CHOLERA PREVENTION AND CONTROL IN KENYA

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ABSTRACT

Gretchen A. Cowman: Cholera Prevention and Control in Kenya
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Kenya experienced widespread cholera outbreaks in 1997-1999 and 2007-2010. The reemergence of cholera in Kenya in the first months of 2015 suggests that cholera remains a public health threat. This study employed a mixed methods approach to investigate the successes and challenges of cholera prevention and control in Kenya through analysis of cholera surveillance data and key informant interviews. The goal of this study was to produce information that will be useful to the Government of Kenya in establishing or strengthening policies and programs that effectively prevent and control cholera.

Key findings from analysis of cholera surveillance data indicate: (1) cholera has been recurrent in various geographic regions with differing climatic conditions, (2) cholera has affected some of the least densely populated rural areas as well as Kenya's largest cities, and (3) cholera occurrence appears to be associated with open defecation, access to improved sanitation, access to improved water sources, poverty, and level of education.

Interventions, policies, and strategies that are perceived to be effective in cholera prevention and control include: (1) Community Led Total Sanitation, which aims to eliminate open defecation, (2) provision of clean water, and (3) the Integrated Disease Surveillance and Response strategy, which is Kenya's platform for implementation of the International Health Regulations. Key challenges include: (1) lack of access to improved water and sanitation for a

large proportion of the population, (2) limited laboratory capacity to diagnose cholera, and (3) poor availability of intravenous fluids and oral rehydration solution.

The findings of this study suggest that there is need to intensify efforts to expand access to improved sanitation and safe drinking water, to strengthen laboratory capacity and disease surveillance, to improve availability of basic medical supplies for rehydration, and to expand poverty reduction programs. Community Led Total Sanitation and the Integrated Disease Surveillance and Response strategy have created programs that should continue to be supported, strengthened and expanded. Devolution of government services from national to county level presents both opportunities and challenges for cholera prevention and control. Both levels of government have key roles to play, and effective collaboration is necessary for success.

To my mother, Norma Cowman, and my brother, Paul Cowman
In memory of my father, Richard Cowman
Thank you for believing in me

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CDC	Centers for Disease Control and Prevention
CFR	case-fatality rate
CHW	community health worker
CLTS	Community Led Total Sanitation
DRC	Democratic Republic of Congo
DSRU	Disease Surveillance and Response Unit
EAIDSNet	East African Integrated Disease Surveillance Network
HIV	Human Immunodeficiency Virus
ICC	inter-agency coordinating committee
ICT	information and communication technology
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations
IRB	Institutional Review Board
IV	intravenous
JMP	Joint Monitoring Program
KEMSA	Kenya Medical Supplies Authority
KIHBS	Kenya Integrated Household Budget Survey
KNBS	Kenya National Bureau of Statistics
MDG	Millennium Development Goal
MOH	Ministry of Health
MSF	Medecins Sans Frontieres
NGO	non-governmental organization

NOAA	National Oceanic and Atmospheric Administration
OCV	oral cholera vaccine
ODF	open defecation free
ORS	oral rehydration solution
ORT	oral rehydration therapy
ProMED	Program for Monitoring Emerging Diseases
SES	socio-economic status
SLIPTA	Stepwise Laboratory Improvement Process Towards Accreditation
SLMTA	Strengthening Laboratory Management Towards Accreditation
SWAP	Safe Water and AIDS Project
UN	United Nations
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
VIP	ventilated improved pit
WASH	water, sanitation and hygiene
WESCOORD	Water and Environmental Sanitation Coordination
WHO	World Health Organization
WHO AFRO	World Health Organization African Regional Office
WSP	Water and Sanitation Program
ZIP	zero-inflated poisson

CHAPTER 1: INTRODUCTION

Statement of the issue

Cholera is an epidemic-prone disease of global significance that has a prominent role in the history of public health. John Snow, considered by many to be the father of modern epidemiology, is well known for his work in identifying drinking water from the Broad Street pump as the source of a cholera outbreak in London in 1851. Since John Snow's time, much has been learned about the causative agent, the mode of transmission, and methods of preventing the spread of cholera. This infectious disease has been virtually eliminated from developed countries due to improved water and sanitation infrastructure, but deadly cholera outbreaks still occur in many low-income countries including Kenya.

Globally, there was a continual increase in the number of cholera cases reported to the World Health Organization (WHO) between 2007 and 2011. [1] In 2011 the World Health Assembly issued resolution 64.15 recognizing that cholera is not being sufficiently addressed and calling for renewed global efforts in cholera prevention and control. [2] A 58% decline in the number of cholera cases reported to WHO globally in 2012 and a further decline of 47% in 2013 may suggest some progress in the global response to this disease. [3,4]

Cholera is endemic in Kenya, meaning that the country experienced cases of cholera in at least 3 of the past 5 years. [5] Large, widespread outbreaks occurred in Kenya in 1997-1999 and in 2007-2010. The average annual incidence of reported cholera cases during the 10-year period 1994-2003 was 20 cases per 100,000 people in comparison to 6 cases per 100,000 people during the 10-year period 2004-2013 (based on WHO cholera data and Kenya National Bureau of

Statistics (KNBS) population projections).[6,7] Incidence is defined as "the occurrence of new cases of disease that develop in a candidate population over a specified time period."[8] This 71% decrease may suggest improved cholera prevention and control in more recent years. Between 2011 and 2013 there were few cases of cholera reported in Kenya, and these cases were limited to a relatively small geographic area in northeastern Kenya. This may reflect success in cholera prevention and control efforts or perhaps this may be explained by others factors such as climatic conditions. This study investigates the successes and challenges of cholera prevention and control efforts in Kenya.

An understanding of past successes and current challenges is important to informing future cholera prevention and control efforts in Kenya. This topic was explored through key informant interviews with individuals engaged in cholera prevention and control efforts in Kenya. This study also examined cholera surveillance data to investigate:

- The geographic distribution of cholera occurrence in Kenya and whether there have been changes in this distribution over time
- The relationship between cholera occurrence and development and demographic indicators related to water, sanitation, education, income, and urbanization

An important goal of development is to improve the health and wellbeing of a population. Given that cholera has been eliminated from developed countries, it is reasonable to expect that general progress in development will lessen the risk of cholera transmission in communities. Health and development programs are often designed to meet targets for specific indicators such as those associated with the Millennium Development Goals (MDGs). Does progress with respect to existing development indicators translate into reduced incidence of cholera, a disease that is typically associated with poverty? The answer to this question has important implications

for the design of programs to reduce the burden of cholera. This study investigated the relationship between selected development indicators and cholera occurrence in Kenya.

This study aimed to identify best practices in Kenya that should be maintained and that may be of relevance to other countries that are combating cholera. This study also aimed to identify areas for improvement and proposed solutions. The goal of this study was to produce information that will be useful to the Government of Kenya and its partners in establishing or strengthening policies and programs that effectively prevent and control cholera.

Background

Cholera is a diarrheal disease caused by the bacteria *Vibrio cholerae*. The infectious agent is acquired through consumption of contaminated water or food. The source of contamination is usually the feces of an infected person. Most cases are asymptomatic or exhibit only mild diarrhea; however, severe cases are characterized by sudden onset of profuse, watery diarrhea, nausea, and vomiting. Severe symptoms lead to rapid dehydration, which can result in death within hours if left untreated. The most common method of treatment is administration of oral rehydration solution (ORS); more severe cases may require intravenous rehydration and antibiotics.[9]

Environmental reservoirs and climatic factors

Vibrio cholerae is known to persist in brackish waters, coastal waters and estuarine environments.[9] In these environments *V. cholerae* is typically associated with copepods that feed on phytoplankton. A number of studies have shown that increasing sea surface temperature can promote phytoplankton growth and consequently *V. cholerae* growth; and, although no clear link has been established between cholera and global warming, it has been suggested that global warming might facilitate more frequent cholera outbreaks.[10-12] Current interest in the use of

satellite remote sensing of environmental conditions to develop an early warning system for cholera outbreaks is based upon the emerging knowledge about links between ocean temperatures, phytoplankton growth, and cholera occurrence. In the Great Lakes region of East and Central Africa, Bompangue et al. observed that cholera occurrence increased during years of El Niño events. [13]

Risk factors and control measures

Cholera spreads rapidly in environments where there is lack of access to safe drinking water, inadequate sanitation, poor hygiene, and crowded living conditions. [9] Outbreaks are often associated with man-made and natural disasters that result in large-scale population movements and overcrowded refugee camps. [9] Studies have found associations between cholera occurrence and access to improved water, access to improved sanitation, socioeconomic status, and infant mortality rate. [14-17]

Control measures employed during epidemics include education of the public on the need to seek immediate treatment, provision of appropriate clinical treatment facilities, disinfection of drinking water, education on hygienic food preparation, and provision of adequate facilities for human waste disposal. [9] In recent years two promising oral cholera vaccines have become available. [1] Both vaccines are administered in two doses spaced 1 to 6 weeks apart and confer immunity for up to 2 years. [18] The vaccines can be administered to adults and to children over 2 years of age. WHO recommends use of the oral cholera vaccine to complement other prevention and control measures in areas where cholera is endemic and in areas at risk for outbreaks. [18] WHO has developed a risk assessment tool and decision-making tool to assist health authorities in determining whether to use the oral cholera vaccine in complex emergencies. Vaccination is

not considered to be effective after an outbreak has started, unless the vaccination campaign is targeted at other well defined, high risk populations not yet affected by the outbreak. [18]

Cholera and the International Health Regulations

Cholera has a prominent role in the historic development of international agreements to prevent cross-border spread of infectious diseases. The International Sanitary Conventions that arose in the 1800s are the earliest precursor to the modern-day International Health Regulations. The first International Sanitary Convention in 1851 was prompted by the need to control the spread of epidemic cholera in Europe. [19] International efforts to control the spread of infectious diseases were later formalized in the 1951 International Sanitary Regulations, which required mandatory reporting of cholera, yellow fever, plague, small pox, typhus, and relapsing fever cases. The International Sanitary Regulations were replaced in 1969 by the International Health Regulations (IHR), which continued to mandate reporting of cholera, yellow fever, and plague cases.

There were major revisions to the IHR in 2005 aimed at improving prevention of the international spread of disease in a manner that avoids unnecessary interference with international trade and travel. [20] The 2005 revisions greatly expand the range of diseases covered by the regulations by requiring notification to WHO of "all events which may constitute a public health emergency of international concern". [20] The IHR 2005 removed mandatory reporting of cholera cases, although many cases will still be reported under the criterion of a public health emergency of international concern. The IHR 2005 requires member states to develop, strengthen, and maintain the capacity to detect, report, and respond to public health emergencies. It is expected that the changes to the IHR will encourage improved cholera surveillance and information sharing. [1]

Cholera occurrence: Global and regional trends

The world is currently experiencing the 7th cholera pandemic. The pandemic began in Indonesia in 1961, spread to the Asian mainland in 1963, reached Africa in 1970, and spread to Latin America in 1991. [9] The disease is now endemic in several African countries. Between 2007 and 2011 there was a continual increase in the number of cholera cases reported to WHO. [1] In 2011 WHO recorded 589,854 cholera cases globally, including 7,816 deaths, reported by 58 countries. [1] In 2012 the global number of reported cases declined by 58% to 245,393 including 3,034 deaths. [3] In 2013 the number of reported cases declined by an additional 47% to 129,064 including 2,102 deaths. [4] There is uncertainty in how well these figures represent reality, however, as vast under-reporting of cholera is suspected, and WHO estimates the actual global burden of disease to be 3-5 million cases annually. [2]

Between 2001 and 2009 African countries accounted for 93% - 98% of all reported cholera cases worldwide. This percentage decreased to 32% - 48% between 2010 and 2013 due to a large outbreak in Haiti. [1,4] In 2009 several countries in Africa, including Kenya, experienced large cholera outbreaks. A total of 217,333 cholera cases were reported from Africa in 2009. [21] The number of reported cases in Africa declined to 56,329 in 2013. [4]

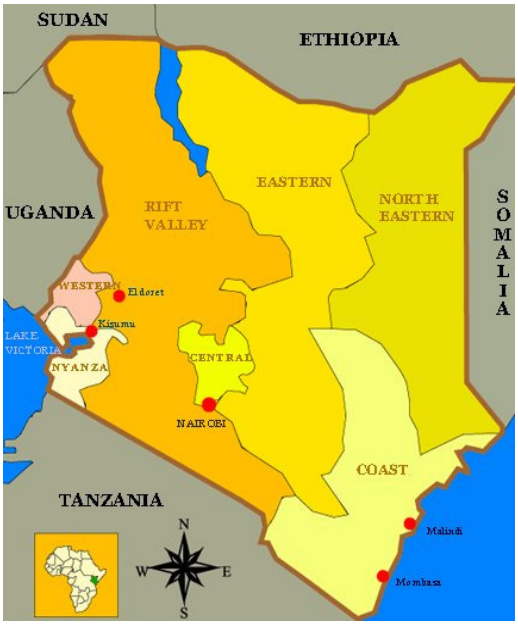


Figure 1. Map of Kenya
Source: www.kenya-advisor.com

Kenya

Kenya is located along the equator on the coast of East Africa and shares borders with Tanzania, Uganda, Sudan, Ethiopia, and Somalia

(Figure 1). The climate is characterized by slight seasonal variations in temperature and conditions ranging from tropical on the coast, cool in the highlands, and arid or semi-arid in much of the interior. Kenya has two rainy seasons that typically occur from April to June and from October to December. Lake Victoria is located in the western part of the country and supports a number of fishing communities. There are large refugee camps at Dadaab in the northeast of the country near the border with Somalia and at Kakuma in the northwest of the country near the border with Sudan. Kenya has a population of 41.6 million (2011 figure). [23] Key health and socioeconomic indicators are provided in Table 1 with a comparison to global averages and averages for the WHO African region (excludes Morocco, Tunisia, Libya, Egypt, Sudan, and Somalia). [24]

Table 1. Key health and socioeconomic indicators, Kenya

Indicator	Kenya	Global average	Africa average
Life expectancy at birth (years), 2011	58 for males 61 for females	68 for males 72 for females	55 for males 58 for females
Infant mortality rate (per 1000 live births), 2011	48	37	68
Under 5 mortality rate (per 1000 live births), 2011	73	51	107
Per capita government expenditure on health (PPP int. $), 2010	29	599	73
Per capita total expenditure on health (PPP int. $), 2010	72	1,017	154
Number of nurses and midwives (per 10,000 population), 2005-2012	7.9	29	9.1
Number of doctors (per 10,000 population), 2005-2012	1.8	13.9	2.5
Population using improved drinking water sources (%), 2011	61	89	64
Population using improved sanitation facilities (%), 2011	29	64	34
Literacy rate among adults aged ≥15 years (%), 2005-2011	87	84	63
Per capita gross national income (PPP int. $), 2011	1,710	11,536	2,513

Kenya has routinely reported cases of cholera to WHO since 1971. The largest recorded cholera epidemic in Kenya began in 1997 and lasted through 1999, with more than 50,000 cases notified to WHO. [25] This epidemic is believed to have started along Lake Victoria near the Tanzania border. Between 2000 and 2007 the number of cases reported to WHO annually ranged from 0 to 1,206 (with cases reported each year except 2003). Another large epidemic occurred between 2008 and 2010, with 17,704 cases notified to WHO during this period. Cholera was widespread in the country affecting at least 7 out of 8 provinces. In 2011 there was a dramatic drop in the number of notified cases to 74 in comparison to 3,188 cases in 2010. [6] This downward trend continued with no cases reported to WHO in 2012 and 2013. [3,4]

Accurate identification of cholera cases can be a challenge. A typical identifying symptom is watery diarrhea, but a number of enteric pathogens other than *V. cholerae* can cause watery diarrhea, especially in children under 5 years of age. [26] Laboratory confirmation is therefore critical to accurately identify cholera outbreaks. Laboratory capacity and networks are weak in many African countries, including Kenya. The standard case definition for cholera in Kenya is:

> Suspected case: If there is no cholera epidemic, any patient aged 5 years or more presenting with acute, profuse, effortless, watery diarrhea (3 or more times within 24 hours). If there is a cholera epidemic, a suspected case is any person aged 2 years and above with acute watery diarrhea, with or without vomiting.
>
> Confirmed case: A suspected case in which *Vibrio cholerae* O1 or O139 has been isolated in the stool, or has been epidemiologically linked to a confirmed case. [26]

Kenya's case definition differs from WHO's standard case definition for cholera which states:

> A case of cholera should be suspected when:
> - In an area where the disease is not known to be present, a patient aged 5 years or more develops severe dehydration or dies from acute watery diarrhea.
> - In an area where there is a cholera epidemic, a patient aged 5 years or more develops acute water diarrhea, with or without vomiting.
>
> A case of cholera is confirmed when *Vibrio cholerae* O1 or O139 is isolated from any

patient with diarrhea. [27]

National policies and strategies relevant to cholera prevention and control

Kenya has a number of health-related laws, policies, and strategies with relevance to cholera prevention and control. The legal and regulatory framework for public health in Kenya is established in the Public Health Act Chapter 242. This act was initially passed by parliament in 1921 and has been subject to multiple amendments over the years.

The legal and regulatory framework for the water and sanitation sector in Kenya is established in the Water Act of 2002. In 2007 the Ministry of Health issued the National Environmental Sanitation and Hygiene Policy. This policy sets the ambitious goal of access to "hygienic, affordable, functional, and sustainable toilet and hand washing facilities" in "every school, institution, household, market, and other public place" by 2015. [28] In 2007 Plan Kenya introduced the Community Led Total Sanitation (CLTS) approach in selected rural communities. This approach aims to mobilize communities to eliminate open defecation and promotes hygiene practices like hand washing. [29] In 2010 the Ministry of Public Health and Sanitation, in partnership with UNICEF and SNV, pilot tested CLTS in 6 districts in Western Kenya. [30] The Ministry subsequently adopted CLTS as its strategy for eliminating open defecation and launched a campaign in 2011 to declare Kenya open defecation free (ODF) by 2013. This campaign was re-launched in 2012, reportedly due to lack of progress since the initial campaign launch. [31]

With respect to MDGs related to water and sanitation, Kenya has made more progress in access to improved water than sanitation. The WHO/UNICEF Joint Monitoring Program (JMP) defines an improved water source as piped water, public tap, borehole or pump, protected well, protected spring or rainwater. [32] Between 1990 and 2012 the percentage of the population that used improved drinking water sources increased from 43% to 62%. [33] Improved sanitation is

defined as facilities that hygienically separate human excreta from human, animal, and insect contact. This includes flush/pour-flush toilets or latrines connected to a sewer, septic tank or pit; ventilated improved pit latrines; pit latrines with a slab or platform of any material which covers the pit entirely except for the drop hole; and composting toilets/latrines. [32] Only modest improvements have been seen in Kenya with respect to sanitation. The percentage of the population using improved sanitation facilities increased from 25% in 1990 to 30% in 2012. The percentage of the population practicing open defecation decreased from 19% in 1990 to 13% in 2012. [33]

At the 2012 Sanitation and Water for All High Level Meeting convened by UNICEF, the Government of Kenya made the following commitments [34]:

1. Harmonize water and sanitation monitoring tools
2. Sustain a budgetary allocation increment of 40% per year in the water subsector
3. Engage in dialogue with partners to support urban sanitation programs
4. Include hand washing with soap and household water treatment in current ODF Rural Kenya 2013 campaign
5. Improve knowledge management, networking, harmonization and evidence based advocacy for increased resource allocation to sanitation among others, through better coordination led by the Interagency Coordination Committee
6. Allocate adequate resources to implement the ODF Rural Kenya 2013 campaign

Kenya's 2013 progress update on these commitments indicates "good progress" on commitments 2, 3, 5, and 6, and "slow progress" on commitments 1 and 4. [34]

The community strategy is another national strategy that may be relevant to cholera prevention and control. In 2007, the Ministry of Public Health and Sanitation adopted this

strategy in the National Health Sector Strategic Plan II. The community strategy aims to enhance community access to health care and to strengthen household and community participation in health and health-related development issues. A cornerstone of this strategy is community health workers (CHWs), who provide primary health care services at household and community level. [35,36]

Kenya adopted the WHO African Regional Office (WHO AFRO) Integrated Disease Surveillance and Response (IDSR) strategy that was introduced in 1998 as a means of improving disease surveillance and response to epidemics. By 2002 Kenya had formally issued IDSR Technical Guidelines to guide district-based, national surveillance for priority diseases in accordance with the IDSR strategy. Published studies from other African countries document improvements in surveillance and response as a result of implementation of this strategy. [37,38] Kenya is also implementing the International Health Regulations (IHR) 2005, which calls upon all countries to strengthen surveillance and response capacities. The goal of both IDSR and IHR 2005 is to strengthen national surveillance and response capacity.

In 2007 WHO AFRO issued a resolution on the resurgence of cholera in Africa. [39] This resolution acknowledged that the cholera situation in Africa had been worsening since the early 1990s and urged member states to engage in activities to strengthen cholera prevention and control including development of multi-sectoral plans. This resolution also called upon the WHO Regional Director to provide technical support for the development, execution, and evaluation of such plans. In response Kenya developed the Multi-sectoral Cholera Prevention and Control Plan. This plan sets forth a framework for coordination of activities among the various governmental and non-governmental organizations that have roles in cholera prevention and control. Two key components of the plan are the Ministry of Health's community strategy

and sanitation strategy. This 5-year plan includes a budget estimate of $12.6 million for implementation.

There have been significant changes in the administration of health, water, and sanitation services since the plan was written in 2011. Prior to March 2013 national ministries had a prominent role in coordination of these services through provincial government structures. The country was divided into 8 provinces: Coast, Northeastern, Eastern, Central, Rift Valley, Western, Nyanza, and Nairobi (Figure 1). Initially the provinces were composed of 46 administrative districts plus the City of Nairobi. The number of districts varied over time, rising to 254 in 2009. In March 2013 as part of implementation of Kenya's new constitution, 47 county governments were established with boundaries matching those of the original 46 districts plus Nairobi at independence (Figure 2). Responsibility for administration and delivery of health, water, and sanitation services has been devolved to these county governments. Another change that has taken place since development of the current cholera prevention and control plan is that the Ministry of Public Health and Sanitation, which took the lead in development of the plan, has since been merged with the Ministry of Medical Services to create one Ministry of Health.

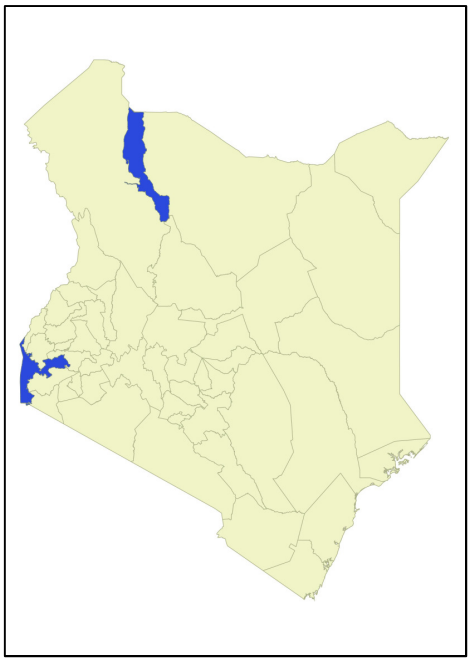


Figure 2. Counties of Kenya

Since 2011 Kenya has experienced a dramatic decline in the number of reported cholera cases. This raises some intriguing questions. Can this be attributable to particular interventions, policies, or strategies like increased access to improved drinking water sources, the ODF Rural Kenya campaign with its CLTS approach, the community strategy, IDSR, or the country's

cholera prevention and control plan? Or have the climatic conditions simply not been favorable to foster an outbreak in the past few years? This study will solicit expert opinion on the role that interventions, policies, and strategies have had on cholera prevention and control in Kenya.

The research question and significance

Much is known about the general mechanisms of cholera transmission and effective interventions for prevention and control of this disease. Despite the vast body of knowledge on cholera, including studies specific to cholera occurrence in Kenya, prevention and control of this disease remains a challenge in many countries. The question persists of how to translate the scientific understanding of cholera into effective policies and strategies that can be successfully implemented in limited resource settings to protect the population from cholera.

There is no published literature investigating the successes and challenges of policies and strategies related to cholera prevention and control in Kenya. This study seeks to identify policies and strategies that have successfully supported cholera prevention and control and to identify opportunities for strengthening such efforts in Kenya. This information is intended to support the Government of Kenya's efforts in reducing the burden of this disease.

The main research question for this study is: ***What are the successes and challenges of cholera prevention and control in Kenya?*** Supporting sub-questions that were investigated are:

- *What is the geographic distribution of cholera occurrence in Kenya, and have there been changes in this distribution over time?*
- *What is the relationship between cholera occurrence and development and demographic indicators related to water, sanitation, education, income, and urbanization?*

The specific aims of this study are to:

1. Qualitatively describe the perceived successes and challenges of cholera prevention and control in Kenya as identified by key informants from the Kenyan government and other organizations supporting cholera activities in Kenya. The specific topic areas of investigation include interventions, policies and strategies, data for decision-making, communication and coordination, Kenya's cholera prevention and control plan, and devolution.
2. Describe the geographic patterns of cholera occurrence in Kenya by analyzing trends in cholera occurrence and endemic status over time by geographic region.
3. Demonstrate whether or not there is an association between cholera occurrence and selected development and demographic indicators measured at district level.

The literature review that follows summarizes findings in the published literature on cholera occurrence in East Africa and, more specifically, in Kenya.

CHAPTER 2: LITERATURE REVIEW

The literature review was designed to capture published, peer-reviewed research articles on cholera in Kenya and additional articles of relevance from the East Africa region. A search was conducted in PubMed and Global Health on June 16, 2013 using the following search string: cholera AND (kenya OR east africa). The search was saved in PubMed, and automatic notification was set up for identification of any new articles detected by these search terms. The initial search returned 226 citations in PubMed and 191 citations in Global Health. Subsequent PubMed notifications added 24 more citations by February 15, 2015 when the literature review was completed. An additional 2 articles with a global or Africa-wide scope were identified through review of the global cholera literature. Upon removing duplicates, 364 unique citations remained. After reviewing abstracts, 42 citations were selected for a review of the full article. The criteria used for inclusion of an article in the review were: 1) the article describes a research study on cholera and 2) Kenya is included in the geographic scope of the study OR the geographic setting is in a nearby East African country and the theme of the article suggests potential relevance to Kenya. A review of full articles yielded 29 articles for inclusion in the literature review. The following information was extracted from each article into a standard template:

- Title, authors, journal, year of publication
- Geographic scope
- Type of study design
- Timeframe
- Independent variables
- Dependent variables

- Data sources
- Key findings

Review of the published literature indicates that the epidemiology of cholera in Kenya is likely influenced by complex interactions among multiple environmental and human factors. The results of the review are organized into the following thematic areas: cholera in Kenya from a global and continental perspective, climate and ecology, causative organism, outbreak investigations, influence of social and cultural factors, interventions, and review of surveillance data.

