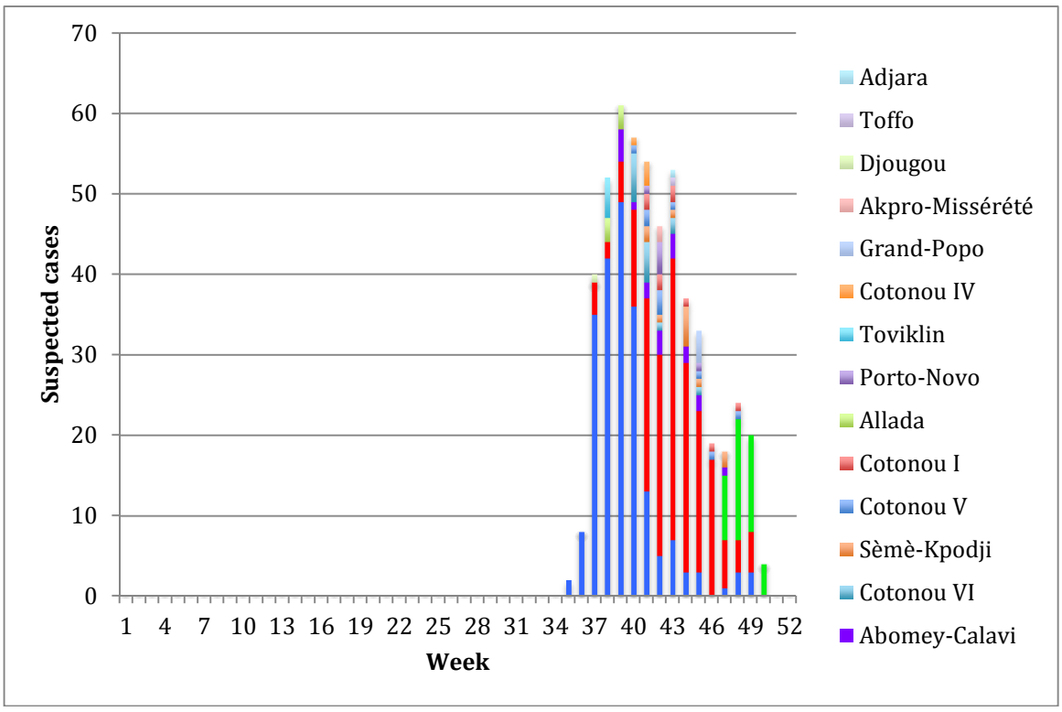

Figure 18. Evolution of the 2013 cholera epidemic in Benin. Each commune reporting suspected cases is indicated in different colors.

To understand the dynamics of cholera in the country, we performed a detailed assessment of the 2014 epidemic (**Figures 19**). The histogram clearly shows two separate outbreaks occurring in separate locations at distinct periods. Accordingly, the hardest hit areas were Toffo (156 of 336; 46.4% of cases) and So-Ava (30.4% of cases). As of week 35, Cotonou only reported four suspected cases in 2014, of which at least two were negative according to the reference lab (cases reported on September 8).

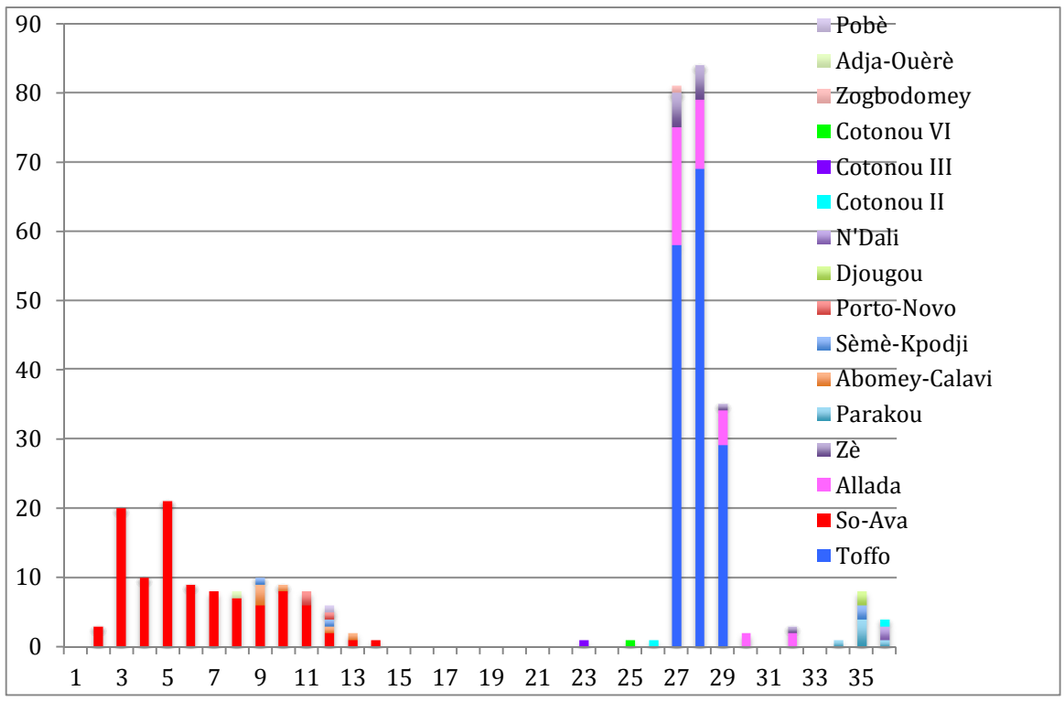

Figure 19. Evolution of the 2014 cholera epidemic in Benin. Each commune reporting suspected cases is indicated in different colors. The histogram clearly shows two separate outbreaks.

The first outbreak was reported in So-Ava from week 2 to week 14. So-Ava is a commune located to the north of Lake Nokoué, where many "floating villages" are located with houses built on stilts in the water (**Figure 20**). The second major outbreak of 2014 was reported north of So-Ava, in Toffo and Allada during weeks 27-32. However, these cases in Toffo and Allada were never confirmed by the reference laboratory.

Figure 20. A typical "floating house" in So-Ava, north of Lake Nokoué. Photo: Sandy Moore.

10.6. WASH: Benin

Selection and status of the local cholera hotspots

Department level

The four coastal departments: Atlantic, Littoral, Ouémé and Mono reported almost 60% of total cases of cholera between 2004 and 2013. Notably, the departments of Atlantic and Littoral reported cholera cases almost every year (9/10 years).
Sites where the cholera starts are mainly located in coastal departments with a recurrence observed in So-Ava, Cotonou, Porto-Novo, Semé-Kpodji, Abomey and Athiémé.
Regularly affected communes with a duration and incidence ranked "medium to high" were located at (1) on the border of Lake Nokoué: So-Ava, Abomey, Cotonou, and Dangbo; (2) at the border with Nigeria: Porto Novo, Semé-Kpodji; (3) at the Togo border: Athiémé; and (4) at some intersection points (commercial crossroads): Allada, Toffo, Dassa-Zoumé, Savalou and Djougou (**Table 5**).