Cholera in Kenya from a global and continental perspective

The published literature includes informative articles that review cholera outbreaks worldwide and Africa-wide. Griffith et al. analyzed cholera outbreak reports in ProMED-Mail, an online forum for the sharing of outbreak information administered by the International Society for Infectious Diseases, over the period 1995 to 2005. [40] Out of 1,798 cholera postings, they identified 632 unique outbreaks worldwide. Outbreaks in East Africa accounted for 20.1% of the total number of outbreaks recorded but only 7.6% of the total number of cases reported. The researchers mapped the number of outbreak reports and number of cholera cases at sub-national level in Africa. The maps indicate that several provinces in Kenya were in the second highest of five ranges of number of outbreak reports, and Nyanza Province in western Kenya was in the mid-range for number of cholera cases reported, while other provinces in Kenya were in the low range for number of cholera cases in comparison to other African countries. The most commonly identified risk factors for cholera outbreaks in East Africa, in order of number of times cited in outbreak reports, were refugee settings, water source contamination, rainfall/flooding, poor sanitation, and imported cases from travelers.

Gaffga et al. compared median incidence, edemicity (number of years a country reported cholera cases over a specified period of time), and cholera case-fatality rate (CFR) for African countries during the period 2000 to 2005. [6,41] The median incidence for Kenya was 25 cases per 1,000,000 people, which falls within a mid-range category in the study. Kenya had reported cases of cholera in 5 out of the 6 years within the date range studied. [6] Kenya's mean CFR was 3.3% (meaning 3.3% of cholera cases died), which was above the 2.4% overall CFR for Africa during this period and well above the maximum CFR of 0.4% seen in all parts of the world outside Africa since 2002.

Climate and ecology

It was mentioned in Chapter 1 that *V. cholerae* is typically found in brackish waters, coastal waters and estuarine environments. There is a growing body of evidence that *V. cholerae* is associated with fresh water lakes in the Great Lakes region of Africa. [13,42,43] This region includes lakes Victoria, Tanganyika, Kivu, Edward and Albert in Kenya, Tanzania, Uganda, the Democratic Republic of Congo (DRC), Rwanda, and Burundi.

Birmingham et al. conducted a case-control study to identify risk factors for cholera infection during an outbreak in Rumonge, Burundi, a lakeshore town along Lake Tanganyika, in 1992. [42] The results of the study indicate that bathing in Lake Tanganyika and drinking water from the lake are positively associated with illness. No foodborne exposures were identified in association with transmission. Toxigenic *V. cholerae* O1, biotype El Tor, serotype Ogawa was isolated from the lake and from patient stool samples. In response, the government of Burundi stationed guards around the lakeshore in Rumonge town to prevent access to the lake for bathing, collecting water, and washing clothes. Drinking water was transported to the town by truck from an alternative source. The number of cases of cholera in Rumonge town rapidly decreased after

implementation of these control measures. Earlier cases of cholera had been identified upstream along the Rusizi River that connects Lake Kivu to Lake Tanganyika. The authors concluded that extensive use of the Great Lakes for transportation and for drinking and bathing promotes the rapid spread of cholera in the region. It is noted, however, that the short duration of cholera epidemics and long periods between them in this region suggest that the fresh water lakes do not provide a very favorable environment for the growth of *V. cholerae*.

In 1999 Shapiro et al. raised the question of whether Lake Victoria in western Kenya is an environmental reservoir for cholera.[43] In a case-control study conducted between June 1997 and March 1998, the researchers found that drinking water from Lake Victoria was associated with an increased risk of cholera. Analysis of the geographic patterns of residence of patients with diarrhea indicated that cholera patients were more likely to live in a village bordering Lake Victoria than diarrhea patients with other pathogens. The authors suggest that Lake Victoria may be an environmental reservoir for cholera, with water hyacinth potentially providing a suitable environment for growth, and that cholera may become endemic in western Kenya.

Feikin et al. investigated the hypothesis that cholera is associated with water hyacinth in Lake Victoria.[44] The researchers found a statistically significant temporal association between water hyacinth coverage in Winam Gulf of Lake Victoria and annual number of cholera cases in bordering Nyanza Province in western Kenya between 1994 and 2008. No association was found between the number of cholera cases and annual rainfall or average annual air temperature. The authors note that during this period Nyanza Province accounted for 38.7% of cholera cases in the country while the province hosts only 15.3% of the national population. The authors cite an experimental study[45] demonstrating a link between water hyacinth and *V.*

cholerae, and they suggest that water hyacinth in East African Lakes might support amplification or maintenance of *V. cholerae*.

Bompangue et al. note that the African Great Lakes region has emerged as one of the most active areas of cholera outbreaks in Africa.[13] From the ProMED-Mail website the authors identified 252 cholera outbreaks in the Great Lakes countries between 1999 and 2008. Of the outbreaks, 63.5% occurred in lake areas, and only 12% occurred in coastal areas. More detailed data from the Democratic Republic of Congo indicated an association between the presence of lakes and roads and the risk of cholera.

A number of researchers have investigated potential links between cholera outbreaks and El Niño events, temperature, and rainfall. El Niño is a warming of surface waters in the Central Pacific of 0.5°C greater than normal. This temperature anomaly tends to occur at intervals of 2 to 7 years and typically lasts for 9 months to 2 years.[46] In East Africa, El Niño events often result in higher than normal rainfall accompanied by floods.

Olago et al. studied climatic factors influencing cholera outbreaks in the Lake Victoria basin.[47] The study focused on the following three sites located on the shores of Lake Victoria: Kisumu, Kenya; Kampala, Uganda; and Biharamulo, Tanzania. Climate, hydrology, and cholera data were analyzed over the period 1978 to 1999. In comparing climate data with WHO cholera data for the region, the authors concluded that regional cholera outbreaks were associated with warm and wet El Niño years. The authors suggest that unusually high temperatures along with high rainfall resulting in flooding are required to precipitate regional cholera outbreaks.

Alajo et al. conducted a prospective study of cholera occurrence in 5 districts in Uganda concurrent with the onset of rains in 2002 and 2003 associated with an El Niño event.[48] They found that nearly all study districts reported cholera outbreaks coincident with the rains and

suggest that there is a link between El Niño climatic events and the occurrence of cholera in Uganda.

In 2006 Anyamba et al. reported on an advisory from the National Oceanic and Atmospheric Administration (NOAA) of El Niño climate conditions for the period November 2006 to January 2007. [49] It was anticipated that this would result in above average rainfall in equatorial East Africa, and the authors warned of increased risk of cholera in East Africa as a result of flooding in dry land areas.

Bompangue et al. investigated the role of climatic conditions with respect to outbreaks and the persistence of cholera in the African Great Lakes region during the period 1978-2008. [13] The authors found that there were 7 El Niño events during this time period, and all but one corresponded in time with a large increase in cholera cases in the region. They observed varying seasonal patterns with rainfall being associated with increased cholera in some areas. The researchers concluded that cholera in the Great Lakes region is associated with El Niño events and that a few lakeside areas in the region play a critical role in maintaining endemic cholera.

In contrast, Feikin et al. found no association between the annual number of cholera cases in Nyanza Province in western Kenya and annual rainfall or average annual temperature during the period 1994 to 2008. [44] Although this study did not focus on the relationship between cholera and El Niño events, the authors claim that there was no temporal synchrony between flooding associated with El Niño events and large cholera outbreaks in Kenya in 1997 and 2008. The authors explain that the 1997 outbreak began before flooding occurred, and the 2008 outbreak began nearly a year after the flooding.

Emch et al. analyzed the relationship between seasonality and cholera occurrence globally utilizing cholera data from WHO Weekly Epidemiological Reports during the period

1974 to 2005. [50] This study does not specifically discuss Kenya, but relevance of the findings to Kenya can be inferred from the country's geographic location on the equator. The findings of this study indicate that countries near the equator tend to experience more frequent cholera outbreaks. There are no distinct seasonal patterns of cholera occurrence near the equator, but seasonal patterns are evident at higher latitudes in both hemispheres. The authors suggest that larger, macro-level climatic factors, such as El Niño and climate change, likely influence the occurrence of cholera.

Causative organism

The types of *V. cholerae* causing human illness that have been identified in Kenya are *V. cholerae* O1, biotype El Tor, serotypes Ogawa and Inaba. Scrascia et al. studied genetic characteristics of 80 strains of *V. cholerae* isolated during the widespread outbreaks in 1998-1999. [51] Of the total, 57 samples were serotype Ogawa and 23 were serotype Inaba. Ribotype patterns could be classified into two groups: 19 strains from 4 outbreaks in Northeastern Kenya by the Somali border were of one type, and 61 strains from 25 outbreaks around the country were of another type. This evidence led the authors to conclude that the cholera that spread throughout the country was of a common clonal origin while the strains causing the 4 outbreaks along the Somali border bear a clonal relationship to strains in Somalia.

Kiiru et al. mention that there has been a shift in the causative agent from serotype Ogawa in the 1970s to 1990s to primarily serotype Inaba in more recent years. [52] In studying serotype Inaba strains, the researchers analyzed the genetics of 65 Inaba isolates collected from various outbreaks around the country between 1994 and 2007. They found very little difference among the samples and concluded that there has been little change in this strain, which has caused outbreaks over a period of 14 years. In another study Kiiru and colleagues investigated

the genetic characteristics of clinical and environmental *V. cholerae* samples collected from various parts of the country between 2005 and 2010.[53] The researchers found that all clinical samples and some environmental samples were O1 El Tor serotype Inaba. The O1 El Tor Inaba isolates were clonally related to strains in other parts of the world. In addition the O1 El Tor Inaba isolates were of two distinct types that the authors suggest may have entered Kenya independently.

Outbreak investigations

A number of cholera outbreak investigations in Kenya are described in the published literature, and these investigations provide insight into who is affected, where, when, and how the disease spreads. The study by Shapiro et al. was previously discussed with respect to Lake Victoria being a potential reservoir of *V. cholerae*.[43] The researchers conducted a case-control study to analyze risk factors associated with a cholera outbreak in Nyanza Province, western Kenya between June 1997 and March 1998. During this period 14,275 cholera cases, including 547 deaths, were reported by health facilities in Nyanza. The case-fatality rate was 4%. An analysis of 31 stool samples positive for *V. cholerae* O1 biotype El Tor indicated that 30 isolates were serotype Ogawa and one was serotype Inaba. Multivariate analysis of risk factors indicated a statistically significant association between increased risk of cholera and the following: drinking water from Lake Victoria or from a stream, attending a funeral feast, and sharing a meal with a person with watery diarrhea.

It was previously mentioned that in a global review of cholera epidemics, Griffith et al. found refugee settings to be the most commonly cited risk factor for cholera outbreaks in East Africa in reports from ProMED-Mail. Shultz et al. investigated a cholera outbreak in Kakuma Refugee Camp near the Sudanese border between April and June 2005.[54] A total of 418 patients

were treated for cholera, and 4 died. 83% of cases were refugees and 17% were Kenyans from the host community. The highest attack rate was located in a section of the refugee camp known as Kakuma 2. *V. cholerae* O1 biotype El Tor serotype Inaba was isolated from 33 patients. The authors conducted a case-control study with 90 cases and 170 matched controls. Storing water in the home in a sealed or covered container was found to be protective against cholera while being a recent arrival to the camp and sharing a latrine with 3 or more households was found to be associated with increased risk for cholera. These associations were found to be statistically significant in multivariate analysis.

Mugoya et al. reported on the spread of cholera across Kenya in 2005.[55] They identified 5 distinct cholera outbreaks between January and June 2005. Four outbreaks occurred in towns along major highways, and one outbreak occurred in Kakuma refugee camp as previously mentioned, which is linked to Nairobi by daily flights. The researchers investigated whether the outbreaks were epidemiologically linked. During this period 990 suspected cases were reported, including 25 deaths. 51% of the cases were children and adolescents. Cases were fairly widely dispersed in each of the outbreak locations. Cases did not differ significantly by sex. All *V. cholerae* isolates were O1 biotype El Tor, serotype Inaba, and isolates were genetically similar. In one location not treating drinking water and storing water in wide mouth containers were found to be statistically significant risk factors in multivariate analysis. In another location attending a funeral, eating food at a funeral, and eating ugali (the staple food) outside the home were found to be significantly associated with elevated risk for cholera. The authors suggest that the genetic similarity of *V. cholerae* isolates, temporal clustering, and transportation links indicate the outbreaks may be linked to one another. The authors point out that spread of cholera

throughout an African country has been rarely reported, and they highlight the possible emerging potential of cholera to spread via transportation systems.

Mohamed et al. reached a different conclusion about the mechanism of cholera occurrence during a large, widespread outbreak that affected most of the country resulting in 11,769 cases between January 2009 and May 2010.[56] In order to investigate the relationship between cholera detected in different parts of the country, the authors characterized the genotypes of *V. cholerae* isolated from different regions. For the purposes of this study, the researchers divided the country into 5 regions: lake, highland, lower eastern, coastal, and arid/semi-arid. Case-patients ranged in age from 1 to 76 years with a mean age of 23 years. Attack rates varied by region, ranging from a low of 0.02% in the lake and highland regions to a high of 0.2% in the arid and semi-arid region. The first reported case was on January 2, 2009 from the lake region in western Kenya. Index cases subsequently emerged in each of the other 4 regions during the next two months. All of the *V. cholerae* isolates were characterized as O1 biotype El Tor, with 84% serotype Inaba and 16% serotype Ogawa. Extensive diversity was observed in the genotypes of the isolates, and there was no clear correlation between geographic location and genotype. The authors conclude that this indicates that *V. cholerae* simultaneously emerged from endemic foci in various parts of the country, and they suggest that this might have been facilitated by environmental and behavioral factors. The authors mention the study by Mugoya et al. and discuss that although there is evidence of previous outbreaks being spread by travelers, the evidence from this study does not support this form of spread of cholera during the 2009-2010 outbreak. The authors reach the conclusion that cholera is endemic throughout Kenya.

Mahamud et al. describe an outbreak in Kakuma refugee camp in 2009 that resulted in 224 cases and 4 deaths.[57] Among the cases were 163 refugees and 61 Kenyan nationals from the surrounding community. The outbreak began in September and lasted through December 2009. This event was in the midst of the large outbreak across Kenya that Mohamed et al. had reported on. The most recent outbreak in Kakuma prior to this one was in April 2005 (described in the studies by Schultz et al. and Mugoya et al.). In the 2009 outbreak, *V. cholerae* O1, biotype El Tor, serotype Inaba was isolated from 42% of 104 stool samples collected. The researchers noted that the region Kakuma 2, which had the highest percentage of unusable latrines (because they were full), also had the highest cholera attack rate of 9.5 cases per 1,000 persons in comparison to an average attack rate of 2.7 cases per 1,000 persons in Kakuma as a whole. Schultz et al. had identified the same section of Kakuma as having the highest attack rate during the outbreak in 2005. The researchers conducted a case-control study. Univariate analysis indicated that the following factors were significantly associated with a lower risk of cholera: presence of soap in the home, hand washing with soap, presence of a latrine in the household compound, access to a clean latrine, and treating water by boiling or with chlorine. Conversely, the following factors were significantly associated with increased risk of cholera: sharing communal latrines with nearby households, visible presence of human feces within the compound, contact with a person with diarrhea, and use of dirty water storage containers. Multivariate analysis showed a statistically significant association between presence of dirty water storage containers in the home and elevated risk of cholera and between hand washing with soap and reduced risk of cholera. No association was found between illness and specific foods.

Loharikar et al. investigated characteristics of two adjacent districts that experienced different case-fatality rates during the epidemic that affected most parts of Kenya in 2009. [58] During this year, the CFR in East Pokot was 11.7% compared to 1.0 % in Turkana South. Both districts are located in the arid northwest region of Kenya and are comprised of nomadic and semi-nomadic populations. The researchers surveyed households, health facilities, and local shops in each district. The household survey investigated community knowledge, attitudes, and practices with respect to cholera. In Turkana South, 81% of household participants correctly identified that drinking bad water causes cholera compared to 53% of participants in East Pokot. A much higher percentage of participants in Turkana South (95%) reported treating their drinking water compared to participants in East Pokot (10%). A higher percentage of participants in Turkana South (34%) reported availability of oral rehydration solution (ORS) compared to participants in East Pokot (10%). The average travel time to a health facility was 2 hours in Turkana South compared to 31 hours in East Pokot. Availability of cholera treatment medications was very limited in local shops in both districts. Overall, 77% of health facilities surveyed reported shortages of ORS or intravenous fluids at some time during 2009. The authors concluded that poor access to healthcare and prevention supplies together with limited knowledge of cholera prevention and treatment in East Pokot compared to Turkana South likely contributed to the higher case-fatality rate in this county.

Kuria West and Migori districts of western Kenya were struck by a cholera outbreak in August 2010. Onyango et al. investigated the outbreak and detected 114 cases including 10 deaths. [59] The first case occurred in Kuria West District and was linked to a traditional marriage ceremony. The outbreak spread to Migori District. The researchers interviewed members of the District Health Management Teams and found that Kuria West District was not prepared to

handle a cholera outbreak. The surveillance system was weak, the district laboratory lacked the capacity to detect *V. cholera*, health care workers lacked training on cholera, and there was a shortage of oral rehydration and intravenous fluids. As a result of these challenges, there was delayed response to the outbreak. The authors surmise that the high case-fatality rate associated with this outbreak was likely due to poor case management, inadequate skills among health care workers, weaknesses in the surveillance system, and poor management support.

Cummings et al. conducted a case-control study during a cholera outbreak in 2010 among semi-nomadic pastoralists in northeastern Uganda to identify risk factors for cholera.[60] This region borders on northwestern Kenya, which also supports semi-nomadic pastoralist populations. The authors noted that semi-nomadic pastoralists transitioning to a more sedentary lifestyle are subject to new risk factors for diarrheal diseases due to the introduction of crowded conditions that they did not previously experience. In this study the following risk factors were significantly associated with cholera disease in multivariate analysis: residing in the same household as a cholera case, eating roadside food, not disposing of children's feces in a latrine, drinking un-chlorinated water, and childhood age. The authors highlighted the role of village health teams, comprised of community members, in surveillance, education, and response.

Influence of social and cultural factors

The study by Olago et al. of cholera outbreaks in the Lake Victoria Basin was previously discussed with respect to climatic factors.[47] The authors also looked at socioeconomic status, effectiveness of governance and civil organizations, quality of public health structures, and awareness of cholera outbreaks to understand human vulnerability to the disease in Kenya, Tanzania, and Uganda. The researchers noted indicators of low socioeconomic status in each of the communities studied with low rates of formal employment, presence of household food

insecurity, and the semi-permanent nature of much of the housing. Lack of access to safe water and improved sanitation facilities affected many of the households in the study area. Weakness of disaster management systems in the region is discussed with the conclusion that government management of cholera outbreaks has been reactive rather than proactive.

Kenya experienced a cholera outbreak in early 2008. This time period immediately followed contentious presidential elections in December 2007. During this time there was violence, protests, and work stoppages throughout Kenya. More than 1,000 people were killed and 350,000 displaced from their homes. Shikanga et al. conducted active case finding in 3 districts in western Kenya between January and April 2008 to investigate the extent of non-reporting of cholera cases and deaths. [61] During this time 546 cholera cases were officially reported from the 3 districts in the study. *V. cholerae* O1 biotype El Tor serotype Inaba was identified from 19 patients. Active case finding in the community identified 46% more cholera cases than those reported by health facilities and 200% more fatal cases. A high case-fatality rate of 16.7% occurred in January. A case-control study was conducted to compare cholera cases who died with cases who did not die. This study identified the following factors as protective against death from cholera: being treated in a government health facility, being admitted to hospital overnight, home treatment with antibiotics, and being educated about cholera by a health worker. These associations were statistically significant in multivariate analysis. The following factors were not associated with death from cholera: sex, level of education, presence of another cholera case in household, household crowding, transportation duration and cost to the nearest admitting facility, and socioeconomic status. Only four patients in the study reported the use of oral rehydration therapy (ORT) at home. This is a disturbingly low number given the well-established evidence of the effectiveness of ORT in treating cholera.

The researchers also found that cholera cases were often mismanaged in health facilities. Many patients who died did not receive intravenous fluids or did not receive the correct type or quantity of fluids. Between January and April 2008 hospitals experienced serious shortages of staff and supplies as a result of disruptions from the violence and protests. This study showed that passive, facility-based surveillance underestimated the number of cholera cases and number of deaths during this cholera outbreak in Kenya. The authors conclude that post-election violence contributed to the extraordinarily high case-fatality rate in western Kenya.

Nyambedha et al. studied community ideas about cholera in urban and rural western Kenya in order to understand the social and cultural factors that influence cholera transmission, prevention, and control and these communities. [62] Interviews of community residents were conducted between March and May 2010 in an urban informal settlement in the city of Kisumu and in Kakum Kombewa, a rural site in Siaya District. Both locations are in Nyanza Province, which borders Lake Victoria. Interview participants were adults aged 18 to 65 with 190 urban and 189 rural participants. During the interview, participants were read a vignette describing a person with typical symptoms. 73% of urban participants and 78% of rural participants identified the described symptoms as cholera. The most frequently cited causes of cholera in both communities were drinking contaminated water, living in a dirty environment, and lack of latrines. Urban participants more frequently mentioned a dirty environment, and rural participants more frequently mentioned contaminated water. Urban residents were more likely than rural residents to perceive women and children as being more vulnerable to cholera. The most frequently reported household treatment for cholera was oral rehydration therapy. Participants from both sites recommended utilizing health facilities for treatment. The authors

discuss the potential for effective public health interventions at health facility level based on this apparent trust in the healthcare system.

In neighboring Tanzania, Penrose et al. studied factors associated with risk of cholera in the capital city, Dar Es Salaam. [63] Approximately 65% of Dar Es Salaam households are in informal areas (often referred to as slums). The researchers found cholera risk to be significantly associated with living in informal housing, high population density, and low income level. Although the literature review did not reveal similar studies in Kenya's urban slums, it is reasonable to expect similar conditions.

Interventions

Conroy et al. describe the protective effect of solar disinfection of drinking water. [64] In 1996 the researchers had published the results of a case-control study in Kajiado District, Kenya demonstrating reduction in diarrheal diseases in children less than 6 years of age by use of solar disinfection of drinking water. Solar disinfection was achieved by leaving drinking water on the roof of the house in clear plastic 1.5 L bottles. The study area was affected by a cholera outbreak between November 1997 and January 1998. In a study of this outbreak, the researchers found statistically significant reduced incidence of cholera in children less than 6 years of age in the households using solar disinfection of drinking compared to households that were not using solar disinfection.

Date et al. investigated the effectiveness of cholera response activities by a local non-governmental organization in Nyanza Province during an outbreak in 2008. The Safe Water and AID Project (SWAP) assisted the Ministry of Health (MOH) by conducting cholera awareness and education activities in affected communities. The researchers evaluated the effectiveness of this response on knowledge, attitudes, and practices by conducting a survey of 358 households in

areas where the intervention was carried out and 365 households in comparison areas where SWAP did not carry out activities. Overall, the researchers found a high level of awareness of cholera symptoms, and more than 60% of participants were aware that cholera can be prevented by treatment of drinking water. Less than 40% of participants, however, identified hand washing as a method of prevention. The researchers also found low awareness in both groups that there had been a cholera outbreak in the area in the past year. Although hygiene knowledge and water treatment practices were higher among participants who had attended a cholera event, only 26% of participants in the intervention areas had attended an event. Also, household water treatment practices appeared to be low in both groups, with residual chlorine detected in only 17% of study households in the intervention areas and 14% of study households in the comparison areas. The researchers highlighted challenges in community mobilization for cholera events, hand-washing education, and sustained behavior change.

Review of surveillance data

Mutonga et al. reviewed national cholera surveillance data over the period 1997-2010 and produced a description of the epidemiology of cholera in Kenya in terms of incidence, case-fatality rate, geographic distribution, causative agent, and occurrence by sex and age. [65] During this period of time a total of 68,522 suspected cholera cases and 2,641 deaths (CFR, 3.9%) were reported to the MOH or WHO. Kenya's largest cholera outbreak occurred in 1997-1999 with 26,901 cases and 1,362 deaths (CFR, 5.1%) reported. Another epidemic occurred in 2007-2009 with 16,616 cases and 454 deaths (CFR, 2.7%) reported. Both epidemics reportedly originated from Nyanza Province. The most frequently affected areas included Nairobi, Nyanza Province, Coast Province, remote arid and semiarid regions, and Dadaab and Kakuma refugee camps. *V. cholerae* O1 serotype Inaba was the predominant causative agent detected in 2007-2010,

although serotype Ogawa was also isolated. A detailed analysis of cases from 2009-2010 showed little difference in sex distribution of cases with 51% male and 49% female. During the same time period the young were disproportionately affected, with children under the age of 15 accounting for 42% of cases. The authors point out that almost no cases of cholera were reported in the second half of 2010 and in 2011, and they suggest that additional research is needed to ascertain what may have led to this dramatic decline.

Bwire et al. conducted a similar review of national cholera surveillance data in Uganda over the period 2007-2011. [66]The researchers found that during this period there were a total of 7,615 reported cholera cases with 181 deaths (CFR, 2.4%). Outbreaks were most common in communities along lakes and rivers, refugee camps, and large urban informal settlements. The highest cholera incidence occurred in 2008 following heavy rainfall and flooding in eastern Uganda. An analysis of the demographics of reported cases in 2011 indicated that 1.6 times more men than women were affected by cholera, and the majority of cases occurred in the age group 15-45 years (61.2%). The authors caution, however, that this information is based on data from only one year when a relatively small number of cases occurred (230 cases). The researchers observed no consistent seasonal patterns of cholera occurrence over the time period studied. Overall, between 2007 and 2011, there was a decline in the number of reported cases. The authors suggest this decline might be attributable to prevention and control efforts carried out by the Ugandan government and development partners including:

- Health education
- Improved surveillance and case management, including use of village health teams for case identification
- Provision of safe water

- Promotion of good sanitation and hygiene practices

The authors also note that the Ugandan government takes a multi-sectoral approach to cholera prevention and control led by the MOH and involving several other government ministries and partner agencies.

Muyembe et al. reviewed national cholera surveillance data in the Democratic Republic of the Congo over the period 2000-2011. [67] The researchers found that the highest annual incidence rates occurred in the eastern provinces of the country bordering the Great Lakes and concluded that cholera is highly endemic around the lake areas. The authors discussed the Congolese government's plan to eliminate cholera in the country, with a focus on 7 endemic areas bordering the lakes. The plan calls for strengthening of surveillance, case management, and coordination, as well as improved water and sanitation infrastructure.

Stoltzfus et al. investigated the relationship between cholera occurrence in Kenya and various climatic, environmental, and demographic factors. [68] This study covered the time period 1999-2009, and the unit of analysis was 69 districts of Kenya. Cholera surveillance data was obtained from the Kenya Ministry of Health, and rainfall and temperature data were obtained from the Kenya Meteorological Department. Data for environmental and demographic factors came from the 2005-2006 Kenya Integrated Household Budget Survey. The authors acknowledge that the cholera data for 1999 and 2000 were "approximate figures reported in intervals of 50." These years contribute to 39% of the total cholera cases between1999 and 2009 based on figures previously published by Mutonga et al. [65] In a comparison of cholera incidence across 69 districts, the researchers found cholera risk to be significantly associated with rainfall, % Muslim population, lack of piped water, distance to the nearest health facility, and proximity to a large body of water (Lake Victoria, Lake Turkana, or the Indian Ocean). The relationship

between cholera and rainfall was complex. The researchers found that increased rainfall between April and June was associated with decreased risk of cholera, while increased rainfall between October and December was associated with increased risk of cholera. The researchers found no association between cholera risk and population density, % of population living below the poverty line, or % of population using unsafe sanitation facilities.

Discussion

A review of the published literature on cholera in Kenya and East Africa raises a number of interesting topics for discussion. There is a body of evidence that cholera is associated with fresh water lakes in the Great Lakes region of Africa. Are the lakes an environmental reservoir for *V. cholerae*, or is water simply serving as a vector for transmission? Feikin et al found an association between cholera cases and water hyacinth coverage in Lake Victoria and suggested that this plant may promote growth or maintenance of *V. cholerae* in the aquatic environment. [44] A fresh water reservoir for *V. cholerae* would be a bit surprising since *V. cholerae* is more commonly associated with brackish, estuarine, and coastal waters. It is interesting to note, however, that while Kenya and Tanzania both have extensive coastlines, the published literature suggests that cholera outbreaks have occurred more frequently in inland lake areas than coastal areas in the region. Are lakes a more suitable environment for *V. cholerae* than coastal areas in East Africa? Or is there more human exposure to contaminated water in the lake regions compared to coastal regions? There is insufficient information in the literature to draw conclusions to these questions. It is interesting that Birmingham et al. hypothesize that although the introduction of *V. cholerae* to lakes and rivers in the Great Lakes region can result in the rapid spread of explosive outbreaks, the short duration of cholera outbreaks and long periods of time between them suggest that the fresh water lakes do not provide a suitable environment for

V. cholerae. This idea may also have some relation to the observation by Griffith et al. that although East Africa accounted for 20.1% of the number of cholera outbreaks reported in ProMED-Mail between 1994 and 2005, it accounted for only 7.6% of the total number of cases.[40] This might suggest a larger number of small outbreaks in the region compared to other areas, or it might mean better capability to detect small outbreaks in this region compared to other regions experiencing cholera outbreaks.

Three studies in this review identified an association between El Niño climatic events and cholera occurrence. [13,47,48] Two of the studies included data from Kenya in the analysis, while one study focused on Uganda. None of the studies focused exclusively on Kenya in drawing conclusions. Feikin et al. suggest that there was no temporal synchrony between El Niño flooding and large cholera outbreaks in Kenya in 1997 and 2008. [44] More research is needed to understand whether there are climatic drivers of cholera outbreaks in Kenya. It is reasonable to expect that climatic conditions are more likely to influence cholera occurrence in communities that lack protection against cholera, such as improved water and sanitation facilities and access to medical care. If there is sufficient evidence to conclude that El Niño events create a favorable environment for the spread of cholera in East Africa, an analysis of cholera occurrence during El Niño years might provide an indication of the progress or lack of progress in implementation of measures for the prevention and control of cholera.

An important element of understanding cholera occurrence in Kenya is an understanding of how cholera has spread during years in which the whole of the country was affected. Mugoya et al. point to the potential role of transportation networks in the spread of cholera across Kenya in 2005. [55] Bompangue et al. also found the risk of cholera to be associated with the presence of roads in districts studied in the DRC. [13] In contrast, Mohamed et al. presented evidence

suggesting that the large number of cholera cases arising across Kenya in 2009 and 2010 resulted from near simultaneous emergence of cholera from endemic foci across the country.[56] These two different models of spread would require different approaches to control. For example, in considering proactive administration of cholera vaccine for prevention of outbreaks, targeting a limited number of geographic areas where cholera has historically initially emerged may be effective if the first model of disease spread is valid, while vaccination in multiple locations across the country might be necessary for effective prevention if the second model of spread is valid.

Much of the available information on cholera in Kenya comes from studies conducted in Nyanza Province in western Kenya. This province borders Lake Victoria, and Feikin et al. pointed out that Nyanza accounted for 38.7% of cholera cases in Kenya between 1994 and 2008, while the population of Nyanza Province comprises only 15.3% of the country.[44] This suggests a higher burden of cholera in Nyanza compared to other parts of the country and might be the reason for more published studies from this region. However, an understanding of what has occurred in other regions of the country is essential to fully understanding cholera in Kenya. It is interesting that Mohamed et al. found a 10-fold higher cholera attack rate in the arid and semi-arid region of northern Kenya than in the lake region of western Kenya during the period January 2009 to May 2010.[56] This might suggest a more recent shift in geographic patterns of occurrence. Outside of Mohamed's report and articles on 2005 and 2009 outbreaks in Kakuma refugee camp, the literature is silent on outbreak investigations in other parts of northern Kenya.

A number of risk factors for cholera were identified in the research studies included in this literature review. Risk factors include: drinking and bathing in water from unprotected sources such as lakes, rivers, and streams, not treating drinking water, storing water in dirty or

uncovered containers, lack of access to improved sanitation facilities, sharing communal latrines, not disposing of children's feces in a latrine or toilet, not washing hands with soap, presence of a cholera case in the household, attending a funeral, childhood or adolescent age, and living more than 5 km from the nearest health facility. There is mixed information in the literature on the risk of exposure from food, but this likely reflects different dynamics of individual outbreaks. There is no clear indication in the literature of a difference in risk by sex.

Shikanga et al. demonstrated vast under-reporting of cholera cases and cholera deaths during a 2008 outbreak in western Kenya as a result of cases not presenting to health facilities.[61] The researchers found previously unidentified cases and deaths by active community case finding. It has long been recognized that it is likely there is vast under-reporting of cholera globally and that rural residents face challenges with accessing health facilities in many countries. This study quantified the problem in western Kenya during a challenging time marked by political violence in the country.

There are important questions that have not been well addressed by the literature. First of all, what are the geographic patterns of cholera occurrence in the country, and have there been changes over time? Some of the literature suggests a disproportionately high burden of cholera in western Kenya around Lake Victoria while a recent study suggests a higher incidence in the arid and semi-arid regions of northern Kenya. Kenya experienced large outbreaks in 1997-1999 and 2008-2010 with intervening years of much lower levels of cases. Also, since 2011 the country has experienced very few cases of cholera. Are there differences in the geographic distribution of cholera during years of large outbreaks compared to years with lower levels of cholera?

Who are the vulnerable populations in Kenya? Is everyone living near Lake Victoria at risk? The literature suggests that both refugee populations and the general population experience outbreaks. What proportion of cases occurs in refugee populations? Understanding the relative burden of cholera in refugee populations and the general population is useful in designing an appropriate prevention and control strategy for the country. Also, what proportion of cases occurs in urban populations versus rural populations? This does not come out clearly in the literature, and this is important for designing effective strategies and targeting appropriate populations.

The literature is noticeably silent on governmental policies and strategies for cholera prevention and control. A keyword search with the terms "cholera AND (policy OR strategy) AND africa" returned few articles, and very few of those cited touched on government policy or strategy. The few articles with most relevance were related to cholera vaccination. Slightly more information is available if the search is expanded beyond cholera to "diarrhea". This dissertation examines perceived successes and challenges of governmental policies and strategies with relevance to cholera prevention and control in Kenya.

A limitation of this literature review is that the review captured only studies published in peer-reviewed journals. It is likely that there are unpublished outbreak reports held by governmental and non-governmental organizations conducting cholera control activities that could further elucidate the patterns and mechanisms of cholera occurrence in the country.

CHAPTER 3: METHODS

This descriptive study employed a mixed methods approach to investigate the successes and challenges of cholera prevention and control in Kenya, to analyze geographic patterns of cholera occurrence over time, to investigate the relationship between cholera occurrence and selected development and demographic indicators, and to make recommendations for enhanced prevention and control.

Quantitative methods were used to:

- Describe the geographic patterns of cholera occurrence over time
- Analyze the relationship between development and demographic indicators and cholera occurrence and case-fatality rate

Qualitative methods were used to:

- Describe the perceived successes and challenges of cholera prevention and control in Kenya as identified by key informants from the Government of Kenya and other organizations supporting cholera activities in Kenya

The quantitative and qualitative components of this study were carried out concurrently.

Theoretical framework

The ecological perspective on health provides a useful framework for analyzing factors that influence the risk of cholera in individuals and in communities. According to the National Cancer Institute, this perspective "emphasizes the interaction between, and interdependence of, factors within and across all levels of a health problem." [69] Key concepts from this framework

that are useful in thinking about cholera prevention and control include the importance of peoples' interactions with their physical and socio-cultural environments and the existence of multiple levels of influence on health behavior and health outcomes. McLeroy et al. described five levels of influence affecting health behaviors: individual, interpersonal, organizational, community, and policy factors. [70]

Drawing upon the concepts of McLeroy's ecological perspective on health promotion programs, a model of factors affecting cholera occurrence and death at various levels of influence is proposed in Figure 3.

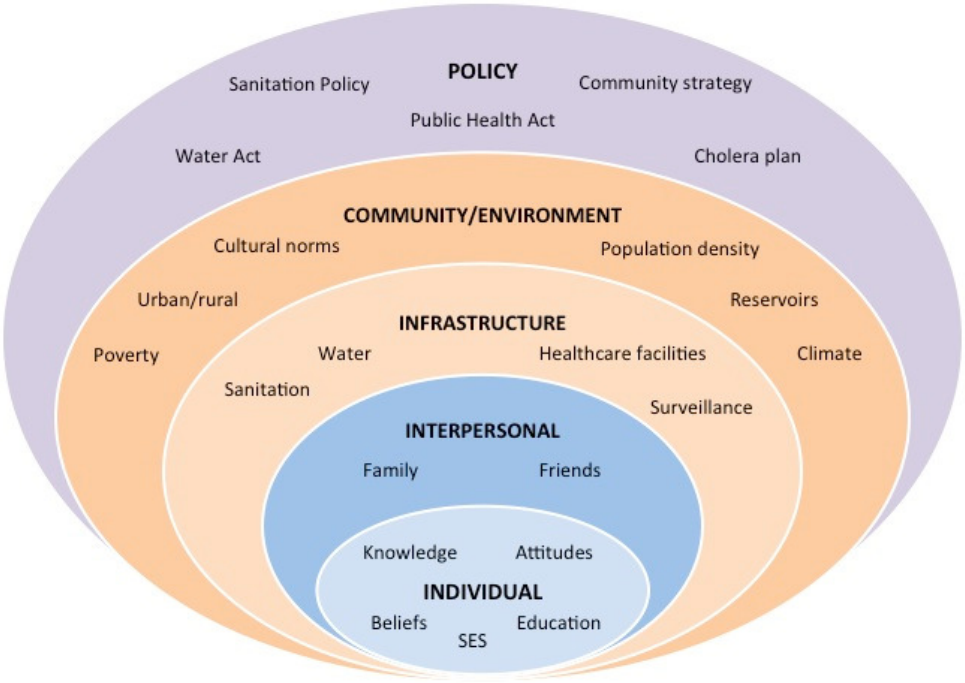


Figure 3. Ecological model of factors influencing cholera occurrence and death

In the context of cholera occurrence and death we can consider that an individual's knowledge, attitudes, and beliefs about cholera influence behavior and cholera risk at the individual level. Knowledge, attitudes, and beliefs are likely influenced by an individual's

educational status; and individual behaviors are likely influenced by socio-economic status (SES). At the interpersonal level, interactions with family and friends can influence risk of cholera. At the infrastructure level, key factors affecting risk include availability of safe drinking water, improved sanitation facilities, and healthcare facilities as well as the existence or absence of a cholera surveillance system. The community/environment level refers to both the human and natural environment. Within the human environment, there is the influence of social and cultural norms, poverty, urban and rural conditions, and population density. Influential factors within the natural environment include climate and the presence or absence of environmental reservoirs for *V. Cholerae*. At the policy level, in the Kenyan context, key policies and national strategies include the Public Health Act, Water Act, National Environmental Sanitation and Hygiene Policy, community health strategy, and the Multi-sectoral Cholera Prevention and Control Plan.

This is not an exhaustive list of factors influencing cholera occurrence and cholera deaths but serves to illustrate the concept that an individual's risk of acquiring cholera or dying from cholera is influenced by multiple factors operating at various levels of influence. Some factors may be viewed as operating at more than one level (i.e. poverty may be viewed as an individual factor or a community factor), and influence may occur in more than one direction (i.e. policy may influence community factors and vice versa). This study recognized the complex nature of factors affecting cholera outcomes by investigating a range of factors at various levels of influence.

Quantitative investigations

Quantitative data was collected and analyzed with two objectives: 1) investigation of geographic patterns of cholera occurrence over time, and 2) investigation of the relationship

between development and demographic indicators and cholera occurrence and case-fatality rate. The first investigation looked at cholera incidence in each of the 47 counties of Kenya over the 10-year time period 2004-2013. The unit of analysis, the county, reflects the current political and administrative structure of government in Kenya. The second investigation used Pearson's correlation coefficient and zero-inflated poisson regression analysis for a cross-district comparison of cholera occurrence and case-fatality rate to selected development and demographic indicators. The time period for this analysis was 2008-2013, which represents three years of widespread cholera outbreaks in Kenya and three years of few, isolated outbreaks. A smaller unit of analysis, the district, was used. This investigation was based on the geographic boundaries of the 158 administrative districts in the 2009 Kenya Population and Housing Census.

Variables and data sources

These investigations were carried out in collaboration with the Kenya Ministry of Health (MOH), Disease Surveillance and Response Unit (DSRU), which maintains national cholera surveillance data. This surveillance data flows from health facilities to the MOH through reporting structures established by the Integrated Disease Surveillance and Response (IDSR) strategy. The dependent variables of interest for this study were number of cholera cases, cholera incidence, and case-fatality rate. Information on cholera morbidity and mortality was obtained from the following data sources provided by the DSRU:

1) Spreadsheet of aggregate numbers of cholera cases and deaths in Kenya for the years 2004-2010 by district and year
2) De-identified line lists with dates and locations of cholera cases and deaths in Kenya for the years 2008-2010 and 2012-2013
3) The Ministry of Health's Weekly Epidemiological Bulletin for the years 2008-2013

Additional information on cholera occurrence was obtained from publicly available reports published by the World Health Organization, the East African Community, and the Program for Monitoring Emerging Diseases (ProMED-mail). [1,71-74]

Cholera incidence was calculated as the number of reported cholera cases per 100,000 people in a given year. For the investigation of geographic patterns of cholera occurrence from 2004-2013, population projections were obtained from the Kenya National Bureau of Statistics (KNBS) for the years 2004-2010 based on the geographic boundaries of 69 districts in the 1999 census. [75] The researcher aggregated this population data according to the geographic boundaries of the current 47 counties. Population projections for 2011-2013 were not available from KNBS at the time of this study, so county population projections used by the Joint United Nations Program on HIV/AIDS (UNAIDS) for modeling of HIV prevalence were selected as an alternate source. [76] For the regression analysis, population data for the 158 districts was obtained from the 2009 census. Cholera case-fatality rate was calculated as the percentage of deaths among cases.

Data on development and demographic indicators was extracted from published survey reports and from a de-identified 10% micro-data set of the 2009 Kenya Population and Housing Census available from KNBS. The following independent variables were analyzed for potential association with cholera occurrence and case-fatality rate:

- Percentage of households with access to an improved water source
- Percentage of households with access to an improved sanitation facility
- Percentage of households practicing open defecation
- Percentage of population with at least some secondary education
- Percentage of population living in urban areas
- Population density

- Poverty headcount ratio
- Number of healthcare facilities per 100,000 population

The independent variables were chosen based on findings in the literature about risk factors for cholera. Definitions and data sources for these indicators are provided in Table 2.

Table 2. Development and demographic indicators with their definitions and data sources

Indicator	Definition	Data source
Percentage of households with access to an improved water source	Number of households with access to an improved water source divided by the total number of households, expressed as a percentage. Improved water sources include the following categories from the 2009 Kenya Population and Housing Census: protected spring, protected well, borehole, piped into dwelling, piped, rain water collection; does not include pond, dam, lake, stream/river, unprotected spring, unprotected well, jabia, water vendor, or other. The WHO/UNICEF Joint Monitoring Program defines an improved water source as piped water, public tap, borehole or pump, protected well, protected spring or rainwater. Improved water sources do not include vendor-provided water, bottled water, tanker trucks or unprotected wells and springs. [32,77,78]	2009 Kenya Population and Housing Census, 10% micro-data set
Percentage of households with access to an improved sanitation facility	Number of households with access to an improved sanitation facility divided by the total number of households, expressed as a percentage. Improved sanitation facilities include the following categories of sanitation facilities from the 2009 Kenya Population and Housing Census: main sewer, septic tank, cesspool, ventilated improved pit (VIP) latrine, and covered pit latrine; does not include uncovered pit latrine, bucket, bush, or other. The WHO/UNICEF Joint Monitoring Program defines improved sanitation facilities as facilities that hygienically separate human excreta from human, animal, and insect contact. *Improved sanitation facilities* include flush/pour-flush toilets or latrines connected to a sewer, septic tank or pit; ventilated improved pit latrines; pit latrines with a slab or platform of any material which covers the pit entirely, except for the drop hole; and composting toilets/latrines. *Unimproved facilities* include public or shared facilities of an otherwise improved type; flush/pour-flush toilets that discharge directly into an open sewer or ditch or elsewhere; pit latrines without a slab; bucket latrines; hanging toilets or latrines; and the practice of open defecation in the bush, field or bodies of water. [32,77,78] The 2009 Kenya Population and Housing Census did not distinguish between a private vs. public or shared sanitation facilities.	2009 Kenya Population and Housing Census, 10% micro-data set
Percentage of households practicing open defecation	Number of households practicing open defecation divided by the total number of households, expressed as a percentage. For the purpose of this study open defecation includes the following modes of human waste disposal from the 2009 Kenya Population and Housing Census: bush, bucket, and other. [77]	2009 Kenya Population and Housing Census

Percentage of population with at least some secondary education	Number of people with at least some secondary or higher level education divided by the total population aged 3 years and above. The educational system in Kenya includes 8 years of primary education and 4 years of secondary education. From the 2009 Kenya Population and Housing Census the following categories of highest level of education reached were included: secondary, tertiary, university, and youth polytechnic. The following categories were not included: never attended, pre-primary, primary, basic literacy, and madrassa. [77]	2009 Kenya Population and Housing Census
Percentage of population living in urban areas	Population living in urban centers whose population was estimated at 2,000 or higher during the 1999 Kenya Population and Housing Census divided by total population, expressed as a percentage. [77]	2009 Kenya Population and Housing Census
Population density	Number of people per unit area. In the 2009 Kenya Population and Housing Census, population density is expressed as number of people per square kilometer. [77]	2009 Kenya Population and Housing Census
Poverty headcount ratio	Percentage of persons living below the poverty line, calculated as the number of persons living below the poverty line divided by the total population. Data is based on the Kenya Integrated Household Budget Survey 2005/2006 as presented in the report *Exploring Kenya's Inequality*. [79,80]	2005/2006 Kenya Integrated Household Budget Survey data as presented in "Exploring Kenya's Inequality" report
Number of healthcare facilities per 100,000 population	Number of healthcare facilities in a district divided by district population and expressed per 100,000 people. Healthcare facilities include public, non-governmental, faith-based, and private facilities. Data was derived from the Ministry of Health's Master Facility List. [81] The following categories of facilities were not included: HIV counseling and testing center, nursing home, regional blood transfusion center, training institution, dental clinic, laboratory, radiology unit, health project, and facilities labeled as "not operational" or "pending opening."	Ministry of Health Master Facility List

This study included two indicators related to sanitation. The percentage of households with access to an improved sanitation facility is similar to the Millennium Development Goal (MDG) indicator of percentage of population with access to an improved sanitation facility, but there is a limitation to the data source for this indicator, the 2009 Kenya Population and Housing Census. The census did not distinguish between private and shared sanitation facilities. All

facilities shared by more than one family are considered to be "unimproved" according to the World Health Organization (WHO)/United Nations Children's Fund (UNICEF) Joint Monitoring Program definition of improved and unimproved sanitation facilities. Since the census did not distinguish shared facilities, this factor was not taken into account when calculating the percentage of households with access to improved sanitation. Because of this limitation in the data, and because there is a major effort to eliminate open defecation in Kenya, the percentage of households practicing open defecation was selected as a second sanitation indicator for analysis.

Percentage of households with access to improved water and percentage of households with access to improved sanitation were derived from a 10% micro-data set of the 2009 Kenya Population and Housing Census available from KNBS. [78] This data set contained information from every tenth household in the census and provided a sample size of 876,784 households for water and sanitation calculations. This data set enabled disaggregation of the 15 types of water sources and 9 modes of human waste disposal, some of which were combined in tables presented in the census report.

The data source for poverty headcount ratio was the 2013 report *Exploring Kenya's Inequality.* [79] The poverty-related data tables in this report are based on the 2005 Kenya Integrated Household Budget Survey (KIHBS). The original KIHBS report presents poverty data for urban and rural areas separately. This presented a challenge for analysis since most districts contain both urban and rural areas. *Exploring Kenya's Inequality* was selected as an alternative data source because it presents poverty data for geographic units taking into account both urban and rural contributions to the data. Data in this report is presented by political constituency rather than by administrative district. The researcher aggregated constituency data by district based on geographic boundaries. Some of the 2009 administrative boundaries did not

exactly match 2013 political constituency boundaries; however, the researcher felt that this was the best way of estimating the values of this independent variable by district based on the data that was available.

Data management and analysis

Data was encrypted and stored on a password-protected computer kept in a physically secure location. Data was backed up to an encrypted, password-protected storage device that was kept in a locked cabinet in the principal investigator's office. Only the principal investigator had access to the data storage devices.

Data analysis began with a review of the completeness of cholera surveillance data and consistency among available data sources. The DSRU spreadsheet of aggregate numbers of cholera cases and deaths by district and year served as the primary data source. Line lists, epidemiological bulletins, and publicly available outbreak reports served as secondary data sources for triangulation. A number of inconsistencies were observed among data sources with respect to absolute numbers of cases and deaths. Secondary data sources were used only to estimate missing values and to check consistency in terms of presence or absence of cholera in a district for a given year.

For the county-level analysis of geographic patterns of cholera occurrence, the researcher aggregated district-level cholera surveillance data by county. For the district-level regression analysis, cholera surveillance data could not be fully resolved among the 158 districts in the 2009 census. The number of administrative districts in the country has varied over time from 47 districts in 1992 to 254 districts by the end of 2009. As a result, cholera data for some of the 158 districts was combined in some years. For example, cholera cases and deaths for Kisumu East and Kisumu West districts were reported for a single district, Kisumu, in the primary data source

for 2008 and 2009. There were inconsistencies in secondary data sources in the numbers of cases and deaths for the two districts, so these districts were combined for the purpose of analysis. A total of 35 districts could not be resolved. Following aggregation of districts that could not be resolved, there were a total of 137 districts for the regression analysis. A complete list of aggregation by county, district, and constituency for the purpose of analysis is provided in Appendix A.

Analysis of geographic patterns of cholera occurrence

County level data was examined over the 10-year period 2004 to 2013. The trend in cholera incidence was graphed over this time period for each county. Each county was categorized with respect to endemic/non-endemic status over the time periods 2004-2008 and 2009-2013. The definition of endemic cholera set forth in the 2010 WHO position paper on cholera vaccines published in the Weekly Epidemiological Record was used to classify county status as endemic or non-endemic for cholera. The WHO definition of endemic cholera is "the occurrence of fecal culture-confirmed cholera diarrhea in a population in at least 3 of the past 5 years." [5]

QGIS geographic information system open source software (version 2.4.0-Chugiak) was used to visualize geographic patterns of cholera occurrence. Choropleth maps were produced to display data on cholera incidence and the number of years each county reported cholera cases.

Analysis of relationship between development and demographic indicators and cholera occurrence and case-fatality rate

District level cholera data was aggregated over the 6-year period 2008-2013. The total number of reported cholera cases, cumulative cholera incidence and case-fatality rate were calculated over this time period for each district. Point estimates for development and

demographic indicators were obtained from the data sources identified in Table 2. Frequency tables for the number of households by main source of water and main mode of human waste disposal were generated in STATA statistical software (StataCorp, version 13.1) from 10% micro-data from the 2009 Kenya Population and Housing Census provided by KNBS. Regression analysis was performed in STATA. The strength of linear association between each independent variable and cholera incidence and case-fatality rate was investigated through calculation of Pearson's correlation coefficient. Potential association between cholera and the independent variables was further investigated by univariate and multivariate analysis using a zero-inflated poisson (ZIP) regression model. Poisson regression is appropriate when the outcome is count data. The outcome variable used in the model was total number of cholera cases. A poisson regression model assumes that the logarithm of the count variable can be described by a linear combination of predictor variables and that the mean and variance of the outcome variable are equal. The ZIP model is a poisson regression that adjusts for zero inflation. Eighty of 137 districts did not report any cases of cholera between 2008 and 2013, and it is plausible that there was zero inflation in the data set. The fact that a district did not report any cases of cholera between 2008 and 2013 may reflect true absence of cholera, or it may be the result of the district simply not detecting or reporting cases of cholera. In addition to adjusting for zero inflation, the model incorporated an offset of the natural logarithm of the 2009 district population to adjust for population.

Key informant interviews

Qualitative data was gathered on the perceived successes and challenges of cholera prevention and control through in-depth interviews with key informants. The main topics explored in the interviews include:

- Perceived effectiveness of interventions
- Policies and strategies relevant to cholera prevention and control
- Availability of data for informed decision-making
- Communication and coordination among organizations engaged in cholera prevention and control activities
- Status of implementation of the Multi-sectoral Cholera Prevention and Control Plan
- Opportunities and challenges of devolution

Study Population

Interviews were conducted with professionals who had experience with cholera prevention and control activities in Kenya. These individuals were recruited from the Kenyan government health sector, multilateral organizations, bilateral agencies, and humanitarian non-governmental organizations (NGOs) operating in Kenya. Sampling was a purposive, non-random design to obtain participants with various perspectives.