Department / Commune	Village	Status	Impact cholera
Atlantique / So Ava	So-Ava, Houedo Aguekon, Sindomé, Ahomey Glon	Entry-point, directly affected, diffusion site	
Littoral / Cotonou	Cotonou, Enagnon, Agbato	Entry-point, directly affected, diffusion site	
Oueme / Seme Kpodji	Kraké	Entry-point, directly affected, diffusion site	
Oueme / Seme Kpodji	Gbakpodji	Entry-point, directly affected	
Atlantique / Abomey Calavi	Abomey Calavi	Directly affected by So-Ava	

Table 5. Principal cholera hotspots in Benin during 2013 and 2014. This list was established based on analysis of the epidemiological data and discussions with health services in Benin. The names of towns and villages and their cholera status are indicated. Red = high risk, yellow = medium risk.

Although cholera does not cause major epidemics in Benin, it is a recurrent issue that affected 36 different municipalities in the country during the last 10 years. Benin shares a border with the country of Nigeria, one of the largest cholera foci in Africa. As of week 47 of 2014, Nigeria reported 35,732 cholera cases. There is a high level of daily exchange between Nigeria and Benin, via both road (at the Kraké border) and boat (lake Yewa leads directly into lake Nokoué). This is the cross point of intense formal and informal trading business characterized by tensions and insecurity. Urbanization is continuously expanding, and self-interest dominates the public interest. The pineapple market at Kraké and the border crossing point are marked by poor public health conditions with accumulated waste, open defecation and a lack of drinking water. In 2012, the epidemic started with an outbreak Kraké. Therefore, Benin is indeed vulnerable to the importation of cholera cases from Nigeria.

The **most persistent cholera entry point** is the commune of So-Ava located north of Lake Nokoué. The main occupation of the population was historically fishing-related activities. However, now that the lake has been over-fished, the people have resorted to finding a variety of alternative means to make a living. Several alternative activities include sand mining and smuggling fuel from Nigeria, which has become the major pillar of the local economy. Intense commercial activity (both legal and illegal) along lake Yewa, which leads into lake Nokoué, appears to represent a major pathway by which cholera cases may be introduced from Nigeria to the lakeside communities such as So-Ava, Cotonou, Gbakpodji, and Porto Novo. However, as these communities are relatively isolated from each other (especially in So-Ava), cholera outbreaks often fail to expand. Furthermore, the principal ethnicities in So-Ava are Toffin, Fon, Aïzo, and Yoruba; therefore, they have strong links with a similar ethnicity and language as Nigerians (Yoruba) and the populations in Toffo and Allada, (i.e., Aïzo and Fon).

Indeed, the communes of Toffo and Allada that have also been affected by cholera in recent years may also be related to the transmission through Lake Nokoué. Toffo is a landlocked area located approximately 80 km north of Cotonou. The principal ethnicities in Toffo are Aïzo, Fon, Adja, and Holli. There is often exchange between the populations in So-Ava and Toffo, as these groups are ethnically close. There is also a major roadway directly connecting So-Ava with Allada (36 km) and Toffo (61 km).

During the mission, we visited several cholera victims in So-Ava, Gbakpodji village (located on the southeast shore of the lake), and two urban neighborhoods of Cotonou (Enagnon and Agbato), which are settled on the bank of the lake. In these communities, access to water, sanitation conditions and hygienic practices need to be improved.

Health services monitor cholera and limit the spread of epidemics. However, at So-Ava, health centers do not have specific equipment for the treatment of cholera, and the remoteness of this commune render mobilization difficult. Although the National Cholera Action Plan is outdated, there are plans to revise the document. The mayors of municipalities have water and sanitation skills, and they are developing multiannual programs. They are supported by several key international actors, such as the Dutch cooperation, Germany and the European Union, which have financed WASH activities carried out by Emmaus International at So-Ava for the past several years.

Water and sanitation in So-Ava commune

So-Ava is divided into seven districts comprised of 69 villages, although most documents/individuals speak rather of 42 historic villages. The resident population is 104,690 inhabitants. In So-Ava, water occupies 65% of the surface; most villages are only accessible via boat/canoe.

The town officials have drafted a water access program (PC Water 2015-2017), which presents an overview and lists the projects planned for the coming years in terms of access to water. As of November 2014, six of seven districts are served by a total of 12 water supply systems, six independent stations, and two boreholes fitted with hand pumps. Only the center district of So-Ava is served by the national water company network (SONEB). The average rate of access to potable water in rural areas is 51%, with the highest coverage in the rural community of So-Ava (68.9%) and lowest coverage in Houédo Aguekon (34.9%). These calculations are based on the theoretical number of users and do not take into account the amount of water actually produced.

While most systems are functional, it appears that many of them rely on makeshift pumping devices. As a result, water is not delivered to some fountains of the networks. In many cases, the water produced is sub-optimal for consumption. The water is sometimes saline and often turbid with a reddish color and suspended particles (**Figure 21**). Furthermore, the water delivered is also sometimes affected by bacterial pollution and the presence of small worms or larvae.

Figure 21. Water collected from community pumps in So-Ava is visibly contaminated with organic particles. Photos: Sandy Moore.

Regarding sanitation, the commune of So-Ava is characterized by the use of latrines on stilts and the practice of open defecation. Family latrines are rare because it is complicated to build septic pits, which must then be emptied to an unknown destination. Concerning public latrines, one hundred units built by Emmaus International/Le Centre Régional pour l'Eau Potable et l'Assainissement currently exist throughout the commune.

11. Multilocus variable-number tandem repeat analysis (MLVA) results

A total of 412 *V. cholerae* isolates from recent cholera epidemics in Ghana, the DRC, Zambia, Guinea and Togo were subjected to MLVA. Analysis of the six VNTRs yielded 101 MLVA types. A Minimum Spanning Tree (MST) was constructed using the combined MLVA data to assess the relationships between the 412 *V. cholerae* isolates and the epidemic populations. The MST clearly grouped the Ghanaian isolates among the West Africa cluster together with isolates from Togo and Guinea. In contrast, the isolates from Ghana were unrelated to isolates from Central Africa (the DRC and Zambia) indicated in shades of blue (**Figure 22**).