Potential participants were identified through review of the list of contributors to Kenya's Multi-sectoral Cholera Prevention and Control Plan, review of the published literature on cholera in Kenya, consultation with a collaborator in the MOH Disease Surveillance and Response Unit, and the investigator's professional knowledge of individuals with a history of involvement in cholera prevention and control efforts in Kenya. Participant selection targeted the following roles and organizations:

- At least one individual who had been engaged in cholera activities in the government health sector at sub-national level as a district or provincial medical officer or as a county health officer
- At least one senior representative from the MOH Disease Surveillance and Response Unit

- At least one senior representative from the MOH Division of Environmental Health
- At least one senior representative from the U.S. Centers for Disease Control and Prevention (CDC) in Kenya
- At least one senior representative from WHO in Kenya
- At least one senior representative from UNICEF in Kenya
- At least two individuals from humanitarian NGOs in Kenya
- A current or former MOH Director of Public Health and Sanitation or the Division of Communicable Disease Prevention and Control

Data collection procedures

The format of inquiry was a semi-structured interview using a guide (Appendix B). The interview guide was initially pilot tested to ensure that it captured appropriate information. Two volunteers were recruited from among professional colleagues who were knowledgeable of cholera in Kenya. The volunteers were informed that their contributions were for pilot testing purposes only, and that their responses would not be included in the study. The pilot test volunteers went through the same informed consent process and were given the same privacy and confidentiality protections as participants. The pilot test interviews were conducted in English. Based on the results of the pilot test, a series of three closing questions were reduced to one question to avoid repetition. The interview guide was organized into the following sections:

1. Introduction and transition: two ice-breaker questions about the individual's roles and responsibilities with respect to cholera prevention and control activities, and their duration of involvement in such activities
2. Key questions: a series of questions focused on aspects of the main research question of the study

3. Conclusion: one question about any additional information participants would like to add

Beginning in June 2014 courtesy calls were made to invite individuals to participate in the study and to provide a brief overview of the investigation. The courtesy call was followed by delivery of a formal letter of invitation explaining the purpose of the study, privacy considerations, and the format of the proposed interview (Appendix C). Invitations were made until interviews were obtained with participants from each of the targeted categories listed above. A total of 13 invitations were made and 11 individuals agreed to participate in the study.

Interviews were conducted between June 20, 2014 and September 9, 2014. Prior to starting the interview, the investigator shared an informed consent form (Appendix D) and gave participants an opportunity to ask questions about the study. Additional information on informed consent is provided in the Ethical Considerations section of this chapter. All interviews were conducted in English. Seven interviews were conducted in person, three were conducted by phone, and one participant responded by email. With permission, the investigator audio-recorded all oral interviews on a portable device and took written notes. The interview was designed to take about 45 minutes. Actual interviews varied in length from 22 to 80 minutes, taking an average of 55 minutes.

At the end of the interview the researcher asked the participant if they may be contacted in the future if additional questions arise or if there is need for clarification of any responses. The researcher briefly described the next steps in the study, provided contact information, and thanked the participant for their time.

Data management and analysis

Audio-recordings were downloaded the same day to the designated data storage computer and immediately removed from the portable device. Recordings were transcribed by the

principal investigator and stored electronically in accordance with the data management plan. Transcripts were verified in their entirety by the principal investigator against the original audio recordings prior to data analysis. Recordings and transcripts were given a code number for identification; no personal identifiers were linked to this data. A list of code numbers and participant names was maintained in hard copy format in a locked cabinet in a separate location from the data. Only the principal investigator had access to the code list, and it will be destroyed upon completion of the study. All transcripts and recordings will be destroyed upon completion of the study.

Analysis of qualitative data from key informant interviews was conducted using CDC EZ-Text software (version 4.0). Initially, transcripts were read in full by the investigator and summary notes were developed from each transcript to identify key ideas and common themes. The questionnaire and transcript data were then entered into EZ-Text. An initial coding manual was based on themes in the conceptual framework of the study and common themes identified during the initial review of transcripts. The investigator then coded each participant's response to each question. Additional codes emerged during this process, and the codebook was refined. Primary codes were developed to capture key themes and ideas, while sub-codes were assigned to track the frequency of occurrence of specific policies, strategies, and interventions in participants' responses. A total of 50 codes were developed (41 primary codes and 9 sub-codes). Data was extracted and analyzed for common themes both by question number and by code. Among the many ideas expressed by key informants, the findings reported in this study were either (1) mentioned by at least two individuals or, (2) mentioned by only one individual, but the finding had strong face validity.

Ethical considerations

The University of North Carolina Office of Human Research Ethics granted an Institutional Review Board (IRB) exemption for study no. 13-3399 on March 26, 2014, and the Kenya Medical Research Institute Ethics Review Committee granted ethical approval for study no. Non-SSC 438 on May 13, 2014.

Risks of participation

This study was of minimal risk to participants. Study participants had been engaged in cholera prevention and control as a normal part of their jobs. Interview participants were not pressured to disclose any information that could potentially bring harm to them. As with any activity that involves collection of information from individuals, there was a risk of breach of privacy or confidentiality of information. This risk was minimized by strict adherence to procedures described in other sections of this dissertation.

Informed consent

Written informed consent was obtained from all participants in key informant interviews. Participants were provided a consent form in English (Appendix D), the investigator briefly explained the contents of the form, and participants were given the opportunity to ask questions. Participants were asked if they consent to being listed as a participant to establish study credibility, with the understanding that no responses would be attributed to particular individuals. Participants were given the option to participate anonymously. The Flesch-Kincaid reading grade level of the consent form is 9.9.

Privacy and confidentiality protections

Participants were informed of their right to privacy and confidentiality of their information. Participants were given the option to choose a suitable location for the interview. In most cases the interview took place in the participant's office. Data was stored securely in accordance with the data management plan described in this proposal. Responses were not attributed to individuals, and any information released was in the form of group summaries.

Autonomy

Participants were informed of their right to not participate in the study and to withdraw at any time.

Compensation for participation

No financial compensation was provided for participation in the study.

Additional Safeguards for vulnerable populations

This study did not include vulnerable populations, and no additional safeguards were required.

CHAPTER 4: RESULTS

Quantitative investigations

Data analysis began with an initial review of the completeness and consistency of cholera surveillance data. For 2004 and 2006 a list of cholera-affected districts and the total number of cases and deaths for the year was available from the primary data source, but a breakdown of the number of cases and deaths by district was not available. A review of outbreak reports available from the East African Integrated Disease Surveillance Network (EAIDSNet), WHO, and ProMED-mail confirmed the cholera-affected districts.[71-74] Reported numbers of cholera cases and deaths for each district were extracted from these reports and used in this analysis. It should be noted that the total number of cases and deaths for each year, based on the data available in the outbreak reports, was less than the totals reported in the primary data source.

For 2008 and 2009 it appeared that a few cholera-affected districts were not captured in the primary data source. MOH line lists, epidemiologic bulletins, and ProMED-mail were reviewed as secondary data sources. If at least two secondary data sources identified a cholera-affected district that was not included in the primary data source, data from the secondary data sources was included in the analysis following consultation with an MOH collaborator. As a result, data was included for Naivasha, Nandi South, and Samia districts in 2008 and Butere district in 2009.

Caution should be exercised in interpretation of absolute numbers in this analysis. There were inconsistencies in absolute numbers among available data sources but reasonable

consistency in terms of presence or absence of cholera in a given geographic location for a given year and the relative magnitude of cholera occurrence.

Key findings

Key findings from the analysis of cholera surveillance data are summarized in this section. These findings are further described in the sections that follow. Key findings include:

1. Twelve counties did not report any cases of cholera between 2004 and 2013. Most of these counties are in the central part of Kenya, north of Nairobi.
2. Four counties reported cholera cases in 5 of 10 years between 2004 and 2013. This was the greatest frequency of reporting. These counties are in the northwestern, northeastern, western, and coastal regions of Kenya and have different climatic conditions.
3. Cholera has affected some of the least densely populated rural areas and the most densely populated urban areas, including Kenya's largest cities.
4. Some of the counties most heavily affected by cholera in northern and eastern Kenya in 2009-2013 had not previously reported cases in 2004-2008.
5. Four of five counties bordering Lake Victoria had lower cumulative cholera incidence in 2009-2013 as compared to 2004-2008.
6. Between 2011-2013 reported cholera cases were limited to Dadaab Refugee Camp and surrounding areas in northeastern Kenya.
7. There is a statistically significant negative correlation between the number of cholera cases and percentage of households with access to an improved water source, percentage of households with access to improved sanitation, percentage of population with at least some secondary education, and population density.

8. There is a statistically significant positive correlation between the number of cholera cases and percentage of households practicing open defecation and poverty headcount ratio.

Descriptive statistics

During the 10-year period under investigation, 2004-2013, the number of reported cholera cases nationally ranged from a low of 5 in 2013 to a high of 11,769 in 2009. Figure 4 shows the national-level trend in cholera incidence in Kenya for 2004-2013. A widespread series of outbreaks began in 2007, peaked in 2009, and began to subside in 2010. Parts of Kenya experienced outbreaks in other years, but at relatively low levels. Since 2011 cholera outbreaks have been limited to Dadaab Refugee Camp and surrounding areas in northeastern Kenya.

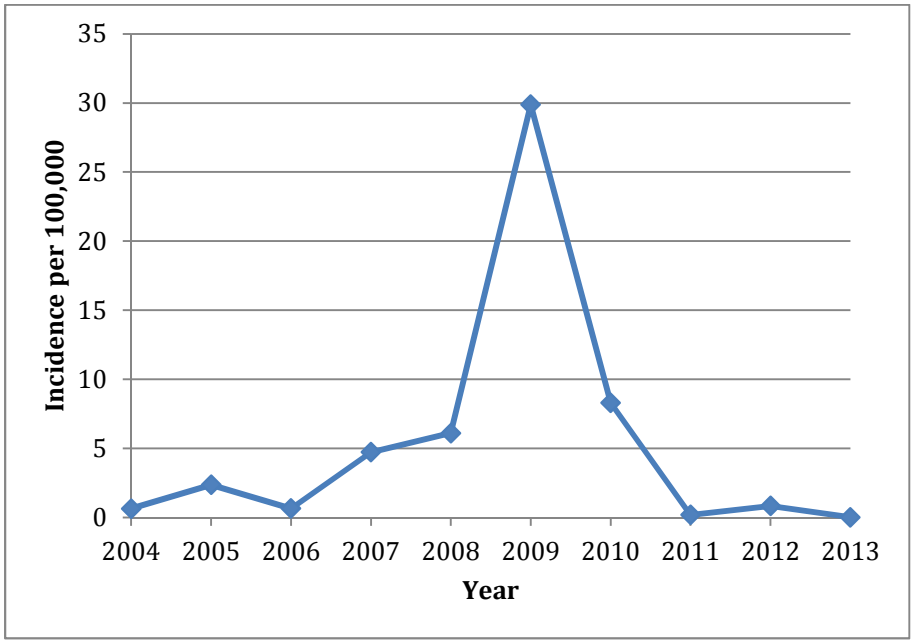


Figure 4. Cholera incidence in Kenya, 2004-2013

The case-fatality rate (CFR) ranged from 0% to 7.1%. During the same time period the average CFR among African countries ranged from 1.7% to 2.95%. The CFR of 0% in Kenya was recorded in 2013 when no deaths were reported among only 5 cases. The CFR of 7.1% was

recorded in 2012 when 339 cases were reported, mostly from Dadaab Refugee Camp. The CFR over the 10-year period is shown in Figure 5.

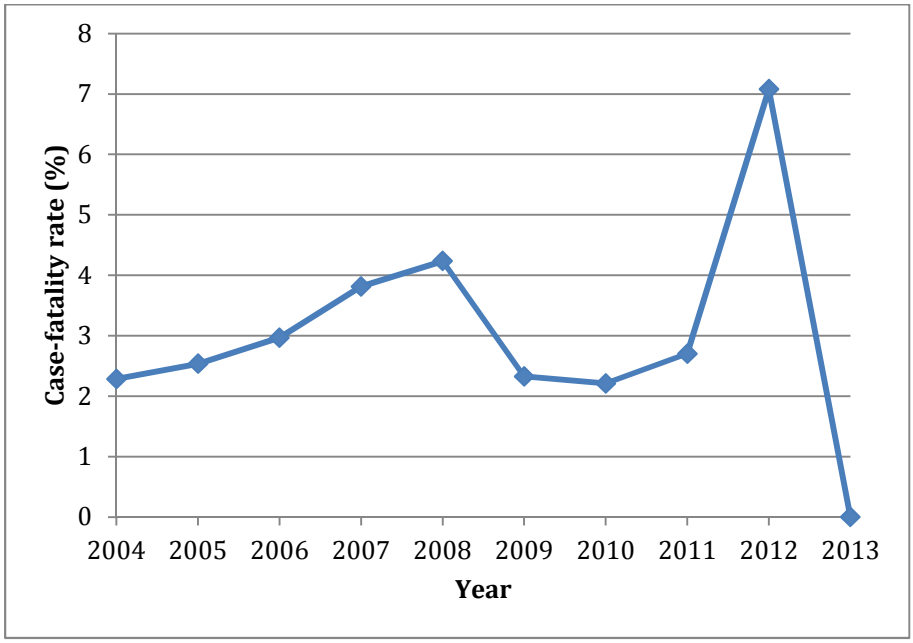


Figure 5. Cholera case-fatality rate in Kenya, 2004-2013

Geographic patterns of cholera occurrence

Several counties experienced a trend in cholera occurrence that was similar to the national trend. One example is Turkana, a predominantly rural county in northwestern Kenya. This county reported cholera in 5 of the 10 years under investigation and experienced particularly high cholera incidence in 2009. The trend in cholera incidence in Turkana County is shown in Figure 6.

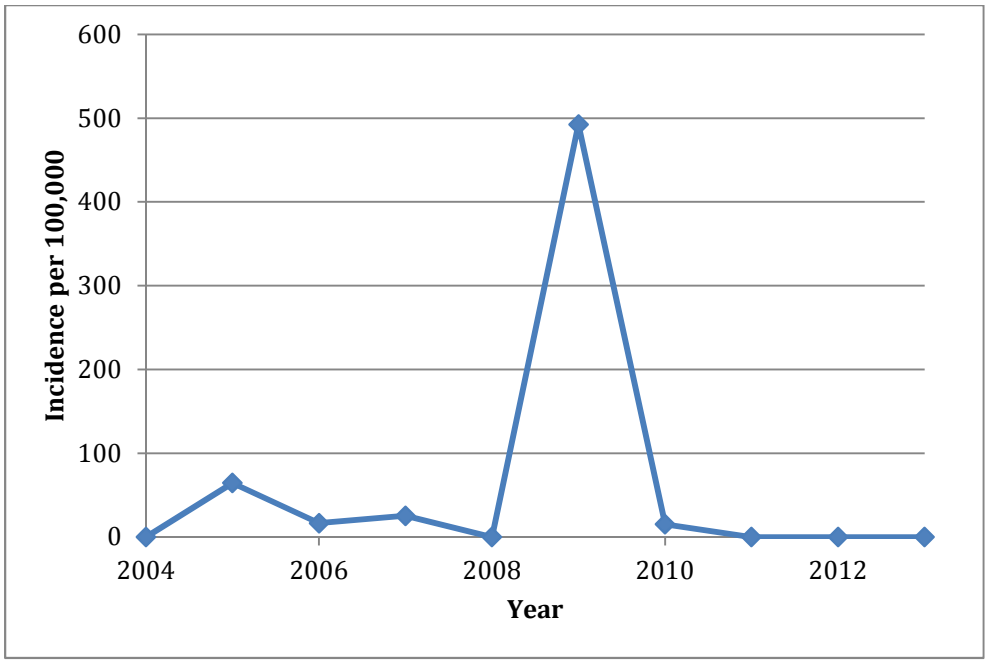


Figure 6. Cholera incidence in Turkana County, Kenya, 2004-2013

By contrast, Busia County in Western Kenya experienced a noticeably different trend in cholera occurrence. This area was hit by cholera in 2005, 2007, and 2008. The outbreaks were mostly controlled by 2009 as shown in Figure 7.

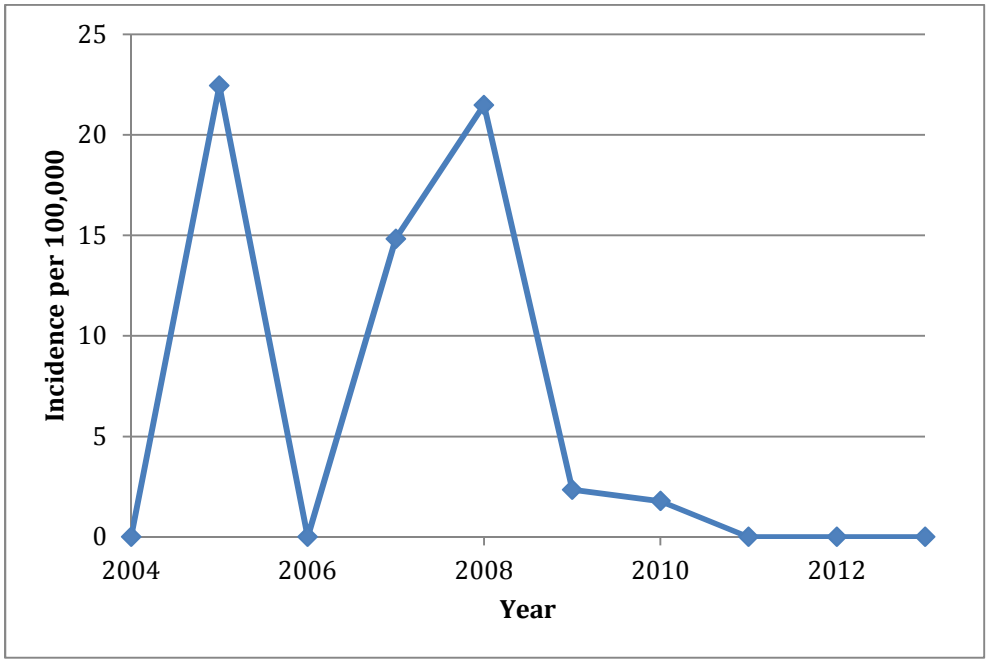


Figure 7. Cholera incidence in Busia County, Kenya, 2004-2013

The trend in cholera incidence in other counties that reported cholera in at least 4 years over the 10-year period 2004-2013 is presented in Appendix E.

The number of years each county reported cholera during the 10-year period ranged from 0 to 5 years. Twelve counties did not report any cases of cholera between 2004 and 2013. The map in Figure 8 shows these counties with no shading. The majority of counties that reported no cases are clustered in the central part of Kenya north of Nairobi. The four counties that reported cholera in 5 of the 10 years represent a variety of geographic landscapes and climatic zones. Turkana County is an arid region in northwestern Kenya that borders on South Sudan, Uganda, Ethiopia, and Lake Turkana, which is a large, saline Rift Valley lake. Turkana is also home to Kakuma Refugee Camp. Garissa County is an arid region in northeastern Kenya that borders on Somalia and is home to Dadaab Refugee Camp. Kwale County is on the Indian Ocean coast in eastern Kenya, borders Tanzania, and has a monsoon type climate. Busia County in western Kenya borders on Lake Victoria and Uganda and has a tropical, humid climate.

Cholera has affected both rural and urban areas in Kenya. Some of the least densely populated areas of Kenya, like Turkana and Marsabit counties in the north, have reported large outbreaks. Kenya's largest cities have also reported outbreaks. The capital city, Nairobi, in the south-central part of the country, reported cholera in 4 of the 10 years under investigation. Mombasa, which is located on the coast and is Kenya's second largest city, reported cholera cases in 3 of 10 years. The third largest city, Kisumu, which is on Lake Victoria in western Kenya, also reported cases in 3 of 10 years.

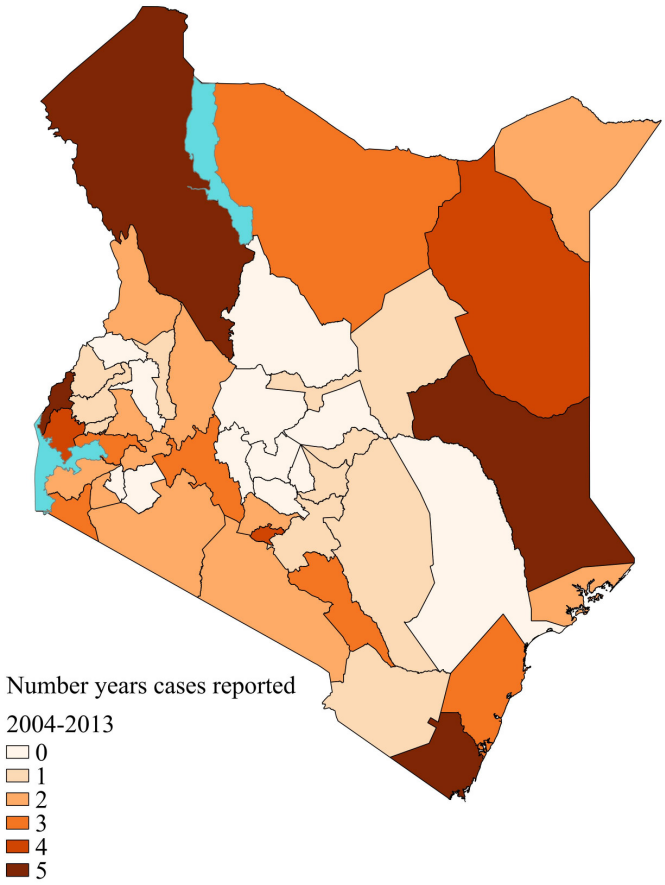


Figure 8. Number of years in which cholera cases were reported in Kenya by county, 2004-2013

Very few counties met the WHO definition of being endemic for cholera based on reported cases. Busia, Turkana, and Kwale counties moved from endemic status in 2004-2008 to non-endemic status in 2009-2013. Only one county, Garissa, moved from non-endemic status in 2004-2008 to endemic status in 2009-2013. All other counties were rated as non-endemic for cholera during both time periods. Caution should be exercised in interpreting these results. If a county reported no cases of cholera in a given year, that may indicate true absence of cholera, or there may have been cases that went undetected. Conversely, many counties reported cases that were not lab confirmed.

Cumulative cholera incidence was mapped over the time periods 2004-2008 and 2009-2013 as shown in Figure 9. Between 2004 and 2008 twenty-three counties reported cholera, and cumulative incidence ranged from 0 to 227 per 100,000. The counties reporting the highest incidence were located in northeastern Kenya (Mandera and Wajir), western Kenya bordering Lake Victoria (Kisumu), and northwestern Kenya (Turkana). The number of counties reporting cholera between 2009 and 2013 increased to 32 and cumulative incidence ranged from 0 to 737 per 100,000. The highest incidence counties were located in northern Kenya (Marsabit and Turkana), eastern Kenya (Isiolo, Kitui, and Tharaka), the coast (Lamu and Kwale), western Kenya (West Pokot), and northeastern Kenya (Garissa). Most of the high incidence counties, with the exception of Kisumu and Lamu, have high poverty headcount ratios (above 50%) and generally low indicators of development. A few counties that were heavily affected between 2009 and 2013, like Isiolo, Tharaka, Kitui, and Lamu in the eastern part of Kenya, had not reported any cases of cholera in the previous 5 years. Mandera County in the northeast, which had reported the highest cumulative incidence during 2004-2008, reported no cases of cholera in 2009-2013. The counties bordering Lake Victoria in western Kenya (Busia, Homa Bay, Kisumu, Migori, and Siaya) reported cholera cases during both time periods. Each of these counties except for Homa Bay reported lower cholera incidence in 2009-2013 compared to 2004-2008.

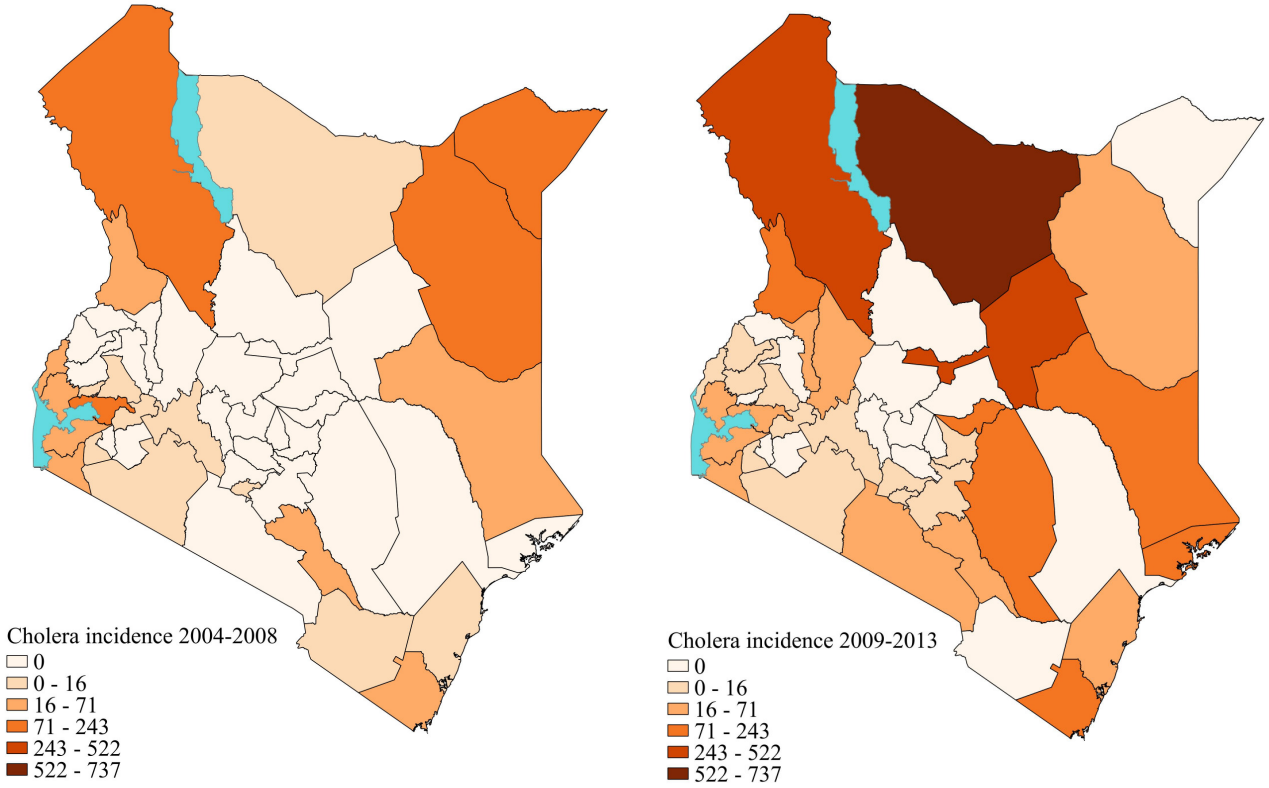


Figure 9. Geographic patterns of cholera occurrence in Kenya, 2004-2008 and 2009-2013

Relationship between cholera occurrence and development and demographic indicators

The relationship between cholera occurrence and development and demographic indicators was investigated by regression analysis over the time period 2008-2013. This time period represents three years of widespread outbreaks and three years of relatively low levels of cholera. A smaller geographic unit of analysis, the district, was used in the regression analysis. During this time a total of 17,882 cholera cases were recorded. Cumulative cholera incidence ranged from a low of 0 cases per 100,000 in 80 districts to a high of 884 cases per 100,000 in the combined districts of Marsabit, Chalbi, and Laisamis in northern Kenya. The range of values for the development and demographic indicators of interest is summarized in Table 3 for the 137 districts in the regression analysis.