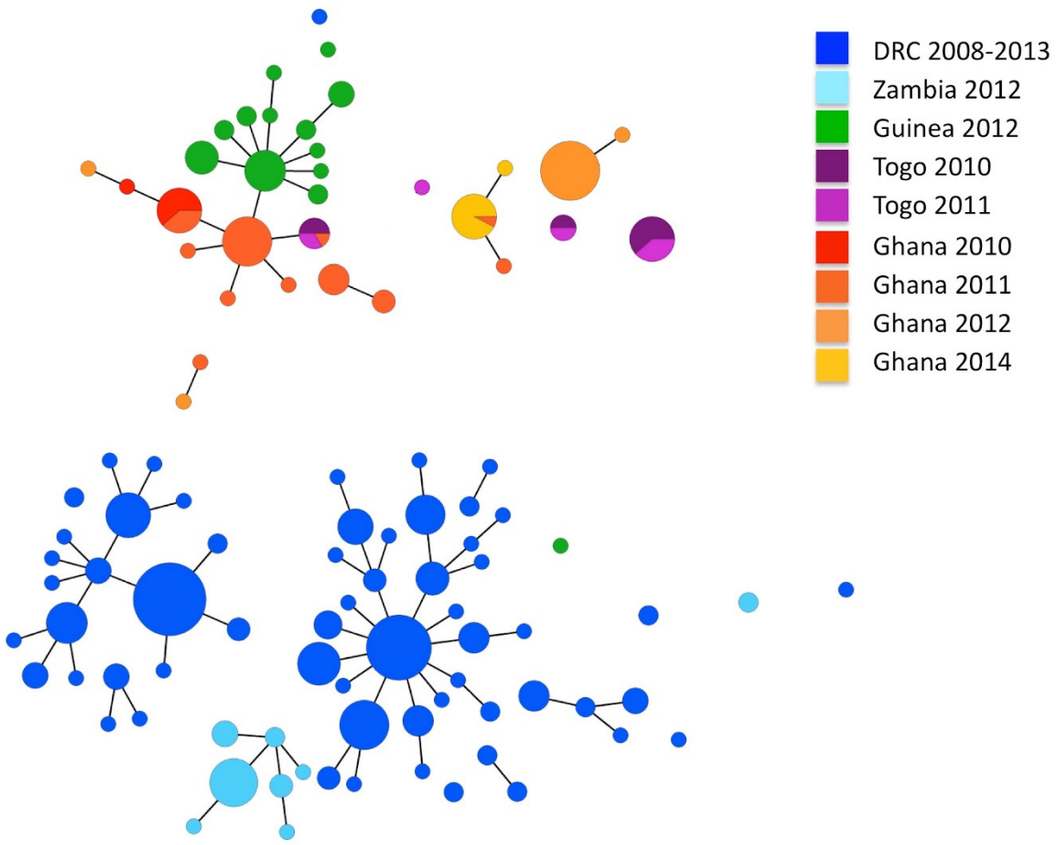

Figure 22. Minimum Spanning Tree based on the MLVA types of 412 *V. cholerae* isolates derived from several recent African epidemics. Each MLVA type is represented by a node, and the size of the nodes reflects the number of isolates of each MLVA type. The relationships between isolate MLVA types are indicated by connecting segments; solid lines indicate the most likely single-locus variation. The distance between the nodes represents the number of varying VNTRs from the center node. The colors reflect the distinct country and period of isolate origin. Pie charts were used to indicate the distribution of strains isolated from different time periods or countries displaying identical an MLVA type.

The cluster in the top-left corner indicates that the Ghana 2011 epidemic isolates were closely related to certain isolates from Ghana in 2010 as well as Togo in 2010 and 2011. The 2011 epidemic, which extended throughout the year, gave rise to isolate diversification and expansion (Ghana 2011: 11 MLVA types, 37 isolates). This cluster indicates that 2011 isolates from Ghana were closely related to and likely eventually gave rise to the 2012 Guinean epidemic.

The loosely linked cluster at the top-right comprises all analyzed Ghana 2014 isolates, most Ghana 2012 isolates, and many Togo isolates. This group may have an alternative origin and seems to be distantly related to the epidemic that spread from Ghana to Guinea.

12. Conclusion

The West African region of Ghana, Togo and Benin is regularly affected by cholera epidemics. From 2011 to the end of 2014, a total of 52,512 suspected cholera cases have been reported from the three countries according to the WHO. However, during this four-year period, over 93% of these cases were reported from Ghana. Furthermore, the epidemiological findings overwhelmingly demonstrate that Accra represents the cholera epicenter of the entire sub-region of Ghana, Togo and Benin. From 2011 to week 49 of 2014, 68.2% of cholera cases in the tri-country region were reported in Greater Accra Region. Strikingly, 80.2% of regional cholera cases of 2011 were reported in Greater Accra Region.

The current epidemic in Ghana occurred following a one-year lull; no lab-confirmed cholera cases were reported in Ghana during 2013 despite typical rainfall. Once the toxigenic bacterium *V. cholerae* O1 is imported into the city, cholera outbreaks appear to rapidly explode throughout western and central neighborhoods/districts of Accra Metro, apparently touching both slum and non-slum areas. Early on, younger women were exposed, and children below the age of six and adults over the age of 60 were not affected until four weeks after the first case. These results suggest that the epidemic quickly reached the heart of the households and subsequently affected children and elderly.

Many elements indicate that the water network plays a major role in this expansive diffusion of the bacteria. According to a 2009 UN Habitat report, access to water in Accra varies according to three main categories of urban dwellers: (1) first class residential areas and are connected to the water supply network and have steady water flow; (2) a large proportion of Accra residents live in areas in which they are connected to the network but do not receive water through their taps on a regular basis; and (3) the majority of residents, mostly the poor and vulnerable groups living in slums and poor neighborhoods, are not connected to the network and must purchase their water from vendors (UN Habitat, 2009). A study of the 2012 epidemic found that drinking community pipe-borne water (OR=2.15) was associated with contracting cholera in Osu-Klottey (Davies-Teye et al., 2014). Initial analysis of the 2014 epidemic demonstrated that the case localization during the first seven weeks (June 10 - July 28) corresponded to zones at the end of the network, where the water supply condition is rated “rationed” or “poor”. Drains running along streets and throughout neighborhoods are partially or completely clogged with trash/solid waste and therefore easily overflow during heavy rains. Water network pipes, which are often of poor quality, are often running through these drains or along the ground. As open defecation is rampant and the water network is often cut off, the water pipes could likely become contaminated with ground water (including human waste), especially during the rainy season. Strikingly, a study has revealed unsuitable residual chlorine levels and the regular presence of fecal coliform in the network water even during the dry season (Karikari and Ampofo, 2013). As Accra is one of the most populated and fast growing metropolises in Africa, with an annual growth rate of 4.3% (UN Habitat, 2009), these issues of poor water access, open defecation and flooding that subsequently contaminates the drinking water network will likely worsen unless steps are taken to drastically improve these conditions.

In general, outbreaks occurring in other regions of Ghana are limited in size and very often linked to index cases contaminated in Accra or traveling with food purchased in Accra. Indeed, field investigations in Ho and Ketu South revealed that local outbreaks were directly associated with travelers from Accra. In contrast to Accra, outbreaks in other regions of Ghana are quickly brought under control before the epidemic explodes.

Togo appears to have regular importation of cholera cases that originate from neighboring countries experiencing outbreaks. Indeed, the high volume of travel between Lomé and Ghana as well as Lacs with other countries, such as Benin, Ghana, and Nigeria, renders the country vulnerable to cholera imported from abroad. Based on the field investigations, we found that outbreaks in Togo, especially in Lomé, were epidemiologically linked to the outbreak in Ghana. Most outbreaks in Lomé occurred in flood zones as well as areas linked with fishing activity. Meanwhile, outbreaks in Lacs were associated with travelers coming from Benin or Nigeria for traditional animist ceremonies. However, when cases arrive they seem to only produce a few secondary cases or small outbreaks. Cholera epidemics in Togo are controlled quickly before they significantly expand. The limited diversification of *V. cholerae* isolates during the Togo outbreaks of 2010 and 2011 indeed supports this observation.

Benin shares a border with the country of Nigeria, home of one of the largest cholera foci in Africa. As there is a high level of daily exchange between Nigeria and Benin, via road and boat (lake Yewa into lake Nokoué), Benin is vulnerable to the importation of cholera cases from Nigeria. Many of the communities affected along the lakes are indeed communities where precarious level renders the people vulnerable to cholera outbreaks. However, as these locales are relatively isolated from each other (especially in So-Ava), cholera outbreaks often fail to expand. Cotonou is also vulnerable to importation of cases from Nigeria due to the massive influx of people traveling by road and boat. However, the populations residing in the most affected zones of Cotonou have ample access to potable water, and therefore outbreaks rarely expand in the city.