Pearson's correlation coefficient and corresponding p-values were calculated to quantify the strength and statistical significance of linear correlation between each of the independent variables and cumulative cholera incidence. Pearson' correlation coefficient can range from -1 to 1, with -1 representing a perfect negative linear correlation between two variables, 0 representing no linear correlation, and +1 representing a perfect positive linear correlation. The results are shown in Table 3.

Table 3. Range of values, Pearson's correlation coefficient, and p-values of development and demographic indicators included in the regression analysis

Indicator	Range of values for 137 districts	Pearson's correlation coefficient	P-value
% of households with access to an improved water source	10.5 - 86.5%	-0.1408	0.10
% of households with access to improved sanitation	3.4 – 96.9%	-0.3289	<0.0001
% of households practicing open defecation	0.1 – 94.6%	0.3529	<0.0001
% of population with at least some secondary education	2.4 – 50.5%	-0.3021	0.0003
% of population living in urban areas	0.0 - 100.0%	-0.0030	0.97
Population density	3 – 4,515 people per square kilometer	-0.1468	0.087
Poverty headcount ratio	18.3 – 87.5%	0.3489	<0.0001
# of healthcare facilities per 100,000 people	6.0 - 76.5	0.0380	0.66

The results presented in Table 3 suggest the following relationships:

1. A weak but statistically significant ($p<0.0001$) positive correlation between cumulative cholera incidence and percentage of households practicing open defecation and poverty headcount ratio.

2. A weak but statistically significant ($p \leq 0.0003$) negative correlation between cumulative cholera incidence and percentage of households with access to improved sanitation and percentage of population with some secondary education.
3. A very weak negative correlation between cumulative cholera incidence and percentage of households with access to an improved water source and population density. This weak correlation is not statistically significant at the level of $p<0.05$.
4. No linear correlation between cumulative cholera incidence and percentage of population living in urban areas or number of healthcare facilities per 100,000 people.

Districts with a higher percentage of households practicing open defecation or a higher poverty headcount ratio tended to have a higher cumulative cholera incidence. Conversely, districts with lower access to improved sanitation and lower percentage of population with secondary education tended to have a higher cumulative cholera incidence. Scatterplots of cumulative cholera incidence versus each independent variable are presented in Appendix F. The scatterplots suggest that the relationship between cholera occurrence and the independent variables of interest may not be linear.

Further analysis of the data used a zero-inflated poisson regression model. This model assumes that the logarithm of the cumulative number of cholera cases for each district could be described by a linear combination of independent variables. An offset of the logarithm of 2009 population was included in the model to adjust for district population size. Univariate analysis was conducted to calculate the relative risk (RR) of cholera when each potential risk factor was analyzed independently. This was followed by multivariate analysis to calculate adjusted relative risk (ARR). Of the two sanitation indicators, percentage of population practicing open defecation was included in the multivariate analysis since the main sanitation program in Kenya,

Community Led Total Sanitation (CLTS), focuses on elimination of open defecation. The regression results are shown for both analyses in Table 4.

Table 4. Results of zero-inflated poisson regression, Kenya, 2008-2013, n=137 districts

Variable	RR (95% CI)	ARR (95% CI)
% of households with access to an improved water source	0.9768 (0.9761, 0.9775)	0.9842 (0.9831, 0.9853)
% of households with access to improved sanitation	0.9745 (0.9740, 0.9751)	
% of households practicing open defecation	1.0220 (1.0215, 1.0225)	1.0021 (1.0011, 1.0031)
% of population with at least some secondary education	0.9469 (0.9456, 0.9483)	0.9855 (0.9815, 0.9895)
% of population living in urban areas	0.9854 (0.9849, 0.9860)	1.0108 (1.0094, 1.0122)
Population density	0.9995 (0.9994, 0.9995)	0.9999 (0.9998, 0.9999)
Poverty headcount ratio	1.0330 (1.0323, 1.0338)	1.0354 (1.0336, 1.0373)
# of healthcare facilities per 100,000 people	1.0164 (1.0146, 1.0182)	1.0608 (1.0586, 1.0630)

The relative risks for each of the independent variables were statistically significant with p-values less than 0.001 in both the univariate and multivariate analyses. The results were similar to the analysis with Pearson's correlation coefficient but with greater statistical significance. This is logical if the relationship between cholera occurrence and the independent variables is better described by a poisson regression than a linear regression. The regression results suggest the following relationships:

1. A statistically significant negative correlation between the number of cholera cases and percentage of households with access to an improved water source, percentage of households with access to improved sanitation, percentage of population with at least some secondary education, and population density.
2. A statistically significant positive correlation between the number of cholera cases and percentage of households practicing open defecation and poverty headcount ratio.

The magnitude of the associations in the multivariate analysis can be described as follows:

- A 1% increase in the percentage of households with access to improved water is associated with a 1.6% decrease in cholera risk.
- A 1% increase in the percentage of population with at least some secondary education is associated with a 1.5% decrease in cholera risk.
- A 1% increase in the population density is associated with a 0.01% decrease in cholera risk.
- A 1% increase in the poverty headcount ratio is associated with a 3.5% increase in cholera risk.
- A 1% increase in the percentage of households practicing open defecation is associated with a 0.2% increase in cholera risk.

It must be noted that open defecation, poverty, and education are highly correlated with one another, with Pearson's correlation coefficients ranging from 0.69 to 0.77. The correlation among these variables may contribute to the decrease in the magnitude of effect seen for open defecation and education in the multivariate analysis. The correlation may describe a relationship between proximal and distal factors affecting cholera occurrence. It is likely that open defecation is a proximal factor contributing to cholera occurrence, which is influenced by a more distal factor, poverty. Secondary education may influence cholera occurrence by reducing the likelihood of open defecation or by promoting other hygiene or health-seeking behaviors.

The univariate analysis indicated that an increase in percentage of population living in urban areas was associated with a decreased risk of cholera. This relationship reversed in the multivariate analysis. A similar effect was seen by linear regression. The results are inconclusive and may suggest confounding. The results for the healthcare facilities variable

suggest that there is an increased risk of cholera in districts with a larger number of healthcare facilities per 100,000 people. There is unlikely to be a direct causal relationship, and this may be a coincidental association or might suggest that districts with a larger number of healthcare facilities are more likely to detect and report cholera cases.

Percentage of population living in urban areas was used as the predictor variable for zero inflation in the model. This variable showed the highest degree of statistical significance ($p=0.038$) for predicting zero inflation and showed a negative relationship with excess zeros. It is plausible that an increase in percentage of population living in urban areas is associated with decreased likelihood that the district did not detect or report actual cholera cases. It tends to be easier for health facilities in urban areas to recruit and retain staff, and it is reasonable to believe that a well-staffed health facility is more likely to submit weekly and monthly surveillance reports.

It was anticipated that some of the independent variables, like number of healthcare facilities, poverty headcount ratio, and percentage of population with secondary education, might have an influence on cholera case-fatality rate. Districts that reported at least 10 cases between 2008 and 2013 were included in the analysis. Eighty districts were excluded because they reported no cholera cases during this time. An additional seven districts reporting 1-10 cumulative cases were excluded because of the limited number of observations from which to calculate a representative CFR.

There was no statistically significant correlation ($p<0.05$), between case-fatality rate and the independent variables included in this analysis. The Pearson's correlation coefficient and corresponding p-values for each of the independent variables is provided in Table 5.

Table 5. Correlation of cholera case-fatality rate with selected development and demographic indicators, Kenya, 2008-2013, n=50 districts

Indicator	Pearson's correlation coefficient	P-value
% of households with access to an improved water source	0.0197	0.89
% of households with access to improved sanitation	0.1874	0.19
% of households practicing open defecation	-0.1850	0.20
% of population with at least some secondary education	0.0661	0.65
% of population living in urban areas	-0.0522	0.72
Population density	0.0443	0.76
Poverty headcount ratio	-0.1753	0.22
# of healthcare facilities per 100,000 people	-0.1820	0.21

These results were also reflected in the scatter plots, which showed a high degree of scatter in the data with no clear trends. The scatter plots for poverty headcount ratio and number of healthcare facilities are shown in Figure 10.

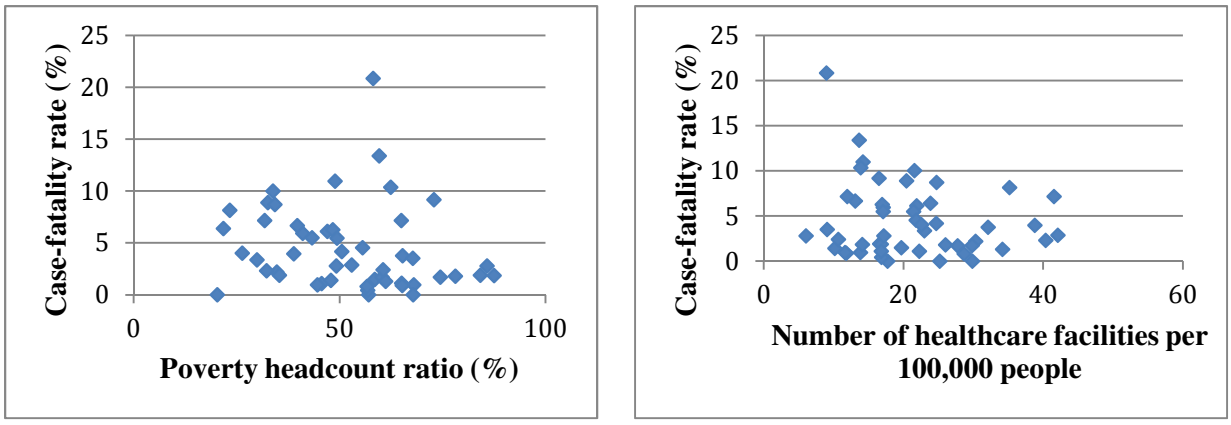


Figure 10. Cholera case-fatality rate in Kenya by poverty headcount ratio and by number of healthcare facilities, 2008-2013, n=50 districts

Key informant interviews

The aim of the interviews was to qualitatively describe the perceived successes and challenges of cholera prevention and control in Kenya as identified by key informants from the Kenyan government and other organizations supporting cholera activities in Kenya. Participants were asked for their views on which interventions, policies, and strategies have been effective in preventing and controlling cholera in Kenya, and they were asked to identify weaknesses in past or current approaches and to provide suggestions for improvement. Participants were also asked for their views on the oral cholera vaccine, availability of data for decision-making, mechanisms of communication and coordination, Kenya's Multi-sectoral Cholera Prevention and Control Plan, and the implications of devolution. The information shared by participants does more than simply contribute to answering the overarching research question of this study, "*What are the successes and challenges of cholera prevention and control in Kenya?"* The participants' responses tell the story of how Kenya has responded to the threat that cholera poses to public health. This chapter presents that story in the words of those who know it best along with their recommendations for addressing cholera moving forward.

Descriptive analysis

Key informants were selected for their experience and expert knowledge of cholera prevention and control activities in Kenya. Participants were drawn from key organizations involved in cholera activities in Kenya. Table 6 summarizes the distribution of participants by type of organization.

Table 6. Participant profile by type of organization for key informant interviews

Type of organization	Number of participants
Government health sector (national level)	4
Government health sector (sub-national level)	2
International multilateral or bilateral organization	3
Humanitarian non-governmental organization (NGO)	2

It must be noted that participants representing the government health sector at national level also had prior experience in their careers at sub-national (provincial or district) level. All participants had several years of experience with cholera prevention and control activities. Four participants reported having been involved with such activities for 15 years or more. Participants included implementers, policy makers, and senior level decision makers. The group of participants represented a range of technical expertise including water, sanitation and hygiene (WASH), clinical case management, and epidemiology and surveillance. Participants are experienced professionals in the field of disease prevention and control and they consented to having their names listed in this report to establish credibility of this study. A complete list of participants with their titles and affiliations is provided in Appendix G.

Key findings

A number of recurrent themes emerged from the key informant interviews. A summary of key findings is provided in Table 7. The findings represent the views and opinions expressed by those interviewed. The order of key findings is based on the organization of topics in the interview guide.

Table 7. Key findings from key informant interviews

Finding #	Theme	Description of finding
1	Water	Provision of clean water is an effective intervention that has contributed to cholera prevention and control in Kenya.
2	Sanitation	Community Led Total Sanitation (CLTS) is an effective intervention that has contributed to cholera prevention and control in Kenya. Data are available on open defecation free (ODF) status for all counties. Community involvement is essential for successful interventions.
3	Behavior change	Children are ambassadors of behavior change.
4	Surveillance	The Integrated Disease Surveillance and Response (IDSR) strategy, which includes cholera as a priority disease, is a key contributor to effective cholera prevention and control in Kenya.
5	Laboratory capacity	Laboratory capacity to distinguish cholera from other diarrheal diseases is weak. Availability of laboratory confirmation data for cholera is a challenge.
6	Case management	Effective case management is critical for cholera control. Managing cases at the source of the outbreak has been effective, but availability of medical supplies is a challenge.
7	Vaccine	The oral cholera vaccine has been discussed but has not been used in Kenya. The vaccine may give a false sense of security and traditional preventive measures are preferred, but the vaccine may be useful in certain settings like refugee camps, urban slums, or other high burden areas.
8	Data	Routine cholera surveillance data from IDSR is available and used by decision makers.
9	Communication	Regular communication between stakeholders could be improved during times of no outbreak and would enhance preparedness. There is need for a communication strategy for health emergencies.
10	Multi-sectoral cholera plan	Implementation of Kenya's Multi-sectoral Cholera Prevention and Control Plan is not well monitored, and the achievements are not well known. A multi-sectoral approach is the right way to go for preventing cholera.
11	Devolution	Devolution presents both opportunities and challenges for cholera control, but the outlook from experts is optimistic. A key advantage of devolution is that counties have the opportunity to set their own priorities and develop customized plans to meet their needs.

The findings of the interviews are also grouped and summarized by perceived successes, challenges, and recommendations in Table 8.

Table 8. Summary of perceived successes, challenges, and recommendations for improving cholera prevention and control

Successes	Challenges	Recommendations
• Provision of clean water • Community Led Total Sanitation (CLTS) • Water, sanitation, and hygiene (WASH) programs in schools • Integrated Disease Surveillance and Response (IDSR) strategy • Availability of cholera surveillance data	• Lack of access to clean water in some communities • Lack of access to sanitation facilities in some communities • CLTS may not guarantee hygienic sanitation facilities • Laboratory capacity for cholera confirmation • Availability of medical supplies • Completeness of cholera surveillance data • Lack of a communication strategy for health emergencies • Monitoring and funding of cholera plan • Lack of water quality monitoring of wells • Staff turn-over in government health facilities	• Continue to expand access to clean water considering both quality and quantity • Continue to expand access to sanitation facilities • Strengthen laboratory capacity for cholera diagnosis • Implement laboratory-based surveillance • Strengthen disease surveillance systems • Develop a communication strategy for health emergencies • Maintain more regular communication among stakeholders even when there are no outbreaks • Map activities of stakeholders who can contribute to cholera prevention and response • Update cholera plan to incorporate county structure • Allocate resources to implement and monitor cholera plan; revise plan to a more feasible budget • Employ a multi-sectoral approach to controlling cholera • Employ a differential approach to controlling cholera in the country based on local needs • Invest in water and sanitation infrastructure • Improve water quality monitoring • Involve traditional healers in cholera activities • Appoint cholera focal persons at national and sub-national level • Provide simple job aids to healthcare facilities • Implement after-action reviews

Key findings are discussed in detail in the following sections in the order that they are presented in Table 7.

1. Provision of clean water is an effective intervention that has contributed to cholera prevention and control in Kenya

Most participants talked about the provision of clean water as a key intervention for preventing cholera. In fact a few participants emphasized clean water as the most effective intervention. One NGO representative commented, "The most effective [intervention] by far, I would say, is provision of safe water." No specific program, policy or strategy for provision of clean water came to the forefront in discussions, but a number of different means of providing clean water were described by participants including provision of piped, chlorinated water, household water treatment, construction of boreholes, and provision of clean water in emergency settings via tanker trucks or mobile water treatment plants. When asked which policies or strategies have contributed to successful cholera prevention and control in Kenya, one government official responded:

> One was the issue of provision of clean water. I think there have been quite a lot of efforts to provide clean water to the population in Nyanza. Then for those who were not able, there is the issue of chlorination of water at household level.

Various methods of household water treatment have been promoted in Kenya including Aquatabs (chlorine tablets), WaterGuard (a liquid chlorine solution), boiling of water, and ceramic water filters. One international organization representative highlighted ceramic water filters that are being locally produced by the private sector at two locations in Kenya:

> It's a bucket with a ceramic bowl, and it's treated with silver, a microbiological agent … So Potters for Peace came along, showed them how to set up to produce these filters. It's very efficient, very well managed, very well done … So setting those factories up in more outlying places, that to me is a win-win. You build up the private sector. You build up the businesses that provide those water filters.

A common component of the emergency response to a natural disaster or cholera outbreak is mobilization of temporary sources of clean water. An NGO representative described the effectiveness of mobile water treatment plants in responding to emergencies:

> Anytime we have flooding or crowding of large populations for whatever reason, whether it's because of displacement by violence or by natural disasters, the one thing that we do now, almost always, is to avail a water purification plant that has the capacity to purify 5000 L per hour … They're mobile units. We just place it in the back of the pickup, or in the back of a Land Cruiser, and you haul it. When we introduced this we found the last few years, the last two disasters, for example the flooding in Tana River, we did not have even an outbreak of diarrheal diseases because people drank potable water.

This participant recounted occasional challenges in getting the mobile units back because of continuing need beyond the emergency response. This highlights the need for longer-term solutions to the provision of clean water in some areas. A government official described the effectiveness of a new borehole that was constructed in northern Kenya in 2009 when cholera outbreaks were sweeping across the country:

> Now there's one particular place where, as the cases were being reported, there was already an investment to drill a borehole. Work was ongoing, and they were almost just concluding it … And in that particular region where that water was made available, apart from the initial cases, there was no more cholera.

Some participants spoke about water quantity issues. Scarcity of water was identified as a risk factor for cholera outbreaks. Some participants reflected on the fact that some of the communities hardest hit by cholera in 2008 and 2009 were affected by dry spells or drought at the time. One government official spoke of outbreaks occurring during dry periods in the early months of 2008 and 2009:

> We were very confident that the main contributor was the dry spell we had. December and January are very dry spells. So there is water scarcity. So lack of water is to me a major contributory factor that I could relate.

Some participants spoke of the relationship between availability of water and the ability of individuals and communities to maintain sanitation and hygiene standards:

> When there's scarcity of water, and especially in large urban areas, the level of sanitation goes down. (Government official)

> From my perspective [there has been] a good correlation between water availability and decrease in cholera and other diarrheal diseases, for the simple reason that people are

> likely to wash their hands if they have enough water. If it's not there, they will keep it for something else. It will only be for drinking. If people have to travel something like 3 hours with a donkey to get two 20L cans of water, in these areas we find, in terms of personal hygiene, significant decrease in the usage of water for that. (NGO representative)

Both water quality and quantity came out as important considerations for cholera prevention and control.

2. Community Led Total Sanitation (CLTS) is an effective intervention that has contributed to cholera prevention and control in Kenya. Data are available on open defecation free (ODF) status for all counties. Community involvement is essential for successful interventions.

Most participants discussed the importance of sanitation in the context of effective interventions, policies and strategies for cholera prevention and control. Participants repeatedly highlighted one program in particular, Community Led Total Sanitation, as an effective intervention. This program focuses on behavior change and community involvement to eliminate open defecation. CLTS has been formally adopted by the Ministry of Health as its strategy for achieving open defecation free status in Kenya's rural areas. In 2011 the MOH launched the Open Defecation Free Rural Kenya Campaign, with CLTS as an integral part of the campaign. In addition to raising awareness about the risks of open defecation, the CLTS approach also promotes hygiene practices, like hand washing, which are integral to reducing the risk of diarrheal disease. The MOH Division of Environmental Health, which oversees this program, houses the CLTS Support, Coordination, and Knowledge Management Unit (The Hub). The MOH issued a national protocol for CLTS in January 2014 that outlines common standards to guide the implementation of CLTS by county governments and partners. The program is supported by a number of partners including UNICEF, SNV, WSP, Plan-Kenya, FHI 360, World Vision, AMREF, and the Kenya Red Cross. Participants had the following to say about CLTS:

> As part of our regular program here we've been doing a lot of CLTS … I'm a very big convert to CLTS. I think it's a fantastic approach to raise that awareness about open

> defecation and all the risks involved in that. I think it's been very effective. (International organization representative)
>
> We are involved in CLTS … So we are designing a five county project where we will scale this up significantly, because right now this is a government policy. (NGO representative)
>
> So then we introduced an intervention called community based total sanitation … It's a concept that we introduced so that the communities own the process … The idea here was to bring shame to the people who were actually defecating openly … We started now celebrating villages that have been declared open defecation free, ODF … They have to maintain it because there will be a follow up after every 6 months … Now we suddenly reduced the diarrheal incidence. (Government official)
>
> We took the approach of Community Led Total Sanitation … The outcome is that we allow people to do things … using their own knowledge and using their own resources. We have scaled up the latrine coverage in some of those places. We have scaled up the information uptake in those places. (Government official)

A government official reflected on the Nyanza region around Lake Victoria when asked which strategies have contributed to cholera prevention and control:

> If you look at Nyanza now, the cases [of cholera] have come down. Nyanza used to be the epicenter of cholera in Kenya … So I think some of the strategies which have been put in place, especially the issue of sanitation. I used to go to Nyanza … there are so many places which have been declared ODF, open defecation free areas. That was one of the key deliberate strategies to bring down the cholera outbreaks.

Another government official pointed out:

> The latrine coverage has markedly gone up in communities and counties that were previously practicing open defecation. In fact many villages in outbreak prone districts have now been certified as open defecation free and most villagers are now using latrines.

Some challenges were identified with respect to sanitation. One participant pointed out that CLTS may result in ODF villages, but this does not necessarily mean the sanitation facilities meet the Joint Monitoring Program's definition of "improved sanitation", which requires hygienic separation of human waste from human, animal, and insect contact. CLTS may place people on the first step of the sanitation ladder, but further work is needed to ensure hygienic facilities and to sustain the achievements. It was also recognized that the campaign launched in

2011 to declare Kenya open defecation free by 2013 was "ambitious" and had not been achieved. A few participants spoke of failures in earlier sanitation programs prior to the adoption of the CLTS approach. Earlier programs were less successful in engaging the community:

> For many years we used to make the mistake where we would tell people to build the toilets, and then they would build them, but they would not utilize them … If there is no clear path leading to the toilet, where you can see people have been walking along to the toilet, then it means the toilet may have been put there just for health workers, just because the health worker said so, but not because the people wanted it. (Government official)

> There was a case scenario where people dug the pit latrines because they were given the slabs, but nobody used it. They said, 'this is for the public health officer, don't use it' … Why? Because they were not told what it is for, what are the benefits. (NGO representative)

The Hub handles monitoring and evaluation of the CLTS program at national level and maintains an electronic platform for counties to report progress and exchange information. The MOH recently completed micro-planning for CLTS and produced a document entitled *Realizing Open Defecation Free (ODF) Rural Kenya: Achievements and the Road Ahead*, which provides detailed data on ODF status for each county and projections of what is needed to achieve ODF. [82] The Hub also produces a quarterly newsletter that highlights CLTS and other environmental health and sanitation activities and achievements. The newsletter, *Shared Sanitation, Hygiene, Information & Tales (SSHIT)*, is available on-line.

The discussion of sanitation brings up the issue of community involvement, which was mentioned by several participants as being critical for implementation of successful interventions. The importance of community involvement was primarily discussed in the context of sanitation, hygiene, and behavior change. One government official remarked:

> So involving the community, mobilizing them, making them understand that actually there is a problem. This we did with the local district administration and provincial administration, and the community awareness actually really helped.

Barazas, or community meetings, were identified as a common forum for engaging the community in cholera activities:

> These were community problems. Through the provincial administration and other partners, we had to organize meetings, the barazas, where now the provincial administration, the chief, and the technical officers would sit down. The chief would call the community in an open place, a gathering. They would be taken through the education on cholera prevention and would identify champions for cholera control for each location and for each village. For each village we had a cholera champion for that purpose. (Government official)

A few participants also spoke of involvement of community health workers in cholera activities. Community health workers provide the first level of service at community and household level in Kenya and have a key role in health promotion and disease prevention. Kenya's community strategy provides for one community health worker for every 20 households. One key informant reported supporting training of public health officers and water officers in cholera prone districts on cholera preparedness and response. This training is cascaded down to community health workers. One government official commented on a key role for community health workers in cholera surveillance since they are on the front lines in the community. This is discussed more under the key finding related to surveillance.

3. Children are ambassadors of behavior change.

Another common theme that emerged from the interviews was that of children as agents of change, particularly with respect to hygiene promotion. Several participants described water, sanitation, and hygiene (WASH) programs targeting the schools. It is anticipated that the impact of these programs extends beyond the school children themselves as they act as ambassadors of behavior change in their homes:

> There is a very big focus on WASH in schools, hygiene promotion, latrines. And I think that has a big impact in terms of using the children as change agents. (International organization representative)

> We have focused ourselves on school going children because we think they make very good ambassadors to the parents … In all our programming we make sure that hygiene and sanitation is integrated. (NGO representative)
>
> So we introduced the hand washing facilities from schools. Because we realize that children can be very powerful agents of change. The moment we introduce these interventions, the children will go and do it at home level. They will pass the same message to their parents, to their guardians. And this is an intervention that will be replicated at household level. (Government official)

One participant recalled his own experiences in primary school in the 1970s:

> By the way I can also go back to 1970 when I was in primary school. I think that's the first time we heard of a cholera outbreak in Nairobi. I remember it was such a big issue. And in primary schools we had to be trained about hygiene, cleaning our hands before eating and everything. It was like if you don't do this you're going to die of cholera. And it was such a big scare. I can almost think it was like the way people now fear Ebola.

4. The Integrated Disease Surveillance and Response (IDSR) strategy, which includes cholera as a priority disease, is a key contributor to effective cholera prevention and control in Kenya.

Many participants spoke of achievements related to surveillance for cholera. Cholera has been a notifiable infectious disease under the Public Health Act since 1948. In 1998 Kenya adopted the Integrated Disease Surveillance and Response (IDSR) strategy and began implementation of this strategy in 2002. Kenya's IDSR technical guidelines were updated in 2012, in part to incorporate changes related to the International Health Regulations 2005. Cholera is listed in the IDSR technical guidelines as a priority epidemic prone disease. The guidelines require immediate case-based reporting of cholera within 24 hours. Health facilities are also required to complete weekly summary reporting forms that include cholera. The IDSR guidelines include a standard case definition for cholera and a standard line list form. The Disease Surveillance and Response Unit (DSRU, formerly called DDSR) within the Ministry of Health oversees implementation of IDSR. DSRU produces a weekly epidemiological bulletin that summarizes IDSR reporting and tabulates reported cases of priority diseases by district. This bulletin is distributed on a weekly basis and is available on the unit's website. When asked

what policies or strategies have contributed to effective prevention and control of cholera, one participant stated:

> Now in terms of strategy, I think the Integrated Disease Surveillance Strategy, IDSR, which DDSR [Division of Disease Surveillance and Response] implements is to me the most critical strategy because now you are having people with the capacity to be able to identify the disease in terms of having a system that can use diagnosis, can get access to laboratories, therefore identify a laboratory diagnosis. (Government official)

Several participants spoke of successful aspects of cholera surveillance under IDSR and also the need to strengthen and maintain surveillance systems:

> For cholera the starting point is ensuring you have a robust surveillance system for early case detection. (International organization representative)

> Surveillance, especially at the border areas and refugee camps, has markedly improved and any suspected case is reported immediately. (Government official)

> Surveillance I think is very key. If we are on top of surveillance then we are able to ensure that cases of diarrhea are picked and we can get it as soon as possible. If you don't have a strong surveillance system, then it can be a problem. And this … it can work very well, especially through the community strategy where you are working through the community health workers. (Government official)

> I know that there's already a good surveillance system in place. I know that we see the figures coming for malaria, diarrhea, all those different diseases. (International organization representative)

Several participants cited the designation of cholera as a notifiable or priority disease to be a key policy contributing to effective cholera prevention and control:

> Kenya has recognized that cholera is a priority disease. And those priority diseases … are included in the national guidelines. So for Kenya, among the epidemic prone diseases, cholera is there, among the top. It has been included in reporting tools, which the country gathers data on weekly basis to know what is happening in the whole country. The standard case definition has been circulated all over. (International organization representative)

> And again, cholera being a notifiable disease of public health concern, that again made us to be able to move very well. (Government official)

The data generated by the surveillance system featured prominently in responses to questions about data availability. This will be discussed in more detail under the key finding about availability of data for decision-making.

5. Laboratory capacity to distinguish cholera from other diarrheal diseases is weak. Availability of laboratory confirmation data for cholera is a challenge.

Laboratory capacity for the diagnosis of cholera is one challenge that a number of participants identified while talking about interventions, policies, strategies, and availability of data. In reflecting on lessons learned from past cholera outbreaks, one government official remarked:

> We need to strengthen our laboratories. In fact one of the lessons learned was that our laboratories are very weak to be able to diagnose cholera and to be able to provide the relevant information. Our labs are just there for malaria and others. But when it comes to things like cholera, it is a challenge.

A few participants commented on the lack of laboratory data when asked what data is lacking for informed decision-making:

> Laboratory-backed data I think is what is lacking. Because sometimes the issue of just reporting a case of diarrhea, and maybe it has not been investigated, you can easily be able to miss the cause of that diarrhea. So we need as much as possible to start now moving towards laboratory data, what is causing that diarrhea? If we are able to diagnose accurately each and every case that is happening, then it moves away from clinical-based diagnosis to laboratory confirmed cases. I think that is what is really lacking. So the strengthening of laboratories, in terms of ensuring that they have the capacity to do that, I think that would be very key. (Government official)

> Now, what we lacked first and foremost was high-level diagnostic interpretation of the cholera outbreak. What strains of cholera were we dealing with? … I would also say we lacked good laboratory diagnosis to differentiate anything else. Because during the same time, the other diarrheal diseases occur. And I remember during that time also there were deaths in Nakuru, and everybody treated it as cholera, but when we finally got the diagnosis I think it was shigella or typhi. So do we have that diagnostic capacity to be able to really pick cholera and also differentiate from any other potential causes of diarrhea? (Government official)

Two participants recommended improving cholera surveillance by implementing laboratory-based surveillance. A representative from an international organization suggested:

> Data that needs to be put in place is to ensure that you have laboratory-based surveillance, because the surveillance that is going on is syndromic. Ensure that in those areas you have sentinel sites, whereby you are doing the testing to see whether there is any circulating cholera.

One government official emphasized the importance of a diagnostic surveillance system in his closing remarks at the end of the interview:

> Do we have a strong diagnostic surveillance system for cholera? That to me is something I think we need. I strongly think if we have a surveillance system, maybe looking at 1,000 population, and even if you pick one [case of cholera] then you know you are in trouble.

Another participant pointed out that there currently are some population-based studies that gather information on a variety of health indicators, such as the Health and Demographic Surveillance System in Western Kenya. Some of these studies have a laboratory component, and some do not. Cholera is not currently among the diseases identified for laboratory-based surveillance in Kenya's IDSR Technical Guidelines.

6. Effective case management is critical for cholera control. Managing cases at the source of the outbreak has been effective, but availability of medical supplies is a challenge.

A few participants spoke of the critical role of case management in controlling cholera outbreaks. Examples were given of both effective case management and important challenges affecting the clinical management of patients with cholera. One government official described mobilizing a rapid local response in 2009, turning two local outpatient dispensaries at the epicenter of the outbreak into inpatient facilities offering 24-hour care:

> My initial decision was, and this is what I told the team, the difference between us controlling the problem and the people suffering so much would depend on our initial response rather than relying on any other extra response … because usually that comes too late … One thing that we did was to establish the temporary inpatient facilities at the epicenter of the cholera [outbreak]. I think that was a very important intervention to

> avoid patients now being transferred all the way, now 60 km, to the district hospital … So that's what we did to get it at, the treatment and the management at the nearest facility.

This discussion brought up a challenge with mobilizing resources from the national level government health sector. Challenges were experienced both in terms of the time it took for national-level resources to be mobilized and the availability of appropriate supplies:

> The supplies from KEMSA [Kenya Medical Supplies Authority] came in after almost more than 2 weeks from the initial outbreak. We were a bit disappointed because when the supplies came in, they didn't have Hartmann's solution [IV fluids], one of the solutions that we seriously needed in dealing with the cases. They didn't even have the antibiotics. They didn't even have the gloves … And yet whatever we had requested, what we really seriously needed, they didn't send.

Another participant described challenges in being able to get funding to maintain national stocks of appropriate supplies for responding to cholera outbreaks:

> I would buy it, it would be used, and then I would have a problem again to get it repositioned. The big problem was getting funding for replenishing the supplies. Because when there is an outbreak everybody is happy to give … When the outbreak is over, funding goes down, so I wouldn't have more supplies until the next outbreak occurs. So it's a question of replenishing the supplies. That was a big problem for all of us.

Despite the challenges, life-saving supplies were made available through the efforts of both the governmental and non-governmental sectors. Several participants described critical supplies being made available by NGOs working in partnership with government health facilities. The participant who described the challenges in getting supplies from KEMSA also stated, "We got some assistance from Medecins Sans Frontieres. They gave us quite some supplies, IV fluids and whatever."

7. The oral cholera vaccine has been discussed but has not been used in Kenya. The vaccine may give a false sense of security and traditional preventive measures are preferred, but the vaccine may be useful in certain settings like refugee camps, urban slums, or other high burden areas.

Participants were asked about their familiarity with the oral cholera vaccine (OCV), the WHO stockpile of this vaccine for countries with endemic and epidemic cholera, whether the

vaccine has been considered for use in Kenya, and their views on potential barriers to vaccine implementation.

All of the participants were familiar with OCVs, and most were aware of the current generation of vaccines that confer immunity for approximately two years. One participant had supervised cholera vaccination in South Sudan and another had voluntarily participated in clinical trials several years ago. About half of the participants were aware of the WHO stockpile of OCVs. Those interviewed generally did not see major barriers to implementation of the vaccine, although a few participants mentioned that cost, availability, and education of the public would need to be taken into consideration.

Oral cholera vaccines have not been used in Kenya, and many of the participants were not aware of the Government of Kenya's position on the use of OCVs. Those who were positioned to be aware of discussions on this matter reported that the issue has been discussed, but no decision has been made to recommend use of the vaccine. One participant noted that no strong recommendation for use has come from WHO. Several participants expressed a concern that the vaccine gives a "false sense of security" in the sense that vaccine efficacy is not 100% and vaccinated individuals may think they are protected from a range of waterborne diseases, which is not the case:

> The issue is it gives you a false sense of security against other diarrheal diseases. You may not get cholera, but it doesn't protect you against bacillary dysentery or the other organisms which cause diarrhea … I think the problem is you may stop the other measures, which are safe water and sanitation. That has to go hand in hand together. (Government official)

> No, Kenya has not used the vaccine … This vaccine does not substitute the public health measures. The primary thing is to ensure that public health measures are in place. Actually, WHO states that cholera vaccine is an additional public health tool to fight cholera outbreaks. And it is most suitable in certain circumstances. If you had an outbreak among displaced populations, either because of civil war or other things, then in such a scenario you can easily deploy the vaccine. In refugee camps if you have massive

> outbreaks, it would be easy to fight using the cholera vaccine. But on routine basis it's not sustainable because one, you need two doses, then the protection period, it doesn't protect for long. And then sometimes it brings some false, how do I call it, some false impression that once I get the cholera vaccine I'm OK. But you know again, the vaccine does not protect [all], the efficacy is not 100%. (International organization representative)
>
> The importance in terms of protecting an individual isn't assured. You can have the vaccine now and if your behavior is risky, then there is nothing … In this country we have not ever relied on use of a cholera vaccine … I don't think I would recommend that. I recommend more work on behavior change, because you are giving people false protection [with the vaccine]. (Government official)

As is evident in the responses above, several participants stressed the primary importance of promoting other preventive measures like provision of clean water and basic sanitation, and several participants expressed a preference for focusing on removing the routes of transmission rather than expending resources on a vaccine. Kenya is home to large refugee camps at Kakuma and Dadaab, and some participants felt that OCVs may be particularly useful in specific settings like the refugee camps, urban slums, or geographic locations with a high burden of cholera.

8. Routine cholera surveillance data from IDSR is available and used by decision makers.

Participants were asked a couple questions about the availability of data for decision-making. The first topic area of the interview was about interventions, and participants were asked what information is available for evaluating the effectiveness of interventions. Later in the interview participants were asked what data are available to decision makers to enable informed decisions on cholera prevention and control strategies. The most common response to both of these questions was that routine surveillance data on cholera morbidity and mortality are available and used on a regular basis. These data are collected and reported by health facilities under the IDSR strategy and compiled at national level by the Disease Surveillance and Response Unit. This includes line lists as well as summary numbers of cases and deaths that are

reported on a weekly and monthly basis using standard forms. Government officials reported using these data to make decisions:

> We have weekly reports on cholera. It's a weekly reporting form that usually comes from facilities. At the provincial level we used to meet every week, we used to meet every Monday. We would review the data that has come from the districts.
>
> We started this surveillance and response database. So when the diarrheas would peak you'd say, "now let's watch out, this is the time when cholera outbreak is eminent" … And we have been monitoring trends over the last 10 years. Every 2 or 3 years we get a peak with an outbreak of cholera.
>
> The data that we found readily available was the number of new cases, number of suspected deaths arising from cholera, and the geographical area. Those are the ones we mainly used to make decisions.

As mentioned previously, the Disease Surveillance and Response Unit produces a weekly epidemiological bulletin that is readily available and includes reported numbers of cholera cases and deaths by district. A number of participants mentioned some challenges with the completeness of the data collected through IDSR.

Participants described preparation of outbreak reports, and a few talked about the importance of learning from outbreak responses. One participant from the NGO sector specifically described an after action review process that took place in his organization:

> There is a report that is done, and we sit in a meeting. We share the report and say, "this is perfect, this is where you went wrong, and this is how you could improve next time." We would do that as my organization … We compare and contrast and say, "Ok fine, this was successful because of 1, 2, 3; this was not successful because of 1, 2, 3 … Next time this is where I need to improve. These are my recommendations."

Another NGO representative pointed out that organizations and individuals do not always take the time to review their actions, but that much can be learned from past mistakes:

> The culture for learning from mistakes is an important one. And the culture for appreciative inquiry, once things have happened, going back to look at, this is the data, this is what happened.

Other data sources were mentioned with lesser frequency. As mentioned earlier, the CLTS Hub maintains data on ODF status in all counties. One government official spoke of using meteorological data for planning purposes, especially for anticipating drought or floods. Another participant mentioned the need for data and models that can be used to predict outbreak occurrence. A few participants identified a weakness in availability of laboratory confirmation data, as previously mentioned. Some participants indicated that lack of data is not a major problem and felt they had sufficient information to make decisions.

9. Regular communication between stakeholders could be improved during times of no outbreak and would enhance preparedness. There is need for a communication strategy for health emergencies.

The researcher asked participants about mechanisms of communication and coordination between organizations, challenges that they have seen, and suggestions for improving communication and coordination with respect to cholera prevention and outbreak response activities.

One coordination mechanism is a national-level health and nutrition meeting that brings together the Ministry of Health and other stakeholders to review and discuss health indicators, meteorological data, and anticipated impacts of weather conditions on health. The frequency of this meeting is approximately quarterly. There are sub-committees like the outbreak contingency committee that may meet more frequently depending on the need. One participant indicated that this committee had recently resumed more regular meetings for Ebola contingency planning. A number of participants commented that the most important communication takes place "on the ground", and of course frequent, even daily, meetings occur at various levels during an outbreak. Several individuals suggested that more regular standing meetings even when there are no outbreaks would be beneficial. Of course there are challenges to having more regular meetings

like competing demands for individuals' time and availability of financial resources to support meetings, especially if travel to or from the counties is required to bring the right people together. A number of participants stressed the importance of face-to-face communication and building trust among individuals from different organizations who will have to come together during the time of an outbreak for a successful response. While discussing the importance of advance planning of outbreak response roles of various organizations, one participant said:

> The discussions should take place in advance, they should be ongoing discussions, and to build trust … you need that trust to be built among the individuals that are working for the organizations … That cannot be built during emergencies. It can't. People are running up and down, there's a lot of pressure, there's press … because one [case] of cholera, it will hit the news … So there won't be time to talk. So I think communication can be increased significantly during the times when there are no outbreaks. (NGO representative)

Another participant commented:

> For communicating, it's really helpful to have in-person communication. I think face-to-face communication is probably the most effective way … I prefer the person-to-person communications for these sorts of important outbreak response activities. (International organization representative)

Two coordinating mechanisms specifically related to water and sanitation were discussed: the Environmental Sanitation and Hygiene Inter-agency Coordinating Committee (ICC) and the Water and Environmental Sanitation Coordination mechanism (WESCOORD). Both coordinating mechanisms bring together government entities, NGOs, and other stakeholders working in the field of water and sanitation. The ICC is chaired by the Ministry of Health and meets quarterly. The location of the quarterly meeting rotates among geographic regions in the country to facilitate participation of counties. The activities of ICC member organizations are shared and documented in the quarterly newsletter produced by the CLTS Hub.

WESCOORD is co-chaired by the Ministry of Water and UNICEF and tends to be regarded as a coordinating forum for WASH stakeholders in an emergency response setting.

This coordination group has prepared maps of who is doing what in which locations in the counties, and the value of investments being made in water and sanitation. This information is available from WESCOORD's website. The available information is impressive, but it must be noted that the most recent maps are from 2012.

The issue of mapping stakeholder activities was raised by a number of key informants. Several participants talked about the need for mapping of partners in order to know who is doing what and where. This issue came up from various perspectives. One participant described the need for a database of NGOs so that facilities on the ground would know who they could call upon for assistance. Another perspective was that of having appropriate information for higher-level coordination of an effective response. Mapping seems to currently be limited primarily to water and sanitation partners.

Effective communication among stakeholders and with the public is important to the success of any emergency response. Cholera outbreaks generate media interest and necessitate clear communication from health leaders. Two participants identified the need for a communication strategy for health emergencies. One government official said:

> One of the important things that needs to be done, and I think this is something that is long overdue, we have not had a communication strategy for quite some time. I think the various units or maybe sections that are involved in this, and especially for disease control, I think we need to have an integrated communication strategy that would spell out exactly what needs to be done when and how and by whom.

Another participant from an NGO spoke of the importance of having an appropriate communication plan in place prior to the occurrence of an outbreak:

> Tools can be developed, including tools for communication … so that … there will be clear indications of how we [should] communicate this news so that they're not becoming alarmist … how do you communicate this … the channels that you communicate through.

It should be noted that the Disease Surveillance and Response Unit within the Ministry of Health has a communication strategy in draft form. The strategy has not yet been finalized.

10. Implementation of Kenya's Multi-sectoral Cholera Prevention and Control Plan is not well monitored, and the achievements are not well known. A multi-sectoral approach is the right way to go for preventing cholera.

The Ministry of Health engaged stakeholders in two consultative workshops in 2010 and 2011 to develop Kenya's Multi-sectoral Cholera Prevention and Control Plan. The executive summary of the resultant document states that the plan aims to "fight cholera in Kenya through a well-coordinated multi-sectoral approach that emphasizes a continuous prevention effort rather than the traditional focus on outbreak response only."[83] The plan is structured around five technical thematic areas:

1. Advocacy, resource mobilization, and coordination
2. Laboratory, risk assessment, and surveillance
3. Water, sanitation, and hygiene (WASH)
4. Disease prevention and health promotion
5. Disease outbreak preparedness and response

The budget for the 5-year plan is estimated at $12.6 million, and an additional $1 million is estimated for implementation of the monitoring and evaluation framework. There were delays in issuance of the final document, which was distributed in 2014. The researcher asked key informants if they were familiar with the plan, if they were aware of achievements and challenges, and if they had suggestions for improving implementation of the plan.

More than half of the participants were familiar with the plan, and several of them had been involved in the plan's development. Even so, among this group, some reported that they

had never seen the final document. Only three participants were able to comment on what had been achieved by the plan. One participant credited the plan with:

- Better coordination of partners and stakeholders at national and sub-national level
- Improvement in resource mobilization for preventive activities
- Marked improvement in surveillance, especially at border areas and refugee camps
- Improved latrine coverage and access to clean water in outbreak prone districts
- Improved cholera awareness in schools resulting in improved hygiene in affected communities

Another participant commented that training aspects of the plan, which included training of district staff on IDSR and other cholera-related trainings, had been accomplished with the support of UNICEF and WHO.

One government official pointed out that a major challenge is inadequate monitoring of implementation of the plan due to lack of funding. This inadequate monitoring likely contributed to the finding that most key informants were not able to comment on what has been achieved by the plan. The government official went on to comment that the issue of inadequate monitoring is further complicated by devolution of responsibility from provincial to county governments. He reported that most of the former provincial governments had been sensitized on the plan and used to provide feedback. Building awareness of the plan among county governments has been a challenge. The plan was shared with counties in electronic form and hard copies may not be readily available. There are logistical and financial challenges with trying to plan review meetings that would include numerous counties. Two other participants pointed out that the plan does not acknowledge the presence of county governments because it was written before the devolved structure came into existence. Suggestions were made to update

the plan to incorporate the new structure of government and to define the roles of national and county governments in implementing the plan. Another challenge pointed out by a government official is that the plan's budget is very high, and it may not be practical for funding:

> When you look at an overly ambitious budget, people tend to get put off by it. The bottom line is too high for anybody to fund it.

This participant recommended revising the plan to a more "realistic" budget.

One common theme that emerged in discussions with key informants is the importance of a multi-sectoral approach for cholera. Participants stressed that successful prevention and control of cholera requires involvement of various government departments and partners. In particular, participants identified effective collaboration between the Ministry of Health and the Ministry of Education with respect to educational programs on water, sanitation, and hygiene in the schools. Participants also spoke of the close working relationship between the Ministry of Health and Ministry of Water with respect to WESCOORD and with respect to collaboration between public health officers and water officers at sub-national level. Participants gave numerous examples of involvement of local officials in response activities, ranging from provincial and district administration to village chiefs. One participant pointed out, "Disease control and risk factor control can never be an individual, one sector approach. It must be holistic."

11. Devolution presents both opportunities and challenges for cholera control, but the outlook from key informants is optimistic. A key advantage of devolution is that counties have the opportunity to set their own priorities and develop customized plans to meet their needs.

Devolution of health services and other government-administered services from central government to 47 county governments is a major shift in how government business is conducted in Kenya. Implementation of devolution began as a phased process in early 2013. Key informants were asked to give their views on the opportunities and challenges that devolution

presents to the prevention and control of cholera. The outlook on devolution was generally optimistic.

Devolution gives the counties local control of resources and most participants saw this as an opportunity for potentially improving prevention and control of cholera and other diseases. This was seen as an opportunity in the sense that county governments have a better understanding of local needs and now have the authority to set their own priorities and plan how best to spend financial resources to address those needs. In addition, local elected officials are accountable to their constituents. Several participants spoke of the need for a differential approach in addressing cholera since some counties are more affected than others and the drivers of cholera may vary by location. For example, one participant pointed out that a specific approach is needed in urban slum areas that would be different from the approach in other areas. Devolution provides an environment that is conducive to creating a differential approach:

> We have decentralized powers of decisions. To me it's an opportunity because the counties will have an opportunity to better understand the community health issues more than when it was [at national level], more than when it was even at the provincial level. They'll be able to structure their disease prevention and control interventions based on the need, based on the information that they are generating. (Government official)

> You can specifically target certain areas. If we said we were to target the 10 areas with the highest burden of disease, you could see figures change significantly … There are parts of the country that are just forgotten from central government … And [the counties] know the issues that are there. (NGO representative)

> First and foremost, one thing that excites me is devolution of health. Because when we addressed diseases of epidemic potential from a national level, some of them are not a priority in certain regions. So I think the national government now could start coming up with more specific policies based on disease burden in a region. (Government official)

> Now there is funding to the county level. The county now can be able to prioritize their issues. Initially it was a blanket kind of funding, which was standardized … [all areas] were given money for almost the same things. But now you can be able to sit down and say, yes, we have money. What are our priorities? So I find that to be an opportunity … You need a lot of advocacy, you need people who are strong in public health in those counties to advocate for the right priorities. Yes, we are saying this is an opportunity, but

> again ask yourself, do we have strong advocates to ensure that these things are budgeted for? (International organization representative)

The last response suggests that county authority to set priorities is a great opportunity but also raises the question of whether there are strong advocates for public health to influence county decisions. Counties are faced with many priorities competing for limited resources. The health sector is just one sector of public services that counties are responsible for. And public health preparedness and prevention programs are just one aspect of the health sector. One government official noted that, "The national government has lost control of devolved units and therefore may not influence cholera issues to be a priority of the devolved governments." Another government official noted that being able to get adequate funding for health, and particularly for preventive programs, will still be a challenge under the devolved system of government. One participant pointed out that there are both strengths and weaknesses to the devolved system with respect to outbreak response:

> The devolution process as it is defined gives more power to the local counties so they can directly mobilize resources more rapidly, be it people or money or stuff. So it's a quicker response. I think that's a distinct advantage and certainly a strength in having the devolution process … And you can obviously see the weakness in that too. If that is getting to the county level and they don't have the resources it just means that what could happen is something could fester for a long time before you have a response to it, before it finally makes it up to the headquarters level. And then you have potentially an outbreak that is out of control. (International organization representative)

Other participants noted the potential for counties to be able to provide a more rapid response than national-level government:

> The advantage is that the counties will be able to address the problem at the point immediately as opposed to coming to Nairobi. You can make a decision within the county and act immediately. (Government official)

> The way I look at it is now it's a smaller unit. The administration is much closer to the people, to the decision makers. And I think the turn-around time in terms of decisions being made … I think it's much shorter than it was before. (Government official)

Some participants indicated that counties are faced with the challenge of building their human resource capacity with respect to both leadership and technical skills. This is something that needs to be taken into consideration and addressed. Some participants also mentioned that employing and building the capacity of people within the counties is likely to result in better staff retention over time.

Other considerations

Besides the key findings that were highlighted in previous sections there are other considerations that were raised by a few of the participants. These considerations include:

- The need for investment in water and sanitation infrastructure
- The need for improved water quality monitoring
- The need to involve traditional healers in cholera activities
- The need for cholera focal persons at national and sub-national levels
- Cholera is an indicator of socio-economic development

In addition, a number of participants spoke about the training of health workers and gave examples of both successes and challenges in the area of training.

Investment in infrastructure

While discussing issues around interventions, policies and strategies for effective cholera prevention and control, a couple participants talked of the importance of investing in infrastructure. The provision of safe water and improved sanitation requires costly infrastructure. When asked how cholera prevention and control could be improved through policy or strategy formulation, one participant from the NGO sector said:

> I think we need to reconsider the issue that these communities can do these things by themselves without major investment. We need to reconsider that. It may be useful for

> government to say that. Yes, we need communities to move by themselves in order to get ownership, but in the short term I think we need certain levels of investment.

One government official spoke of the importance of investing in infrastructure for the provision of safe water:

> It is true, [water infrastructure] is expensive, but you must look at it then in the context that it must really be a priority if you have to prevent cholera ... So I think it's an area worth investing.

Water quality monitoring

A couple participants spoke of the need to improve water quality monitoring. When asked about weaknesses in existing policies and strategies, one government official indicated that he did not necessarily see weaknesses in the policies themselves, but rather in their implementation. He gave the example of implementation of water quality monitoring. Water corporations monitor the quality of piped water, but other water sources, like wells, are not routinely monitored. This is of particular importance in some cholera-prone areas like Mombasa and Wajir, where there are thousands of shallow wells. Another participant recommended establishing a national database for water quality monitoring so that "hot spots" can be identified and interventions put in place.