MLVA was performed on 87 Ghanaian isolates corresponding to epidemics in 2010, 2011, 2012 and 2014. These results were then compared with an extensive panel other recent African *V. cholerae* epidemic isolates. Interestingly, Ghanaian epidemic of 2011, which spread throughout the entire year, likely gave rise to the cholera epidemic in Guinea during 2012. The epidemic isolates from Ghana 2011 and Guinea 2012 form a very compact complex, and the founder MLVA type of the Guinean epidemic displays a very high level of similarity to the predominant isolate from Ghana in 2011. However, these isolates should be assessed via whole-genome sequencing to confirm this hypothesis. Several clusters indicated that certain outbreaks in Togo were directly linked to the epidemic in Ghana as clinical isolates displayed identical or closely related MLVA types. Unrelated isolates from Togo and Ghana may be associated with imported cases from Benin or other regions affected by cholera (Nigeria); however, further genetic analyses would be required to confirm this hypothesis. Finally, the explosive epidemic of 2014 in Ghana appears to be due to very closely related isolates (only 2 distinct MLVA types), which indicates parallel

expansion of likely imported case rather than exposure to an environmental reservoir of diverse *V. cholerae* populations.

In conclusion, Accra is clearly the main hotspot of cholera in this tri-country region of West Africa. Once toxigenic *V. cholerae* is introduced, the city functions as an amplifier of cholera epidemics, which then gives rise to outbreaks in other regions as populations migrate. Indeed, cholera appears to spread in a highly dynamic manner that poses a significant public health threat at a regional level in West Africa. Therefore, it is critical to continue this investigation and understand the dynamics of cholera epidemics in Accra. Controlling cholera in the capital of Ghana would likely have widespread effects throughout the Gulf of Guinea.

13. Recommendations

13.1. Stop the current epidemic in Ghana

As cholera outbreaks are linked and shown to spread along the West African Region, as observed during the 2010/2011 epidemics that spread from Accra to Guinea in early 2012, it is critical to stop the current epidemic in Accra before it explodes again enhancing the risk of diffusion into Ebola-affected countries.

- **Objective**: To avoid household and environmental contamination by improving case tracing (by geo-localizing cholera patients) to target WASH intervention as well as improving water network chlorination, especially during the rainy season.
    - **Indicator:** The number of people affected from the same premise has decreased compared with the previous period.
- **Impact**: Short-term, good (impact to stop the epidemic); long-term, good (prevent case carryover and future outbreaks).
- **Feasibility (case tracing)**: The Disease Control Unit of the Ghana Health Service health districts of the Ghana Health Service shall trace cases of cholera at their home and educate other residents. To complete the protocol and disinfect areas contaminated by the patient (e.g., bed, living area, and toilets) the Disease Control Unit teams must be accompanied by Environmental Health Officers of the Ministry of Local Government and Rural Development. To achieve the goal, the two entities must coordinate the flow of information and act quickly in the health districts. Joint planning must be established to synchronize field visits.
- **Expected result (case tracing)**: Operational teams implement appropriate case tracing.
- **Beneficiaries**: Direct beneficiaries are the number of cases recorded per week.
- **Management/Procedure (case tracing)**: Disinfection requires a minimum of logistics as material must be transported and cases are spread throughout the Greater Accra Metropolitan Area. To facilitate interventions, two teams from the regional Environmental Health Office, each with a vehicle, must be ready every day. Based on the established schedule with the Disease Control Unit, they can visit the district concerned and implement the disinfection with the support of the sector officers.
- **Duration (case tracing)**: Three months.
- **Cost (case tracing)**: Resources have been already allocated by UNICEF for this activity.

13.2 Further analyses are required to better elucidate how cholera functions in Accra, and specifically understand the function of the water network during cholera epidemics.

- Examine characteristics such as network chlorination and contamination.
- Perform case-control studies investigating risk factors for cholera, especially during the periods of rapid increase of cholera incidence.

13.3. Reinforce cross-border collaboration

These findings strongly highlight the importance of reinforcing cross-border collaboration, especially during a cholera epidemic.

- Communication should be enhanced not only involving border districts, but also temporary migrant areas.

- Key stakeholders from the concerned countries (Togo, Benin, Ghana, and Nigeria) should have access to international workshops established to define the framework for cross-border collaboration.
    - Discussions should involve the mechanisms of cholera epidemics at a regional level, exchange of good practices, lessons learned, and the development of a plan to monitor and implement the recommendations.
    - To streamline meetings, preparative workshops should be organized at a national level. Country representatives should each prepare a description of the epidemic and an inventory of strengths and weaknesses of cross-border collaboration. The funds for document translations and publications should be covered by the budget.
- Key stakeholders should be granted access to a revised and specific version of the strategic cholera plan
    - The project includes workshops/meetings to develop the strategic plan to fight cholera at the national level. These workshops shall develop a comprehensive, dynamic and strategic reading of cholera in each country in connection with the strategy developed at the regional level (see Platform Cholera WCAR). The plan should prioritize key actions and target both entry points and major diffusion sites. This approach will mobilize all relevant partners in specific geographical areas. Work groups will be organized, and the necessary costs to publish documents will be provided.
    - The strategic plan to fight cholera will integrate the following aspects:
        - The epidemiology of cholera in the country with a sub-regional vision and the identification of hotspots
        - Prioritize strategic activities according to the typology of hotspots (preparation, cross-border collaboration, vaccination, sustainable WASH project, etc.)
        - An intervention strategy in line with the regional "sword and shield" strategy
        - The implementation of sustainable WASH interventions based on a diagnosis of the context
        - The integration of cross-border cooperation with neighboring countries
        - A scheme to validate and implement the strategic plan to fight cholera and a round table to mobilize donors

13.4. Continue the analysis of *Vibrio cholerae* isolates collected in the region to understand cholera epidemics at both a country and regional level

MLVA of *V. cholerae* isolates from Ghana and other West African countries has indeed provided valuable insight into the dynamics of cholera in both Ghana and the West Africa region. Therefore, it critical to continue collecting strains from Ghana and expand the analysis of isolates to include those from Togo, Benin, Sierra Leone and Côte d'Ivoire (fishermen from Ghana spread the 2014 epidemic to Côte d'Ivoire (UNICEF)).

Analysis of strains from the 2014 epidemic in Togo, together with strains from neighboring Ghana, would support epidemiological findings and determine whether outbreaks in Togo originated from Ghana (especially in Lomé and Golfe) or Benin (Lacs). A similar analysis of strains from Benin would be essential to determine whether outbreaks in the country originate from

Ghana, Togo, Nigeria, or other countries. Clearly understanding the origin and transmission route by which cases are imported into Benin would be critical to put in place specific targeted prevention measures to stop future outbreaks. Eventually, analysis of *V. cholerae* strains from Nigeria would complete this aspect of the study to obtain a solid understand of the mechanisms by which cholera functions in West Africa, at both a regional and national level.

Whole genome sequencing of these isolates would especially help to confirm parentage between strains using an indisputable method and determine whether the strains have or the ability to acquire genetic material from environmental strains.

13.5. Support local studies of hotspots within Accra

A detailed analysis of the 2012 epidemic has already been conducted in the sub-district Osu-Klottey (Davies-Teye et al., 2014), and the group has started a similar analysis of the 2014 epidemic. The study involved consultations with all cholera patients in the area. The team gathered extensive case information, including place of residence, the suspected place where the disease was contracted, and the location of toilets they use. GPS coordinates were also recorded, which is used to generate dynamic maps of epidemic evolution and localize cases. However, the study of the 2014 epidemic has not been completed. For 1,700 cases, only 150 randomly selected cases were traced (as of December 2014). To identify hotspots within Accra Metro, the data collection should be completed, especially for the cases occurring at the beginning of the epidemic. If this method proves successful, it may be appropriate to replicate this approach in other early-affected sub-districts of Greater Accra Region.

- **Indicator**: Number of hotspots identified.
- **Impact**: Short term and no guarantee for impact.
- **Expected results:** Targets areas (10) for intervention (WASH and others) are identified.
- **Beneficiaries:** 10 locations and a total of 100000 people (?).
- **Duration:** Three months.
- **Cost:** < 50000 $ (?).

13.6. Further evidence is required prior to launching a vaccination campaign in Ghana

The current investigation findings indicate that vaccination campaigns would not be effective in Accra, as specific target populations could not be identified. However, taking in account the cross-border spread characteristics of cholera epidemics, populations that migrate extensively with poor access to potable water, such as fishermen that travel long distances, may be candidates for vaccination campaigns.

13.7. Review Ghana National Cholera Action Plan

- **Objective**: To improve the capacity to prevent and react to outbreaks based on the regional epidemiological studies conducted by epidemiologist at the Aix-Marseille University (Sandy Moore and Renaud Piarroux) with Ghanaian collaborators. Prioritize strategic activities according to the localization of regularly affected areas. Establish a differential approach between preparedness, emergency and long-term interventions. Establish a strategy in line with the regional approach (shield and sword) that promotes the use of a Geographic Information System in urban settings (geo-referencing patient dwellings).

Support/coordinate cross-border communication with neighboring countries, including standardized data sharing and identification of focal persons.

- **Expected results**: Publication concerning cholera in Ghana and a strategic cholera action plan outlining activities to carry out over several years.
- **Duration**: 6 months.
- **Cost**: < 60000 $ (?).

13.8. Inventory the current state of the water network in Accra

- Perform an inventory of the Accra water network, noting weak and strong points, and including assessment of chlorination levels and tests for fecal coliform and other bacterial contamination.
- Assure the continued monitoring of the quality of water (including regular sampling for fecal coliform, other bacteria, and residual chlorination level tests).
- Ensure regular communication from Ghana Water Company Limited concerning results.
- Investigate possibility of strengthening post-chlorination of the network by installing dosing chlorine pumps at strategic points along the network in Accra.

13.9. Togo: specific recommendations

- The cholera action plan should be revised taking into account the dynamic characteristic of epidemics and prioritize interventions according to the status of the areas concerned.
- Concrete actions should be undertaken in the village of Katanga and the health zone of Adakpamé to improve (1) access to water, (2) access to public latrines, and (3) treatment of drinking water. Steps should also be taken to prevent cholera outbreaks and ameliorate hygienic behaviors (**Table 6**).

  - <u>Improve population access to water facilities</u>

The project should include the construction of six water supply facilities, two in Katanga and four in Adakpamé. The precise location will be determined with the project partners. To ensure the construction of these facilities, the project should involve the following steps:

- Carry out technical feasibility studies, and identify the most appropriate locations for the facilities. The water facilities should be boreholes with submersible pump fitted by solar panels and connected to a water tank.
- Drill boreholes, install the pumping system, and install the network. The boreholes should be drilled in the sedimentary aquifer at a depth of between 20 and 40 meters.
- Train Village Development Communities regarding the management and maintenance of the facilities.

  - <u>Ensure that households have access to chlorine products</u>

To promote water treatment in homes in Katanga and Adakpamé, the project should finance the completion of a social marketing study to determine the expectations of the people in this area. The methodology of social marketing includes market research, a study of the supply chain, definition of a pilot product, definition of pilot promotional material, and a test phase. Once the

desired product is defined, the “market facilitation phase” should be implemented, serving to support production and fund promotional campaigns.

- The population have access to improved public latrines

The project should include the construction of eight public latrines, two in Katanga and four in Adakpamé. To ensure the construction of these structures, the project should include the following steps: (1) determine the technical feasibility and select the most appropriate locations for their facilities; (2) build the latrines; and (3) train the village committee concerning the management and maintenance of the facilities.

- Feasibility study for ECOSAN latrines in Adakpamé

To respond effectively and sustainably to family sanitation concerns, the project should involve a feasibility study regarding the ECOSAN device in the context of Adakpamé. It should be determined whether this approach is possible in Adakpamé and if there is a sufficiently large agricultural demand to justify implementing an ECOSAN latrine network.

- Improve the hygienic conditions during traditional animist ceremonies in the health zone of Lacs (**Table 6**).

In the district of Lacs, the organization of traditional animist ceremonies constitutes a risk for cholera diffusion. To assess this issue, an anthropological study should be performed by a local consultant. The findings should then include methodological recommendations to improve the WASH practices during these major events. Following the study, workshops and training should be conducted with key stakeholders to promote good hygiene practices. At the end of the training, equipment kits should be distributed to organizers of traditional animist ceremonies.

Recommendations	Duration	Impact	Benefit	Budget
Cholera action plan and cross-border coordination	3 years	High	150	180000 €
Drinking water infrastructures (6 units)	3 years	High	9000	300000 €
Household water treatment (study and market facilitation)	1 year	Low	30000	80000 €
Public latrines (6 units)	3 years	High	1200	180000 €
ECOSAN (1 study)	1 month	Low	-	15000 €
Awareness campaigns (12 units) (proximity and media)	3 years	Medium	36000	180000 €
Recommendations for traditional ceremony masters	1 year	High	120	39000 €
TOTAL			**76470**	**974000 €**

Table 6. The duration, level of impact, number of beneficiaries, and budget for each WASH activity in Togo.

13.10. Benin: specific recommendations

- **The strategic national action plan to fight cholera should be revised** taking into account the dynamic characteristics of epidemics and prioritizing interventions according to the status of the areas concerned.
- **Concrete actions should be carried out in Kraké and communities located along the shores of Lakes Yewa and Nokoué**

1) Improve access to water (construction/rehabilitation of water points), public latrines, and treatment of drinking water (social marketing approach)

- Improve population access water facilities

We propose a project including the construction of eight water supply facilities. The targeted villages targeted should be determined with the project partners, although initial activities may include the installation of four facilities in the commune of So-Ava and four in other lakeside villages. To ensure the construction of these facilities, the project should include the following steps:

1) Perform technical feasibility studies and identify the most appropriate locations for facilities. Depending on the location, water network systems, pumping stations or single boreholes with hand pumps may be installed.

2) Drill boreholes, install the pumping system and install the network.

3) Train the village committee regarding the management and maintenance of the facilities.

- Ensure that households have access to chlorine products

To promote the water treatment in homes in So-Ava and Kraké, the completion of a "social marketing" study should be financed to determine the expectations of the people in this area. The methodology of social marketing includes market research, a study of the supply chain, the definition of a pilot product, the definition of pilot promotional material, and a test phase. Once the desired product is defined, the "market facilitation phase" should be implemented by supporting the production chains and funding promotion campaigns.