Involving traditional healers

One participant from the NGO sector felt that more could be done to involve traditional healers from the community in an outbreak response. He pointed out, "The kind of influence these people command in the community is massive". This influence can potentially be a hindrance to a successful outbreak response if cholera patients seek help from traditional healers and do not receive appropriate care or advice. The key informant who raised this issue felt that

traditional healers are often not recognized by the formal health sector, but that they should be engaged in cholera response activities so that they become points of referral for the hospitals.

Cholera focal person

When asked for suggestions for improving communication and coordination among organizations, one government official suggested appointing focal persons for cholera at national and sub-national levels. These individuals could be champions for cholera prevention and coordinate communication between various stakeholders.

Cholera is an indicator of development

A concept that appears in the literature is that cholera is a disease of poverty. One participant from an international organization spoke of cholera as an indicator of development:

> Cholera is one of the social indicators of development. If a society is not well off, if you cannot assure people of good livelihoods, of good access to safe water and sanitation, you can be assured that cholera will always be there.

When asked for suggestions on how cholera prevention and control could be improved through policy or strategy formulation, a government official recommended that county governments address cholera from a developmental perspective. Considerations should include water, sanitation, and urban planning.

Training of health workers

Training of healthcare and public health workers was identified as a successful intervention and also an area in which there have been challenges. Some participants described a health workforce that was poorly prepared to respond to the outbreaks that occurred throughout the country in 2008 and 2009. One participant with a national-level perspective stated:

> My experience with either the 2008 or 2009 outbreaks is that the health workers were not ready for it, especially in the lower health centers, the health center dispensary level. They didn't have a high index of suspicion.

A participant who was directly involved in the cholera response in the field in 2009 also felt that many healthcare workers were not very familiar with cholera and were unprepared. This may be understandable, given that many parts of the country had not seen cholera since 1999, but this highlights the challenge of maintaining vigilance for cholera.

One of the goals of IDSR is to be able to maintain this vigilance, and some of the participants spoke of more recent IDSR-related trainings of clinicians, surveillance officers, and other public health workers as a specific accomplishment:

> At the health workers' level again, a lot of training has been done on IDSR to ensure that the health workers have high indexes of suspicion of cholera. We have given case definitions to all those health facilities and trained all those regions … But again, the question that arises, are the people trained still there? … And there is a time we prioritized those regions that were hard hit by cholera just to ensure that we do IDSR training but with special focus on cholera. (International organization representative)

> Under IDSR there was a lot of capacity building in the country. It was that every district had to be trained on IDSR. The trainings were very effective. (Government official)

One participant witnessed challenges in the accuracy and completeness of surveillance records in health facilities and strongly recommended more routine supportive supervision in this area.

One of the responses above raises the issue of staff turnover. A number of participants spoke about staff turnover, but there were different views expressed on this matter. A few participants spoke of staff turnover being a serious challenge, but others described working with staff who had been in the same positions for many years. It is anticipated that devolution of health services will help promote staff retention by encouraging hiring of staff from the local area.

One participant made a recommendation that development of simple cholera-related job aids for healthcare workers would be helpful. He noted that the WHO guidelines for cholera management are good guidelines, but that they are very detailed and require a lot of forms to be filled out. This can be overwhelming to staff on the ground who often have limited time for paperwork due to immediate patient needs. Distilling the detailed information from the guidelines into simple, clear job aids could potentially be an effective means of raising and maintaining healthcare worker awareness of proper medical management of cholera cases.

Closing remarks

At the end of the interview, participants were asked if there was anything else they would like to share that had not already been discussed during the course of the interview. Participants closed with the following words of wisdom:

> Where you do not have working and functional health systems, cholera will always remain … I remember one of the challenges that we used to have is that of having IV fluids. That was really a challenge … You really need to have working health systems. And a working system that communicates with the people. Because you may have working health systems, but if they are not able to communicate with the people or to understand and respond to the needs of the people, it will be very difficult to contain, not only cholera, but most of the communicable diseases. And again the issue of a multi-sectoral approach. This is very critical because Ministry of Health on its own cannot contain diseases. You need the inputs or participation of everyone. (Government official)

> I think that you cannot ignore the issue of infrastructure over time. If you're going to talk about cholera control, the infrastructure, the investments around that. Anything else would be just patching things. You need to take availability of water to the people that need it, and the infrastructure for the disposal of waste. If we are not addressing this, you know this will just roll back any of the other advantages we would have gotten. (NGO representative)

> Make sure that the counties are on routine surveillance, routine chlorination, because somebody has to do it. We cannot say, "Water is not our business." Somebody has to take that responsibility. Otherwise they'll see the same situation that we used to see earlier on … Now the counties will have to make sure that they look at this water which is being consumed by the households. Somebody has to look at it. You see, it is between the cracks that things fall apart, and then you get an outbreak. (Government official)

This is a disease that can actually be prevented, and we can ensure that the serious outbreaks that used to occur are no longer happening … The most important thing is that we have to be vigilant all the time, and through surveillance make sure that we are not caught unaware when eventually it happens … So we should not be complacent, it can still happen, we just have to remain vigilant. And we must have adequate resources to go towards the aspect of prevention. (Government official)

And one of the things I think the Ministry of Health in Kenya now needs to do is to come with policies and strategies that guide the counties towards what they need to really fund more holistically, to deliver a package of health … I think you need a coordination of both governments for any outbreak … And then just the preparedness of counties for any emergencies. I think given now with devolution it may be easier for counties to coordinate in terms of preparedness, including simulating disease [outbreaks]. (Government official)

CHAPTER 5: DISCUSSION

Cholera and water

Most key informants spoke of provision of clean water as a key intervention for preventing cholera. *V. cholerae* can be transmitted through contaminated water. Expanding access to improved water is a common strategy for reducing incidence of waterborne diseases. In Kenya the percentage of population with access to an improved water source increased from 43% in 1990 to 62% in 2012. Kenya is not on track, however, to reach the Millennium Development Goal (MDG) for improved water. In order to halve the percentage of population that lacked access to an improved water source in 1990, Kenya would need to achieve coverage of 72% by 2015. In urban areas the percentage of population with access to improved water sources actually decreased from 92% in 1990 to 82% in 2012. There was very little mention in the key informant interviews of programs aimed at providing clean drinking water in the urban slums. One key informant raised a concern about lack of water quality monitoring of shallow wells in Mombasa. It was previously mentioned that Kenya's largest cities, Nairobi, Mombasa, and Kisumu, have all experienced cholera outbreaks multiple times between 2004 and 2013. These urban communities will continue to remain at risk for cholera as long as there are populations that lack access to clean drinking water.

The results of this study suggest an association between access to an improved water source and reduced risk of cholera. This is similar to a multi-country study by Leidner et al. that found a relationship between access to improved water and cholera incidence.[17] Leidner's study was based on a cross-country regression analysis utilizing WHO data on global cholera

occurrence between 1990 and 2008. The association between access to improved water and cholera occurrence is also supported by a study by Stoltzfus et al. that found a statistically significant association between cholera risk and lack of access to piped water in Kenya. [68]

A few key informants pointed out that ensuring access to adequate quantities of water is also important for preventing cholera. Some spoke of cholera outbreaks occurring during dry spells or times of drought. This is somewhat counterintuitive, given that cholera is often thought to be associated with heavy rainfall and floods. Key informants gave anecdotal evidence of drought stricken communities turning to poor quality water sources when other water sources dried up. Stories were told of competition between communities for water sources. Understanding the role that drought plays in cholera occurrence in Kenya could be an important issue. Little information related to this issue was found in the literature review, and this is a recommended topic for further study.

Cholera and sanitation

Community Led Total Sanitation (CLTS) is one intervention that many key informants perceived to be effective in the prevention of cholera. CLTS raises awareness of the risks of poor sanitation and hygiene practices. Several key informants claimed that latrine coverage has increased in Kenya and some associated increased latrine coverage with reduced cholera incidence. The results of the cross-district regression analysis suggest that open defecation may be associated with cholera occurrence in Kenya.

The proportion of the population in Kenya practicing open defecation decreased from 19% in 1990 to 13% in 2012. [33] In rural areas open defecation declined from 22% of the rural population in 1990 to 17% in 2012. In urban areas open defecation remained constant at 3% of the urban population over the 22-year period. The proportion of the population with access to

improved sanitation in Kenya increased modestly from 25% in 1990 to 30% in 2012. This falls far short of Kenya's MDG for improved sanitation. In order to achieve the MDG of reducing by one-half the proportion of the population that lacks access to improved sanitation, coverage would have to increase to 63% of the population. In Kenya a large proportion of the population uses shared sanitation facilities. Facilities shared by more than one family are not considered to be improved sanitation, and there is some evidence that use of shared sanitation facilities is a risk factor for cholera.[54,57] In 2012, 48% of the urban population and 19% of the rural population in Kenya used shared sanitation facilities. This is a key contributor to Kenya's poor coverage of improved sanitation. Another key contributor in rural areas is use of uncovered pit latrines that do not meet the JMP definition of improved sanitation. The JMP data indicate that despite modest progress in the provision of sanitation, the majority of Kenya's population still lacks access to improved sanitation facilities.

Between 2009 and 2013, parts of northern and eastern Kenya experienced particularly high cholera incidence. Some of the most affected counties, Marsabit, Isiolo, Turkana, Kwale, Garissa and Lamu, have a high prevalence of open defecation. Less than 10% of villages in these counties have claimed open defecation free (ODF) status. In Lamu 0% of villages have claimed ODF status, and in Turkana and Garissa only 1% of villages have claimed ODF status.[82] One of the key early stages of CLTS is "triggering" of villages for behavior change. In Marsabit, Turkana, Kwale, and Garissa counties less than 18% of villages have been triggered. In Lamu, 0% of villages have been triggered. This suggests limited or no presence of CLTS programs. Scaling up CLTS in these counties may help to prevent large cholera outbreaks in the future. Isiolo County has one of the highest percentages of villages triggered in the country at 78%. This suggests that the CLTS program is present and widespread in the county, although only 9%

of villages have claimed ODF status. The low percentage of villages claiming ODF status raises questions about the effectiveness of CLTS, but it may be too early in the implementation process to draw conclusions.

There was a fair amount of discussion in the key informant interviews about increased latrine coverage and reduced cholera incidence in the Nyanza and Western regions of Kenya bordering Lake Victoria. Busia, Kisumu, and Siaya counties have the highest percentages of villages in Kenya claiming ODF status at 33%, 29%, and 29%, respectively. The percentages of villages triggered range from 33% in Busia to 37% in Kisumu, and 47% in Siaya. These figures are above the county average of 15%, but there is still much to be done in order for these counties to achieve 100% ODF status. It was previously mentioned that the results of this study indicate a lower cumulative cholera incidence between 2009 and 2013 as compared to 2004 and 2008 in these three counties. This may suggest success of the CLTS program, which began roll out to western Kenya in 2010, in preventing cholera. Homa Bay and Migori counties, also bordering Lake Victoria, have shown less progress towards eliminating open defecation. In Homa Bay 21% of villages have been triggered and 10% have declared ODF, while in Migori 16% of villages have been triggered and 7% have declared ODF. It must be noted that Homa Bay is the one county bordering Lake Victoria that did not show an appreciable decline in cholera incidence in 2009-2013 compared to 2004-2008.

It is important to recognize that CLTS focuses on eliminating open defecation and does not necessarily result in hygienic sanitation facilities. There is a need to evaluate the CLTS program in Kenya to gain an understanding of the outcomes. Given the commitment of the Ministry of Health and other organizations in Kenya to the CLTS approach, there is need to gather appropriate information to determine whether the approach is being implemented

effectively, whether it is producing the expected outcomes, and whether there is an impact on health.

This study suggests a positive correlation between open defecation and cholera incidence. There is varying evidence in the literature on the relationship between cholera occurrence and sanitation. The study by Leidner et al. provided evidence of a potential relationship between sanitation and cholera incidence.[17] The authors found a negative correlation between cholera incidence and access to improved sanitation facilities. A study by Stoltzfus et al. did not find an association between cholera risk and use of "unsafe" sanitation in Kenya.[68] The authors noted that lack of variability in some of the independent variables across 69 districts and lack of statistical power may have limited the ability of the study to detect associations among some of the variables.

Cholera in refugee settings

Kenya is home to two very large refugee camps. Dadaab, which is located in Garissa County in northeastern Kenya near the Somali border, is the largest refugee camp in the world with a population of approximately 400,000 people. Kakuma is in Turkana County in northwestern Kenya near the border with South Sudan and houses approximately 125,000 refugees. Griffith et al. had identified living in a refugee camp as the most common risk factor for cholera among a review of cholera outbreak reports in ProMED-Mail between 1995 and 2005.[40] Dadaab and Kakuma both experienced cholera outbreaks during the time frame of the current study, 2004-2013. Cases were reported from Dadaab in 2009, 2011, 2012, and 2013, and from Kakuma in 2005 and 2009. There is published literature on outbreak investigations in Kakuma in 2005 and 2009, but the researcher did not find reports of investigations of outbreaks

in Dadaab in the literature. [54,55,57] This is an important area for further research since there have been frequent outbreaks in Dadaab, and this likely represents a risk to the rest of the country.

Cholera and poverty

The results of this study suggest that there is an association between cholera and poverty. Several of the counties most affected by cholera in recent years in Kenya have particularly high poverty headcount ratios. Cholera is sometimes referred to as a disease of poverty in the literature, and at least one key informant made reference to cholera as a disease of poverty. The results of this study support similar results published by Root et al. and Talavera et al. from other parts of the world. [14,15] Olago et al. had also noted low socio-economic status as a vulnerability in cholera-affected communities in the Lake Victoria Basin of Kenya, Uganda, and Tanzania. [47] In contrast, Stoltzfus et al. did not find a detectable association between cholera and poverty in Kenya. [68]

Implications for case management

Several key informants spoke of challenges with respect to adequate supplies of intravenous (IV) fluids during cholera outbreaks. This is documented in the literature as well. Shikanga et al. studied outbreaks in 2008 in Kisumu East, Rongo, and Migori districts of Nyanza Province and reported that 68% of the health facilities included in the study reported reduced or no supply of IV fluids, and 37% of facilities reported shortages of oral rehydration solution (ORS). [61] Shikanga also reported that only 4 of 86 cholera patients in the study reported use of ORS at home. Onyango et al. studied a 2010 outbreak in Kuria West and Migori districts in Nyanza and found a shortage of both IV fluids and ORS. [59] Loharikar et al. reported shortages of IV fluids and ORS in 77% of health facilities surveyed in a study of outbreaks in 2009 in East Pokot and Turkana districts in northwestern Kenya. [58] Maintaining adequate supplies of IV fluids

and ORS in health facilities is clearly an issue that needs to be addressed. These are basic life-saving supplies for patients with cholera or other diarrheal diseases. It must be noted that very little was said about ORS in the key informant interviews. The investigator recommends further research into the availability and use of ORS in Kenya.

Limitations of the study

This study is subject to a number of limitations. One limitation is quality of cholera surveillance data. It is likely that there is variability in surveillance capacity among the geographic regions in Kenya. As a result, data quality may not be uniform across all regions. For example, violence and instability in the northeastern region of Kenya, often associated with armed conflict in Somalia, presents a challenge to the delivery of healthcare services and collection of routine surveillance data in this region. The low level of availability of healthcare services in the vast, arid region of northwestern Kenya, characterized by semi-nomadic populations, also suggests likelihood of underreporting of cholera in this area. It is expected that regional variations in surveillance capacity will have more of an influence on the detection of low numbers of cases during non-epidemic years as compared to epidemic years. Outbreaks, once detected, typically result in a national response supplementing local capacity with enhanced surveillance. The issue of potential variability in reporting across counties is partly mitigated in the cross-county regression analysis by averaging cholera incidence and case-fatality rate over several years, including both epidemic and non-epidemic years.

There is an inherent limitation in the investigation of the relationship between cholera occurrence and case-fatality rate and selected development and demographic indicators in that the regression analysis and calculation of correlation coefficients is a relational analysis that does not prove or disprove causality between the independent and dependent variables. More detailed

case-control studies or individual case investigations would be necessary to establish causes of cholera outbreaks. This study does not attempt to establish causality.

There is a limitation in the unit of analysis for the regression analysis. Data was analyzed at district level, yet it is recognized that differences in cholera risk exist at much smaller geographic units. For example, Nairobi as a whole has relatively high access to improved sanitation, high access to improved water, high level of education, and low poverty headcount ratio. Yet cholera occurs in Nairobi's urban slums where the indicators of development are low in comparison to the average for the district. This study was not able to distinguish between areas of varying conditions within districts.

Another limitation of this study is availability of data on the development and demographic indicators of interest. These indicators are not measured annually, so this study relied upon single measures from a particular survey and year based upon what was available. It is assumed that measured values of the development and demographic indicators do not vary dramatically from one year to the next.

Most of the indicator data is taken from the 2009 Kenya Population and Housing Census. There is a challenge with measuring access to improved sanitation facilities using the census data. The census report did not distinguish between private vs. public or shared sanitation facilities. Households accessing shared sanitation facilities are likely to be included in the improved sanitation facility category although use of shared facilities has been documented as a risk factor for cholera. It is also recognized that meeting the WHO/UNICEF Joint Monitoring Program definitions of improved water source and improved sanitation facilities does not guarantee safe drinking water or sanitary waste disposal. For example, a household may access piped water from a municipal water supply that is contaminated with *V. Cholerae*. Conversely, a

household may access contaminated water from a lake and render the water safe for drinking by household water treatment. Accounting for water quality and sanitary conditions of waste disposal facilities is beyond the scope of this investigation.

There is uncertainty in population figures used to calculate cholera incidence for some districts. The 2009 Kenya Population and Housing Census noted anomalies in population figures for Lagdera district in Garissa County, Wajir East, Mandera Central, Mandera East, Mandera West, Turkana Central, Turkana South, and Turkana North districts. These districts showed a higher rate of population increase than population dynamics would support, age and sex profiles that deviate from the norm, and significant growth in household size without accompanying growth in number of households. The 2009 district population was used to adjust for population in the regression analysis. If the figures for these districts are anomalously high, the relative magnitude of cholera occurrence may be underestimated for these districts in the regression analysis.

The number of key informant interviews was limited to eleven for practical considerations. This is recognized as a limitation since all possible perspectives on cholera prevention and control in Kenya may not have been captured by the study. The design of the study attempted to mitigate the impact of this limitation by careful selection of highly knowledgeable key informants from a variety of organizations engaged in cholera activities in Kenya. In addition, the study design mitigated this limitation by focusing the inquiry on a limited number of strategically selected topic areas.

CHAPTER 6: POLICY IMPLICATIONS AND THE PLAN FOR CHANGE

The goal of this study is to produce information that is useful to the Government of Kenya and its partners in establishing or strengthening policies and programs that effectively prevent and control cholera. Towards this goal, the study was conducted in collaboration with the Ministry of Health (MOH), Disease Surveillance and Response Unit (DSRU). This chapter synthesizes information gained from the study to make recommendations for change that will improve cholera prevention and control efforts.

When this study began in 2014 Kenya had experienced three years with very few cases of cholera, and those cases were limited to a small geographic area in northeastern Kenya in and around Dadaab Refugee Camp. The urgency to address cholera issues seemed to have waned from the time Kenya's Multi-sectoral Cholera Prevention and Control Plan was developed in 2011 immediately following the widespread outbreaks of 2007-2010. A new public health threat, Ebola, took center-stage in 2014. In the first months of 2015 cholera is in the news in Kenya again, with confirmed cases in Nairobi, Migori, Homa Bay, and Kisii counties. This demonstrates that cholera is still a public health threat in Kenya. Most of the recommendations from this study have implications for improving public health beyond the realm of cholera alone. Framing the recommendations in the context of broader public health benefits makes sense from a scientific perspective and is more likely to generate support. This chapter begins with an analysis of the contextual parameters, resources, and key players affecting cholera prevention and control efforts in Kenya. This is followed by specific recommendations and then a plan for change for successful implementation of the recommendations.

Contextual parameters, resources, and key players

One of the key contextual parameters influencing cholera prevention and control in Kenya is devolution of public services to county governments. This is a recent development and a major change in how government business is conducted in Kenya. Another key contextual parameter that will be discussed is the Global Health Security Agenda. This is a new global initiative that aims to accelerate progress in preventing infectious disease threats and to promote global health security as an international security priority. There are potential resource implications for Kenya, which the country must capitalize on effectively.

Among key players in cholera prevention and control in Kenya, the Ministry of Health and county governments hold a key leadership role. Within the MOH, cholera-related issues fall under the umbrella of the Directorate of Preventive and Promotive Services. Relevant divisions and units within this Directorate include the Division of Communicable Diseases Prevention and Control, the Division of Environmental Health and Sanitation Services, and the Disease Surveillance and Response Unit. In the devolved system, county governments now set priorities and determine budget allocation for health and public health services. Other key players among government agencies are the Ministry of Education, Science and Technology and the Ministry of Environment, Water and Natural Resources. Key players among United Nations (UN) agencies include the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the Office of the United Nations High Commissioner for Refugees (UNHCR). The Centers for Disease Control and Prevention (CDC) and the U.S. Agency for International Development (USAID) have key roles among U.S. Government agencies in supporting public health programs with relevance to cholera prevention and control in Kenya. The major players in cholera response among the humanitarian non-governmental organizations (NGOs) are Medecins Sans

Frontieres (MSF) and the Kenya Red Cross. A number of other NGOs support water and sanitation programs in Kenya.

Devolution, a key contextual parameter

Under Kenya's new constitution, which was ratified in 2010 and went into effect in 2013, a wide range of political, fiscal, and administrative powers was devolved from national government to 47 county governments. The two levels of government are recognized as equals under the constitution, which states that the national and county levels of government are "distinct and interdependent and shall conduct their mutual relations on the basis of consultation and cooperation."[84] Some of the key principles and objectives of the constitution include accountable exercise of power, self-governance by the people, equitable share of resources, and the right of communities to manage their own affairs and further their development. Article 43 of the constitution recognizes the following rights related to health:

(1) Every person has the right –
   a. To the highest attainable standard of health, which includes the right to healthcare services, including reproductive healthcare;
   b. To reasonable standards of sanitation;
   c. To be free from hunger and have adequate food of acceptable quality; and
   d. To clean and safe water in adequate quantities

The constitution provides some guidance on the distribution of health-related responsibilities among the national and county governments, but there are many areas for which responsibility is not clearly defined. National government is responsible for health policy, national referral health facilities, and capacity building and technical assistance to counties. County governments are responsible for a wide range of activities falling under service delivery and implementation of national health policy and guidelines. Responsibility for health information systems and laboratory services is not addressed in the constitution and is currently considered to fall under the oversight of the national Ministry of Health in collaboration with the

counties. The Kenya Health Policy 2014-2030 includes a section on health information that directs:

> The Ministry of Health will put in place mechanisms to ensure generation and management of information to guide evidence-based decision-making in the provision of health and related services at the national and county levels. All healthcare providers shall therefore be obligated to report on information emanating from their activities through established channels in a manner that meets safety and confidentiality requirements, and according to the health research and information policies, regulations, and standards that will be developed. [85]

This policy document also states that the health response to national disasters, emergencies, and disease outbreaks will be coordinated by national government in conjunction with county governments. The national Director of Medical Services is responsible for declaring epidemics and disease outbreaks of public health concern.

Key informants who were interviewed for this study generally expressed optimism that devolution has the potential to improve prevention and control of cholera and other outbreak-prone diseases. This optimism is mainly based on the notions that counties have a better understanding of local health issues and are therefore better positioned to allocate budgets appropriately based on need and that counties potentially have the ability to respond more quickly to disease outbreaks. Key informants expressed concern, however, about whether there is sufficient advocacy for health issues at county level to ensure adequate budget allocation and about the current technical, leadership, and management capacities of staff at county level. Kenya is still in a transition period in implementing devolution, and this is a critical time for national and county governments to collaborate on charting the way forward together.

The Global Health Security Agenda, a key contextual parameter

The Global Health Security Agenda was launched in February 2014 and is aimed at improving global capacity to prevent, detect, and respond to infectious disease epidemics and

other public health threats. This initiative is led by the U.S. Government with support from other countries, international organizations, and public and private stakeholders. A key motivator for this agenda was recognition of the fact that less than 20% of WHO member states achieved full compliance with the International Health Regulations (IHR) 2005 core capacities by the 2012 deadline. The IHR 2005 is aimed at improving global capacity for surveillance and response. One goal of the Global Health Security Agenda is to accelerate efforts of member states to fully realize the goals of IHR 2005 implementation. The agenda has nine specific objectives organized under the key concepts of prevent, detect, and respond. The objectives include strengthening and linking surveillance systems, improving transparency, accuracy and speed of reporting public health emergencies, strengthening laboratory systems and developing novel point-of-care diagnostic tests, building the capacity of the disease surveillance workforce, and developing an interconnected global network of Emergency Operations Centers. Over the next five years the U.S. has committed to working with at least 30 countries to advance the objectives of the agenda. [86] In the Consolidated and Further Continuing Appropriations Act, 2015 the U.S. Congress appropriated $597 million to the Centers for Disease Control and Prevention (CDC) to support global health security and the development of national public health institutes in countries around the world. [87]

Recommendations

Several key recommendations can be made from this study based on a synthesis of the information gathered from the interviews with key informants, analysis of Kenya's cholera surveillance data, and consideration of development-related indicators. Recommendations are summarized in Table 9. Each recommendation is elaborated upon in the discussion that follows.

Table 9. Key recommendations of the study

Recommendation Number	Recommendation
1	Intensify efforts to expand access to improved sanitation facilities and clean drinking water. Expand support for Community-Led Total Sanitation (CLTS).
2	Expand support for the Integrated Disease Surveillance and Response Strategy (IDSR).
3	Intensify efforts to improve laboratory capacity for microbiological testing and explore new diagnostic technologies.
4	Make actionable information on cholera available to the counties to support evidence-based decision-making.
5	Intensify poverty reduction efforts in order to improve cholera prevention.
6	Improve cholera case management by ensuring adequate stocks of intravenous (IV) fluids and oral rehydration solution (ORS) and through development of cholera job aids for primary care providers.
7	Improve routine communication between the Ministry of Health, county health departments, and other stakeholders through use of new technologies and finalize a communication strategy for health emergencies.

1. Intensify efforts to expand access to improved sanitation facilities and clean drinking water. Expand support for Community Led Total Sanitation (CLTS).