- Improve population access to public latrines

The project should include the construction of eight public latrines, four in So-Ava and four in Kraké. To ensure the construction of these facilities, the project should involve the following steps: (1) determine the technical feasibility and select the most appropriate locations for facilities; (2) build the latrines; and (3) train the village committee concerning the management and maintenance of the facilities.

- Launch Community-Led total Sanitation campaigns in villages located on the banks of lake Nokoué

The villages around the lake are primarily “floating villages”. Nevertheless, it is necessary to initiate the Community-Led total Sanitation approach whenever possible. The Community-Led total Sanitation approach will prove to be beneficial in this region, although the level of results may vary by location.

2) Improve strategies to prevent cholera outbreaks and ameliorate hygiene behavior (proximity and media awareness campaigns).

- **Improve hygienic conditions** during some major traditional events organized throughout the year at various sites within the country.
  - Ensure that the populations have access to cholera prevention and management campaigns

Twelve "proximity campaigns" should be initiated with families, key actors, and students from communities targeted for the project. These campaigns should be carried out by local partners involved in the targeted areas. The campaigns should benefit from teaching materials provided by UNICEF and WHO. These “proximity campaigns” should be conducted in conjunction with six media campaigns via radio and local newspapers.

- Ensure that the managers of major traditional ceremonies in Benin have access to recommendations concerning hygiene practices

In some communes, the organization of traditional or cultural ceremonies constitutes a risk for cholera diffusion. To assess this issue, an ethno-sociological study should be established and performed by a local consultant. Methodological recommendations should be proposed to improve the WASH practices during these major ceremonies. Following the study, workshops and training should be conducted with key stakeholders to promote good practices. At the end of the training, equipment kits should be distributed to ceremony organizers.

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15. Annex

15.1. Analysis performed prior to the field investigation

Once the terms of reference was finalized and signed, various databases were obtained from the corresponding countries and transmitted to the cholera epidemiology team (Sandy Moore and Renaud Piarroux) at Aix-Marseille University. The databases were cleaned and organized, and subsequently received updated case data were then integrated. To assess the spatiotemporal dynamics of cholera epidemics in the region, the aggregated weekly case data for the past four years were mapped, by district (Ghana and Togo) and commune (Benin), using shapefiles of administrative divisions obtained from DIVA-GIS (http://www.diva-gis.org/gdata) and Quantum GIS v2.4.0 and Philcarto. A series of weekly maps (208 maps covering a period of 4 years) was constructed to study in detail the spatiotemporal dynamic of cholera in the sub-region. These maps have already been forwarded to UNICEF Dakar at the end of October 2014.

Databases received before the field mission began:

- Ghana
    - National weekly cases/deaths by district for years: 1998-2002, 2004-2005, 2007, 2008 (partial, approximately 1043 cases missing), 2009 (up to week 6), 2010-2014 (up to week 37)
    - Line lists: 2011, 2014
- Togo:
    - Monthly cumulated case/death numbers by district: 2001, 2002, 2004, 2005, 2006 and 2013
    - National weekly cases/deaths by district for 2008
    - Line list for 2009 and 2014
- Benin
    - National weekly cases/deaths by commune: 2002-2014 (until week 36)

15.2. Progress of the Mission

15.2.1 Ghana

The mission started (November 13, 2014) with a 2-week field investigation in Ghana. We met with key stakeholders and obtained pertinent epidemiological data as outlined below. Field investigations were conducted in key affected areas of Ghana, which were identified via epidemiological analysis of initial data. The field studies were carried out, by the two epidemiologists and the WASH expert, in areas affected by cholera in Greater Accra Region, Volta (Ho) and Ketu South. Investigations involved tracing and interviewing of index cases and other individuals affected by the disease, discussions with local medical authorities, and assessment of local community conditions that supported cholera emergence and transmission (access to potable water, latrines, and treatment facility, etc).

During the field mission we met with many stakeholders including:

- Ministry of Health/ Ghana Health Service members (at national, regional, and hospital levels) (Accra) (Emmanuel Dzoti, James Addo, Ashon Ato, Bernard Bright Davies-Teye, John Eleeza, Kweku Quansah, Michael Dogbe, Jonas Amanu, and Rosemary Gbadzida)
- Ministry of Local Government & Rural Development (workshop and national, regional and sub-metro levels) (Accra)
- University of Health and Allied Sciences (Ho, Volta Region) (Bismarck Dinko and Anthony Dongdem, Frank Nyonator (Dean), Fred Binka (Vice-Chancellor), John Tampuori (Acting Director, Volta Regional Hospital))
- Ghana Health Service, Ho, Volta (Atsu Seake-Kwawu)
- Ketu South Municipal Health Directorate (Joseph Kwami Degley)
- Ministry of Water and Ghana Water Company Limited: headquarters, water analysis department, and Accra East Distribution Region
- National public health reference laboratory (culture of 196 *V. cholerae* isolates) (David Opare)
- World Bank project
- Global Communities
- CSIR (Council for Scientific and Industrial Research) Water Research Institute, Achimota, Accra (Anthony Karikari)
- Chiefs of villages, families, fishermen, water sellers and public latrines attendants in areas affected by cholera

Databases obtained during the Ghana field mission:

- Ghana: updated line lists for GAR (2011, 2012 and 2014) and Ketu South (2014)

Field investigation sites visited:

- Accra: Dome, Agbogbloshie (village and meat market), Nima, Osu (Osu-Alata; village and fishermen), Jamestown (fishermen), Chorkor (fishermen), Apapa, La (village and fishermen), Nungua Old Town, Abeka, Mamobi (Polyclinic), and Teshie
- Volta, Ketu South: Aflao and Denu
- Volta: Ho

15.2.2 Togo

The field mission in Togo was conducted from November 29 – December 8. During the field mission we met with many stakeholders including:

- Members of the Ministry of Health at national, regional, and hospital levels (Kossivi Agbelenko Afanvi, Balanhewa Aguem-Massina, Amidou Sani and Kwoami Dovi) for facilitating the mission as well as Stanislas Tamekloe (Division of Epidemiology) for discussions and proving cholera case databases.
- Adodo Sadji from the National Institute of Hygiene Togo, Lomé
- Mawuvi Tamakloe at the World Health Organization, Lomé for fruitful discussions and valuable insight concerning cholera epidemics in the country

- Segla Zissou (Profadel, Katanga, Lomé) for discussions concerning cholera in Katanga and providing water analysis data (pending)
- Members from the Red Cross working in Katanga, Lomé
- Chiefs of villages, families, fishermen, water venders, public latrines attendants other community members in areas affected by cholera

Databases obtained during the Togo field mission:

- National weekly cases/deaths by district for years: 2010 - 2014
- Line lists for 2013 and 2014

Sites visited:

- Lomé District 3: Katanga
- Lomé District 2: Adakpamé, Akodessewa (Danguipé), and Anfamé
- Golfe: Agoé Zongo
- Lacs: Seko

15.2.3 Benin

The field mission in Benin was conducted from December 9 – 15. During the field mission we met with many stakeholders including:

- Ministry of Health actors including division of Epidemiological surveillance (Gregoire Adadja, Nadine Agossa and Adjakidje Senami Aurel)
- Honore Bankole, Agnes Hounwanou and Francois Hounsou at the Bacteriology Laboratory, Cotonou
- The mayor of So Ava
- Heads of water and sanitation for So Ava et Semé-Kpodji
- Benin/Nigeria frontier health/environmental surveillance team
- Sub-prefectural Management Committee, water point committees, water venders, public latrines attendants, chefs of villages, fishermen and families in neighborhoods affected by cholera.

Databases obtained during the Benin field mission:

- Line lists for Atlantique (2013 and 2014) Littoral/Cotonou (2011 and 2013)

Sites visited:

- So Ava center, Houedo Aguekon (Sokomey), Ahomey-Gblon, Ahomey-Gbekpo, Kraké, Gbakpodji, and Cotonou (Enagnon and Agbato)

15.3. REPORT ON OUTBREAK OF CHOLERA IN KETU SOUTH MUNICIPALITY, KETU SOUTH MUNICIPAL HEALTH DIRECTORATE, 5TH OCTOBER, 2014

Provided by Joseph Kwami Degley

INTRODUCTION

Ketu South Municipality is one of the 25 Administrative Districts/Municipals in the Volta Region. It occupies an area of about 400 square kilometres. The Municipality is located in the south-eastern corner of Ghana. The district shares common boundary with Republic of Togo in the East, with Ketu North District in the North, and North-west and with Keta in the South –West and with the Gulf of Guinea (Atlantic Ocean) in the South. By the virtue of where the municipality is located in term of borders, business activities involving people from all works of life is very high. This makes the municipality prone to most communicable diseases especially cholera. During the last two years, issues on cholera outbreak used to be things of the past in the municipality just because of effective surveillance system, effective health education on personal and environmental hygiene and proper education and screening of food vendors. In the recent times the outbreak in Accra has contributed to pockets of outbreaks in all the regions in the country. This contributed to the cholera outbreak in Ketu South

INVESTIGATION AND OUTBREAK PREPAREDNESS

As a result of outbreak of cholera in most sister districts where certain lives were lost and economic activities came to halt, Ketu South Municipality's epidemic preparedness committee sent cholera alert signal to all health facilities and other health partners such as CBSV, NGOs and other relevant stakeholders to investigate any diarrhea case that may report at their facility for samples to be taken for laboratory confirmation. Quite apart from this, series of announcement were made and these announcements are still ongoing on the four local FM stations in the municipality. The messages being carried duels on personal, environmental and measures to adapt to prevent the disease and further spread. Other partners in to health especially Environmental Health Department was alerted. Logistics and other material that may matter in Cholera outbreak were planed for through proposal writing to Ketu South Municipal Assembly. Regional Health Directorate was also informed for the necessary contingency.

On the 28th of July 2014, eight (8) cases of dirrhorea were reported by the Municipal Hospital, Centreal Aflao and Sape Agbo Memorial hospitals. Investigation conducted revealed that all these cases came from Adina, a fishing community in Some Fugo sub municipality of Ketu South. Samples were taken for three of the cases as they were all from one area but proved to be negative of Vibro cholera.

Whiles waiting for the outcome of the laboratory investigation, the immediate contacts of these suspected cases were traced and investigated. It was realized that none of the contacts developed diarrhea. Prophylaxis using Doxycycline and erythromycin were provided to the immediate contacts depending on their ages, their pregnancy and lactating status.
Another episode of severe diarrhorea and vomiting hit Ketu South municipal hospital and Central Aflao Hospital on the 11th of August 2014 where eight (8) and two (2) diarrhorea cases were recorded by Ketu South Municipal Hospital and Central Aflao hospital respectively. Three samples were taken and the lab outcome indicated that they were positive for vibro cholerae.

Again, contacts were treated and education on personnel and environmental hygiene were done using Doxycycline and erythromycin.

CONDITIONS IDENTIFIED TO BE MAJOR CAUSE OF SPREAD OF CHOLERA IN THE MUNICIPALITY

1. Poor Environmental Hygiene: Poor environmental situation has been identified as one of the major causes of fast spread of the disease in the Municipality. Most people used unauthorized places as refuge dumps creating an opportunity for people to use them as their toilets.
2. Most food vendors were not cooperating that is leaving their food uncovered

Dumping of refuge at unauthorized place in Aflao

A refuge dump that is being used as toilet in Aflao Beat 7

3. Some refuse containers were full without it been carried to the final disposal site

PUBLIC HEALTH INTERVENTION ACTIVITIES INITIATED

- Provision Prophylaxis to all immediate contacts.
- Health Education on personal and environmental hygiene at CWCs, OPDs at Churches, Schools and at Assembly meeting intensified.
- Spraying of refuse dumps and toilets where most cases are coming from.
- Radio announcements and discussion on what cholera is, mode of transmission, possible signs and symptoms and its prevention.
- Chiefs and opinion leaders engagement and involvent (chiefs organize durbar for health staff to educate the public.
- Cross-border meeting to discuss cholera and ebola among neighbouring districts in Togo and Ghana.
- Intensify surveillance in water front communities. Same was done at border communities.
- Arrangement of logistics such as Cholera replacement fluid, Doxycycline, ringers lactate and normal saline from Regional Medical Stores to argument the system.
- Submission of proposal by Municipal Health Directorate to Ketu South Municipal Assembly for support.
- Queen mothers taking the initiative to educate market women on environmental cleanliness.
- Stoppage of fee collection at public places of convenience
- Prompt and hurried completion of some public toilets.
- Regular briefing of MCE and some opinion leaders about the cholera situation.
- Involvement of assembly members.

INFORMATION ABOUT CHOLERA (INDEX) CASE IN KETU SOUTH MUNICIPALITY
11th August 2014

On the 11th of August 2014, a case suspected to be cholera reported at Ketu South Municipal Hospital. The symptoms presented were Acute Gastro enteritis, severe dehydration with which the clinician suspected cholera. Specimen was taken and it was positive for *Vibrio cholerae*. The case was treated and discharged

Below is the background information of the case:

PATIENT'S NAME: Kunu Belief
AGE: 26yrs
SEX: Female
ADDRESS: Kunu's house Gbubla-Aflao
OCCUPATION: Trader
COMMUNITY/ LOCATION: Gbugbla-Aflao
SUB-DISTRICT: Aflao West
DATE SEEN AT HEALTH FACILITY: 11/08/2014
DATE OF ONSET OF DISEASE: 11/08/2014

ACTION TAKEN

Investigation done on the 11th of August 2014 and the result indicated that the index case ate rice and beans with a brother's wife after returning from Accra and both of them developed diarrhorea. The diarrhorea of the brother's wife subsided. The immediate contacts including the brother's wife were educated on personal hygiene and given prophylaxis. No other person in the area has developed the disease. It also indicated that the patient did return form Accra and developed the condition on that same day. Dietary history showed that he took rice and beans, which they purchased from a food vender.

Health education was carried out in the community after which prophylaxis was given to the contacts.

Active surveillance on the community is ongoing.

NUMBER OF CASES REPORTED

- The municipality recoded one hundred and seventy five (175) cases including two deaths as at 16th of September 2014,
- Fifty nine (59) of them were males whiles One hundred and sixteen (116) were female
- Most of the cases came from Gbugbla, Teshie, Rainbow and Timber Market all suburb of Aflao where environmental sanitation was very poor.
- Most of the cases are within the age range of 20-30 yrs
- Most of the cases were recorded by Ketu South Municipal Hospital.

BURIAL OF A DECEASED CHOLERA CASES

A team of heath staffs, environmental health officers and four selected family members were involved in the burial of the above mentioned case in Viepe and Aflao all in Aflao West Sub Municipality on the 19th and 20th of August 2014.
Fumigation of the body, the coffin and clothes that were used to wrap him took place in the mortuary. The bucket of official pick up vehicle used to convey the body was also fumigated. Hand gloves, mask and Izal were also provided to ensure staff safety. The fumigation was again done at the grave side that is in the grave and after the burial. Members of the team that did the burial were advised to wash their clothes used for the burial services immediately. Prophylasis was given to every member of the team that did the burial.
Final arrangement by a team of health staffs and environmental Health officer to dispose off cholera corps

Collaboration
There was effective collaboration between Municipal Health Direct and other stakeholders into prevention and management of cholera cases in the municipality. Eg Environmental Health, Private Health Facilities, Assembly men, CBSV etc.
Challenges

1. Lack of fund to carry out all desire public health intervention to prevent further spread of the disease.
2. Inadequate supply of logistics for management of Cholera cases.

Surveillance was still kept on those communities that reported a lot cases during the outbreak after the last case was reported on the 16th of September 2014. There were few diarrhoea cases

after 16th of September 2014, which were not true cases of cholera looking at the signs and symptoms presented.

Again samples were taken to find out if the organism causing the diarrhoea was still vibrio cholerae. The outcome indicated that the organism was shigella but not vibrio. From that time to date no cases was reported by any of the facilities.
The outbreak was declared over after two successive incubation periods. That was on the 5th of October 2014.

15.4 Cholera Experience in Ho, 2014

Provided by Atsu Seake-Kwawu

2014 will pass as an important year for disease surveillance and control as Ghana is experiencing its most massive outbreak of cholera. All regions of the country experienced outbreaks of the disease following on massive outbreak running over the past few months in the Greater Accra region. The Ho Municipal Health Directorate has been in a heightened state of surveillance since.

The first suspected case investigated was a 33 year old man from Ho, who reported to the Volta Regional Hospital on 8th August, 2014 and who tested negative for *Vibrio cholerae*. There were no cases arising from his household contacts over the next five days, suggesting any transmission. The next series of cases with diarrhoea and vomiting were reported by phone on 12th August, 2014 from the same hospital. The response team of disease control officers followed up for preliminary investigations which showed that there were four cases, all hailing from a neighbouring district (Kpedze in Ho West). Rectal swabs results released the next day tested negative. These results were nevertheless communicated to the Ho West District health authorities for further community level investigation, and the Regional Health Directorate surveillance officer.

On the 13th August, 2014, a gentleman who had visited Ho from Accra on the 11th August, 2014 and begun having symptoms reported to the same hospital and was investigated, but tested negative. Follow up education and visits showed that the next five days were uneventful for the host household.
On 20th August, 2014, three other cases seen from Ho West, also tested negative. One of these, a 70 year old man, died the next day. One suspected case in a resident of Ho, who had been drank water from the river *Tordzie* (which flows through from Ho West, through Nyive and other parts of Ho, and through Agotime Ziope, another neighbouring district to the east, and could get contaminated with infected faecal matter upstream) while at Nyive over the previous few days, also reported but tested negative.

On the 21st August, 2014, another suspected case, a contractor from Ashaiman, who had travelled into the northern part of Volta region (Krachi East), was referred to Regional hospital from Worawora hospital after he had fallen ill with diarrhoea and vomiting. He died the following day, testing negative.
Over the weekend beginning 22nd to 24th August, 2014 three new cases reported and were confirmed positive:

The first was a local hospital orderly who attended a lady patient from Ho West while she was on admission. This was the first confirmed case from Ho municipal.

The second was a pastor resident in Ashaiman in the Greater Accra region, who developed symptoms just

prior to visiting his family in Ho and had to be hospitalised before he had settled down in Ho. When he was interviewed and probed for other possible exposed persons, he placed a call to his house in Ashaiman only to learn that four persons in his household also developed the disease in his absence.
The third confirmed case took care of her daughter from Ho West while she was on admission with suspected cholera. After discharge, she never left the hospital when she developed her own symptoms
Apart from these, one suspected case from Ho itself tested negative. No epidemiological link could be established. One other case in the Ho Municipal, who was also exposed to water from the river *Tordzie*, from Nyive tested negative.

On the 25th August, 2014, another young adult, 15, from Ho who had symptoms and had been exposed to the same *Tordzie* river at Nyive, was tested negative. Similarly another case from the neighbouring Agotime Ziope, also exposed to the *Tordzie* downstream in that district also reported but tested negative. On the 27th August, 2014, another resident of Ho reported with diarrhoea but tested negative. No epidemiological linkage was established.

The month of August ended with two more new cases, one of which was confirmed positive. The positive case was in a businessman, resident from North Dayi district in the Volta region, who had travelled in three other districts before coming down sick and seeking care in Ho. The other case was an unconfirmed patient from Ho West.

The first week of September was most eventful. Twelve (12) cases were reported, eight (8) from Ho and four (4) from residents outside Ho. Ho had a localised outbreak within one compound house, initiated by a trader who travelled back from Accra with symptoms, after spending a few days there. Conditions in the house, which allowed for common sharing of water and sanitary facilities facilitated a quick spread in the house. But for the timely and appropriate intervention of the response team, the entire members of the house would have suffered the disease. Five cases were identified from this house, of which two were positive, and the other three negative but these patients had already started their own antibiotic therapies from chemical shops before reporting and testing. The three other cases were from different parts of the municipality, not found to be linked to any known case, and tested negative.

The four cases from residents outside Ho tested negative. Two came from Agotime-Ziope. One came from Ketu South, which was also experiencing an outbreak, and had antibiotic treatment before testing. The other one, arrived in Ho as the best man for a wedding from Asuogyaman district in the Eastern region, and developed symptoms. He had travelled to Accra earlier. He ended up hospitalised. Treatment with antibiotics was initiated before testing was done, possibly explaining the negative results.

The second week of August saw one more confirmed from the compound house with the outbreak. The early discovery of this patient who had been taken out of the affected house to hide in another part of town in fear, led to the prevention of another local outbreak.
On the 18th September, one case, a citizen of Ho West, arrived from Accra for hospitalisation. This patient, with onset two days earlier, sought help from Korle Bu hospital and 37 Military Hospital but none could offer her bed, till she sought help in Volta Regional Hospital.
The last reported case from Ho municipal was on 21st September, 2014. This tested negative. One case also came in from Adaklu district on 21st September but tested negative.

DESCRIPTION OF THE CASES

A suspected case is any person with acute watery diarrhoea, with or without vomiting. A confirmed case is therefore a suspected case in which *Vibrio cholerae* O1 or O139 has been isolated in the stool. The outbreak period started from the 32nd epidemiologic week, till the 39th week. Two cases died, out of the 37, giving a case fatality rate of 5.4%.

36 of the 37 cases seen were tested to confirm the presence of *Vibrio cholera*. Eight (8) cases tested positive meeting the confirmed case definition, with the rest were negative. Many of the negative tests are explained by the fact that test samples had been taken after antibiotic had been initiated. Seven (7) cases had an epidemiological linkage with another known case. Females were predominantly affected, accounting for 54% (n=20) of cases. The age group 20-29 years was the most affected, followed by the 30-39 year group. The elderly were the least affected.