Issues of water and sanitation typically come to the forefront in any discussion of cholera. Cholera has been largely eliminated from high-income countries with well-developed water and sanitation infrastructure. The benefits of improved water and sanitation extend well beyond addressing the issue of cholera. Kenya's Health Policy 2014-2030 lists unsafe water, sanitation, and hygiene as the second leading risk factor to health, after unsafe sex, contributing to 5.3% of total deaths. [85] Death from diarrheal diseases tends to disproportionately affect the young, and 9% of deaths of children less than five years of age in Kenya in 2010 were attributable to diarrhea. [24] Kenya's constitution recognizes access to safe water and reasonable standards of sanitation as basic human rights. Kenya made commitments to the Millennium Development Goals and to Water and Sanitation for All. Yet 70% of Kenyans lack access to improved sanitation facilities and 38% lack access to improved water sources. This should be a call to action to national and county governments to work together on solving this problem.

The Ministry of Health has taken a leadership role in promoting CLTS. Many key informants in this study view CLTS as a successful intervention for improving cholera prevention. At the beginning of 2014, 15% of villages across the country had been triggered for CLTS and 7% of villages had claimed open defecation free (ODF) status. This presents a need and an opportunity for county governments to support and expand the CLTS program, for which there is available technical guidance and support. The Ministry of Health has established monitoring and evaluation structures for this program and should continue to gather and analyze implementation data and disseminate information on program results in order to evaluate program effectiveness and guide future directions of the program. Of particular importance will be to evaluate whether CLTS actually results in hygienic sanitation facilities and whether community achievements are sustained over time. This program currently has support from a number of donors, and documenting achievements will help national and county governments to leverage further donor support. There is anecdotal evidence that in the current cholera outbreak in Migori and Homa Bay counties, some ODF villages have managed to remain cholera-free despite being surrounded by cholera-affected villages. There is an opportunity for local and national public health officials to investigate this further in order to determine whether there is evidence that elimination of open defecation is protective against cholera.

It is notable that no particular water-related policy or strategy was highlighted in this study as a success. In the area of sanitation the government launched the ODF Rural Kenya campaign, but the investigator is not aware of any national campaigns related to safe drinking water. This presents a leadership opportunity for the Ministry of Health and Ministry of Environment, Water, and Natural Resources to develop a campaign that would raise awareness

of safe water issues and leverage resource support from county governments. There are a number of water-related needs, but a few potential options for a campaign include:

- Household water treatment and safe storage
- Access to clean drinking water in urban slums
- Water security in drought-prone areas

The Water Act of 2002 is also in need of revision to align with the new devolved structure of government. This is an opportunity for the Ministry of Environment, Water, and Natural Resources to create an enabling policy environment for current water-related development issues to be advanced within the new governance structure.

An issue of concern that was raised in this study is water quality monitoring of non-piped water sources like wells. Assignment of responsibility for this monitoring under existing policy guidance is unclear. This presents an opportunity for national and county governments to take on a joint leadership role in finding a solution to this problem. The National Water Quality Management Strategy 2012-2016 points out serious challenges with funding, human resources, and laboratory capacity. There is need for significant input of financial and human resources if water quality monitoring programs are to reach all water sources that the population relies on for drinking water.

2. Expand support for the Integrated Disease Surveillance and Response Strategy (IDSR).

IDSR is the framework for Kenya's national public health surveillance and response system for priority diseases and conditions or events of public health concern. This is also the key framework within which the surveillance and response requirements of the IHR 2005 are being implemented. It is notable that the IHR 2005 is being implemented within the framework of IDSR and did not replace IDSR. This may point to enduring success of the IDSR strategy and

the degree to which African countries have embraced this strategy. IDSR has been successful in Kenya and the surveillance system provides real time information on disease trends in the country, enabling response to outbreaks and evidenced-based decision making. There is room for improvement, especially with respect to frequency and completeness of reporting from sub-county units. IDSR is a cornerstone of public health in the country, and there is need for the Government of Kenya to increase support for this national program. There is also need for county governments to support implementation of IDSR at facility and community level through provision of adequate human resources, provision of financial support for training of surveillance and clinical personnel on IDSR, and provision of adequate information and communication technology (ICT) infrastructure for timely and accurate reporting and analysis of data.

The Government of Kenya should look to use its own commitments to leverage other resources for surveillance and response. Key stakeholders include the Ministry of Health, county governments, WHO, and CDC. It is likely that new financial resources from the Global Health Security Agenda for strengthening surveillance and response will become available through CDC in 2015. This presents an opportunity for these organizations to collaborate in identifying key priorities and developing an implementation plan for effective use of these resources.

3. Intensify efforts to improve laboratory capacity for microbiological testing and explore new diagnostic technologies.

Laboratory diagnostic capacity for cholera was identified as a weakness, and this challenge is not unique to Kenya. A WHO external assessment of national reference laboratory capacity in 48 African countries covering a time period of 2002-2009 found that cumulative acceptable laboratory performance for bacterial enteric diseases was only 65%. [88] The performance of laboratories and laboratory networks depends on a number of factors, including availability of appropriately trained human resources, infrastructure, equipment, reagents, and

systems for sample collection, storage, and transport. There have been ongoing improvements to laboratory systems in Kenya including introduction of the Strengthening Laboratory Management Towards Accreditation (SLMTA) and the Stepwise Laboratory Improvement Process Towards Accreditation (SLIPTA) programs in accordance with WHO guidance, major construction and renovation of laboratories at national and county levels, and efforts to strengthen supply chains through the Kenya Medical Supplies Authority (KEMSA). Much of this has been donor supported. Key stakeholders include the Ministry of Health, county governments, the Kenya Medical Research Institute, the World Bank, the CDC, and the U.S. Department of Defense.

There is need for the Government of Kenya and county governments to lead the way in increasing support for laboratories. Laboratory strengthening activities are not disease-specific. A higher level of commitment from the Government of Kenya could be used to leverage other sources of funding. In particular, there are likely to be new financial resources available to support laboratory strengthening through the Global Health Security Agenda. This initiative also aims to promote novel point of care diagnostic technologies. The Kenya Medical Research Institute may be particularly well positioned to test new technologies for cholera diagnosis in collaboration with the Ministry of Health and local health officials.

4. Make actionable information on cholera available to the counties to support evidence-based decision-making.

One key issue that came out in this study is that there is a need for a differential approach to cholera in different parts of the country. Cholera is a major public health threat to some counties but not to other counties. A different approach is likely needed in urban slums from the approach in rural areas. Some key informants raised the questions of whether there are strong advocates for cholera prevention at county level and whether counties will prioritize cholera.

One of the Ministry of Health's key roles in a devolved government is to provide technical assistance to the counties. The MOH has expertise in cholera prevention and control, and there is a key leadership opportunity for the MOH to make actionable information on cholera available to the counties. Making information available will enable advocates at county level to make a rational case for cholera and will promote evidence-based decision-making.

The Ministry of Health has previously produced county health profiles and HIV county profiles. There is information available for the MOH to collaborate with counties on producing cholera county profiles. Such information would be helpful to counties for determining whether or not cholera is a priority issue, and which particular aspects of cholera prevention and control are most in need of attention. County profiles may include such information as:

- Trend in cholera occurrence over the past 10 years
- Cumulative disease burden and incidence over the past 10 years
- Population access to improved water and sanitation
- Poverty headcount ratio
- Heath facility performance in submitting weekly cholera reporting forms on time
- NGO's and other partners supporting WASH and cholera-specific activities in the county
- Levels of investment in WASH activities from governmental and non-governmental sources in the county

It is also advisable to map locations of past cholera outbreaks in order to identify high-risk areas within counties. There is data available from 2009 and 2010 line lists to map cases by village or urban neighborhood within many of the affected counties. There is also high quality open source mapping software that can be downloaded from the internet at no cost. Epi Info and QGIS are just two examples. There is an opportunity for the MOH to provide leadership in building the capacity of county health departments to incorporate mapping in the analysis of surveillance data.

5. Intensify poverty reduction efforts in order to improve cholera prevention.

This study and others have shown a relationship between poverty and cholera. Although the link between poverty and cholera is not fully understood, it is reasonable to conclude that poverty influences more proximal risk factors for cholera like access to adequate sanitation, access to safe drinking water, and general hygiene conditions in the home and the surrounding environment. Identification of an association between poverty and cholera suggests that policies and programs aimed at alleviating poverty are likely to contribute to prevention of cholera. One of the great hopes of devolution is that it will result in more equitable distribution of resources that will enable communities to further their development. There is an opportunity now for county governments to reduce poverty among their constituents and promote development through strategic allocation of resources.

6. Improve cholera case management by ensuring adequate stocks of intravenous (IV) fluids and oral rehydration solution (ORS) and through development of cholera job aids for primary care providers.

Shortages of IV fluids and ORS were reported by health facilities during previous cholera outbreaks. Procurement of medical supplies is now a function of county government, and there has been concern about ensuring a smooth transition of this responsibility. It is important for counties to recognize that maintaining adequate stocks of these basic supplies was a challenge in the past when procurement and distribution of supplies was a national function. There is an opportunity for the Ministry of Health to take a leadership role in reviewing the status of availability of basic medical supplies following this transition of responsibility to county governments. A number of studies have shown low use of ORS at household level in Kenya, which is troubling. A potential area of collaboration for the MOH and county health departments

is to look into the availability of ORS in communities, review current guidelines for use of ORS, and review community health worker training on ORS.

Another issue that came up in this study is the need for cholera job aids for primary health care providers. A number of key informants felt that health care workers were not well prepared for the 2007-2010 cholera outbreaks. Simple job aids may be effective in raising cholera awareness among health care workers and in providing key guidance for case management. It would be appropriate for the MOH to take a leading role in developing job aids, and this would be a beneficial form of technical assistance to counties.

7. Improve routine communication between the Ministry of Health, county health departments, and other stakeholders through use of new technologies and finalize a communication strategy for health emergencies.

Several key informants spoke of the need to improve routine communication during times of no outbreaks. This would build relationships and improve preparedness for disease outbreaks or other public health emergencies. The first National Health and Leadership Congress took place in February 2015. This was a major event that brought together the Ministry of Health and county health officials to address current issues in a devolved health system. This is an important forum for exchange of ideas and information between national and county government and amongst county governments. There are of course other meetings between the MOH and county health officials organized by various departments for specific purposes. And when there are disease outbreaks frequent meetings are organized to respond to the immediate emergency. At times costs related to travel and venues can be a prohibiting factor for establishing a regular schedule of meetings. Although the value of in-person meetings is recognized and was highlighted by key informants, creative solutions are needed to ensure regular communication.

One area that could be dramatically improved upon is ICT infrastructure for linking the MOH and county health departments. Given the need for rapid communication and information sharing during disease outbreaks, there must be further investment in ICT infrastructure. Current systems are weak. Besides improving reliability and capacity of basic internet services, there is also great opportunity for improving video conferencing and conference calling capabilities. Kenya is a regional hub for ICT with relatively fast internet speeds at relatively reasonable costs compared to many other African countries. There is good mobile network coverage of voice and data services across the country and more than 31 million mobile subscriptions among a population of approximately 40 million people. There may be potential to use government investment to leverage additional funds through the Global Health Security Agenda. Goals of this new initiative include strengthening and linking global networks for real-time bio-surveillance and establishing Emergency Operations Centers with access to real-time information systems.

The need for a communications strategy for health emergencies also emerged in this study. Managing communication effectively is a critical component for the success of any outbreak response. Disease outbreaks can create panic, and the public needs clear and consistent communication from a trusted source. The public will look to national and local health authorities for guidance. The MOH and county health departments can easily lose credibility if communications are not managed well, and this hinders the response. Regarding crisis and emergency risk communications, the CDC recommends to public health agencies, "Be first. Be right. Be credible."[89] There are a number of resources available from the internet on crisis and emergency risk communications in the context of public health. One example is the materials available from the CDC's website emergency.cdc.gov/cerc. It is a great risk for the MOH to

operate without a formal communication strategy. This issue rises to the highest levels of the Ministry of Health, and there is a great opportunity here for senior leaders to ensure that a communication strategy is put in place.

The plan for change

Kenya is still in a transition phase with implementation of devolution. This change in the structure of government administration was embarked upon with the belief that the change would improve the lives of the Kenyan people. The Ministry of Health is called upon to redefine its functions and to find effective ways to collaborate with county governments in promoting health. The discussion that follows sets out some recommendations for how the Ministry of Health and county governments can collaborate to promote issues of public health importance like the prevention and control of cholera and other infectious diseases. This discussion also includes specific actions the investigator proposes to take to contribute to the change process.

Devolution transferred power and resources to county governments. One concern among advocates for health is whether county governments will allocate sufficient financial resources for health. This concern is not unique to Kenya's devolved system of government, but rather reflects a challenge that existed prior to devolution and a challenge faced by health systems in many countries of the world. In 2001 heads of state of African Union countries met in Abuja, Nigeria and pledged to increase government spending on health to at least 15% of the annual budget. Ten years following the Abuja Declaration, only one African country, Tanzania, had met this target. [90] Advocating for public health prevention programs can be particularly challenging since the results of successful programs, i.e. absence of disease, are often not well publicized or recognized.

How can the Ministry of Health influence county governments to prioritize issues like cholera prevention in their budgets? The constitution recognizes the two levels of government as equals, and the old model in which the Ministry of Health had control over financial and human resources at sub-national level and the authority to decide how to use those resources no longer exists. The question now is how to exert influence over those whom one has no direct authority. Power and influence do not stem from formal authority alone.[91] The Ministry of Health leads the nation on issues related to health. The Ministry of Health has technical experts within the organization and the ability to engage technical experts from other organizations. This expertise can be used to exert influence in the form of rational persuasion. Rational persuasion uses facts and logical arguments to show that a proposal is feasible and relevant for meeting goals.[91] One way in which the MOH can be effective in this respect is by collecting data and transforming that data into information that can be shared with decision makers. Collaboration between national and county governments is a fundamental element of devolution moving forward. Collaboration can also be an influence tactic. With this type of influence one party offers to provide necessary resources and assistance while the target party agrees to carry out a proposal.[91] As a result, collaboration is a joint effort to carry out a common objective. In the context of cholera prevention and control, one example of collaboration would be leveraging funding at national level for strengthening surveillance accompanied by a commitment of county resources for personnel, infrastructure, and personnel training.

Kotter's eight steps for leading change is a useful framework for examining how the Ministry of Health, in collaboration with county governments, can ensure that cholera prevention is advanced within a devolved health structure. This change model assumes that change is a process that goes through a series of steps and that typically requires a considerable commitment

of time. [92] It is anticipated that critical mistakes at any point in the process can have devastating effects on the overall progression of change.

Step 1: Establish a sense of urgency

In order to draw attention to cholera it is necessary to establish a sense of urgency. This is an opportune time to do so with cholera in the headlines in Kenyan newspapers. The Ministry of Health can make the facts available about the magnitude of the current crisis and the vulnerabilities exposed by previous outbreaks. This information can be used to initiate frank discussion about the public health threat that cholera continues to pose in Kenya. Even if cholera recedes from the headlines, the case for urgency can be made. Discussions should point out the unpleasant reality that while the country aims to achieve middle income status by 2030, many Kenyans are being left behind and do not even have a decent toilet or clean water to drink. Cholera is a disease of poverty and should not be allowed to persist in a country aspiring to the level of development that Kenya is moving towards. It is recognized that cholera is not a threat in all parts of Kenya. This should be made clear through dissemination of factual information so that individual counties can make informed decisions.

Step 2: Form a powerful guiding coalition

In order for a change effort to be successful, it is important to get enough people involved in guiding the effort, and it is important to involve people in positions of power. In the case of cholera prevention it is not likely to be sufficient for one department within the MOH or one county health department to lead the effort. Those who want to see change should seek to engage senior leaders in the MOH and other appropriate government ministries, county governors, county health officials, and leaders within civil society. Enlisting the support of a few county governors may be particularly effective as these individuals may be able to influence their

counterparts in other counties. The MOH already has strong relationships with a number of key stakeholders, like WHO, UNICEF, CDC, MSF, and the Kenya Red Cross, who can be powerful allies in advancing support for cholera prevention efforts. Monitoring the progress of current programs and sharing accurate information on achievements is important for leveraging additional resources from these supporters.

Step 3: Create a vision

In order to lead change it is necessary to have a clear, simple, and compelling vision. What does the team leading the effort envision for the future? Should the vision be specific to cholera or encompass a broader range of infectious or epidemic-prone diseases? One example of a vision statement is the Ministry of Health's vision of "a healthy, productive and globally competitive nation."[93] There is no simple formula for developing the perfect vision, but it should be simple, clear, and concise. It will serve as a unifying principle to guide the actions taken in the change effort. Developing an effective vision is not a simple process, and leaders should expect to invest time in this process.

Step 4: Communicate the vision

Just as important as developing a vision is being able to communicate that vision. A leader is more likely to be effective in communicating a vision when it is simple, clear, and concise. Imagine being in an elevator with an influential county governor. You have only a few minutes to communicate your vision. A good vision can be communicated in 5 minutes or less with the target person acknowledging understanding and interest. It is a good idea to have an "elevator speech" prepared. Kotter recommends using every vehicle possible for communicating the vision. In this case, this can be more effective when various members of the guiding

coalition are committed to communicating the vision and can do this in their respective organizations and forums.

Step 5: Empower others to act on the vision

Some ways in which the Ministry of Health can empower others to implement change that will reduce the burden and threat of cholera are by providing information, providing technical assistance, establishing policies and guidelines that create an enabling environment, and by leveraging resources from other organizations. Formal adoption of CLTS as a national strategy for eliminating open defecation is one example of a way in which the MOH has created an enabling environment. A comparable strategy or campaign for promoting safe drinking water would be beneficial. In empowering others it is also important to identify obstacles to achieving the vision and to then remove those obstacles. What are the obstacles to preventing cholera? Funding? Lack of water and sanitation infrastructure? Behaviors? Lack of knowledge? It is important to take the time to critically analyze the situation using best available evidence in order to identify the key obstacles. Once they have been clearly identified, actions can be taken to remove them.

Step 6: Plan for and create short-term wins

Visible success is a motivating factor. It is important to plan short-term goals that can achieve quick wins that will keep the momentum going. CLTS is one example of an intervention that has short-term wins built into it. One element of CLTS is celebration of villages that achieve ODF status. This is a reward for the successful village and a motivating factor for other villages. It is important for CLTS programs in Kenya to ensure adequate resources to verify and certify villages that claim ODF status. If verification and certification do not take place, this

program will lose momentum. County governments can play a critical role in recognizing villages for their accomplishments.

It is also possible to devise a way to reward facilities, sub-counties, and counties for improving their reporting rates in submitting routine surveillance reports. This information is tracked by the MOH Disease Surveillance and Response Unit and reported in the Weekly Epidemiological Bulletin. There must be a creative way of highlighting and motivating excellent performance in reporting.

Step 7: Consolidate improvements and produce more change

The change process may take several years, and a common pitfall to producing lasting change is to assume victory too early. This pitfall may be a particular threat to cholera prevention and control, since cholera is a rare disease that does not occur every year. Kenya experienced large outbreaks in 1997-1999 and 2007-2010. It is not well understood why cholera is prevalent in some years and not in other years, but it is likely there are influencing climatic factors. It is tempting in the intervening years when there are low numbers of sporadic cases to conclude that cholera has been controlled. This can create a sense of complacency. Then communities and public health officials are taken by surprise when cholera reemerges again. One approach to maintaining the momentum for change is to make use of the fact that most programs that contribute to cholera prevention and control have an impact on a wide range of infectious diseases. CLTS is one example. Publicizing the short-term wins from this program will help to maintain momentum and support for the program. CLTS is not a cholera-specific program and its benefits to public health are communicated in much broader terms. The challenge of trying to sustain cholera-specific change efforts in years when there is very little

cholera in Kenya is a reason to focus advocacy on strategies with wider public health benefits like CLTS, IDSR, and strengthening laboratory systems.

Step 8: Institutionalize new approaches

In order for a change effort to be sustained it must become part of organizational culture. Formal adoption and endorsement of strategies is one approach for incorporating change into organizational culture. The MOH has done this through adoption of key strategies like IDSR and CLTS. Core strategies can remain relevant and useful by updating them to accommodate new changes. A good example is the IDSR strategy that was updated in 2012 and serves as the foundation for implementation of the IHR 2005 requirements. The opportunity now with a devolved health system is to build commitment to these and other national strategies within the counties. One important way to build this commitment is to document the achievements of these strategies and to disseminate that information.

The investigator's role in advocating for change

I selected cholera in Kenya as a dissertation topic for two reasons: 1) cholera is a classic public health problem that can and should be controlled in parts of the world that are still susceptible to outbreaks, and 2) I am a CDC employee assigned to Kenya, and I wanted to do research that will make a difference for the Kenyan people. I designed the study with a co-investigator in the Ministry of Health to help ensure that the results will be relevant and useful to the Government of Kenya. For the key informant interviews I engaged knowledgeable and influential individuals from key organizations involved in cholera prevention and control in Kenya. The results of this study have been shared with key informants, and their feedback has been taken into account in developing the recommendations of the study. I will use the relationships I have built in the course of this study to advocate for cholera as a priority. I will

condense this dissertation into a final report to share with the Ministry of Health and the key informants. I will advocate with the Ministry of Health to make this information publicly available. In particular, I will advocate for presentation of these results to county health officials at the National Health Congress forum. My co-investigator and I intend to publish the results of this study in a professional journal.

At CDC I have already been involved in helping to set the necessary groundwork to enable transfer of Global Health Security funds to the Ministry of Health when these funds become available. I have also contributed to improving the public health infrastructure in Kenya through overseeing construction of a new national public health laboratory in Nairobi, a county hospital laboratory in Kisumu, and a new Ministry of Health administration building in Nairobi that includes conference rooms with videoconferencing capability.

I intend to further pursue the possibility of a study to investigate whether villages that have achieved open defecation free status in Western Kenya are at lower risk of cholera in the current outbreak. This could be a good project for a resident in Kenya's Field Epidemiology and Laboratory Training Program (FELTP), which is supported by CDC. I also plan to engage CDC's communication specialist and emergency preparedness and response specialist to further explore the opportunities for supporting the Ministry of Health in developing a risk communication plan.

Conclusion

The process described by Kotter's change model is presented in eight steps, but this should be viewed as an iterative process. A lot of work has been done in Kenya to improve cholera prevention and control, and it is recognized that there is a history of change. The model is presented as guidance for provoking thought on specific actions that may be taken to advance

the change process. There are existing strategies that should continue to be supported, and there are opportunities for improvement. Cholera has not been eliminated from Kenya, and the devolved system of government presents an opportunity for the Ministry of Health and county governments to work together on addressing this important public health issue.

APPENDIX A: DISTRICTS, COUNTIES, PROVINCES, AND CONSTITUENCIES

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Nairobi	Nairobi West	Nairobi	Nairobi	Dagoretti South, Langata, Kibera
	Nairobi East	Nairobi	Nairobi	Embakasi South, North, Central, East and West, Makadara
	Nairobi North	Nairobi	Nairobi	Roysambu, Kasarani, Ruaraka, Kamukunji, Starehe, Mathare
	Westlands	Nairobi	Nairobi	Westlands, Dagoretti North
Nyandarua North	Nyandarua North	Nyandarua	Central	Ol Kalou, Ol Jorok, Ndaragwa
Nyandarua South	Nyandarua South	Nyandarua	Central	Kinangop, Kipipiri
Nyeri North	Nyeri North	Nyeri	Central	Kieni, Mathira
Nyeri South	Nyeri South	Nyeri	Central	Tetu, Othaya, Mukurweini, Nyeri Town
Kirinyaga	Kirinyaga	Kirinyaga	Central	Mwea, Gichuga, Ndia, Kirinyaga Central
Murang'a North	Murang'a North	Murang'a	Central	Kangema, Mathioya, Kiharu
Murang'a South	Murang'a South	Murang'a	Central	Kigumo, Maragwa, Kandara
Kiambu	Kiambu	Kiambu	Central	Kiambu, Kiambaa
Kikuyu	Kikuyu	Kiambu	Central	Kikuyu, Kabete
Limuru	Limuru	Kiambu	Central	Limuru
Lari	Lari	Kiambu	Central	Lari
Githunguri	Githunguri	Kiambu	Central	Githunguri
Thika	Thika East	Kiambu	Central	Thika Town
	Thika West	Kiambu	Central	Juja
Ruiru	Ruiru	Kiambu	Central	Ruiru
Gatanga	Gatanga	Muranga	Central	Gatanga
Gatundu	Gatundu	Kiambu	Central	Gatundu South, Gatundu North
Mombasa	Mombasa	Mombasa	Coast	Kisauni, Mvita, Nyali
	Kilindini	Mombasa	Coast	Changamwe, Likoni, Jomvu
Kwale	Kwale	Kwale	Coast	Matuga
Kinango	Kinango	Kwale	Coast	Kinango

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Msambweni	Msambweni	Kwale	Coast	Msambweni, Lunga Lunga
Kilifi	Kilifi	Kilifi	Coast	Ganze, Kilifi North, Kilifi South
Kaloleni	Kaloleni	Kilifi	Coast	Kaloleni, Rabai
Malindi	Malindi	Kilifi	Coast	Malindi & Magarini
Tana River	Tana River	Tana River	Coast	Bura & Galole
Tana Delta	Tana Delta	Tana River	Coast	Garsen
Lamu	Lamu	Lamu	Coast	Lamu East, Lamu West
Taita	Taita	Taita Taveta	Coast	Mwatate, Wundanyi, Voi
Taveta	Taveta	Taita Taveta	Coast	Taveta
Marsabit	Marsabit	Marsabit	Eastern	Saku
	Chalbi	Marsabit	Eastern	North Horr
	Laisamis	Marsabit	Eastern	Laisamis
Moyale	Moyale	Marsabit	Eastern	Moyale
Isiolo	Isiolo	Isiolo	Eastern	Isiolo North
	Garbatulla	Isiolo	Eastern	Isiolo South
Meru Central	Meru Central	Meru	Eastern	Central Imenti
Imenti North	Imenti North	Meru	Eastern	North Imenti, Buuri
Imenti South	Imenti South	Meru	Eastern	South Imenti
Meru South	Meru South	Tharaka	Eastern	Chuka/Igambangombe
Maara	Maara	Tharaka	Eastern	Maara
Igembe	Igembe	Meru	Eastern	Igembe North, Igembe South, Igembe Central
Tigania	Tigania	Meru	Eastern	Tigania West, Tigania East
Tharaka	Tharaka	Tharaka	Eastern	Tharaka
Embu	Embu	Embu	Eastern	Manyatta, Runyenjes
Mbeere	Mbeere	Embu	Eastern	Mbeere South, Mbeere North
Kitui	Kitui	Kitui	Eastern	Kitui West, Kitui Central, Kitui East, Kitui Rural
	Mutomo	Kitui	Eastern	Kitui South

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Mwingi	Mwingi	Kitui	Eastern	Mwingi West, Mwingi Central
Kyuso	Kyuso	Kitui	Eastern	Mwingi North
Machakos	Machakos	Machakos	Eastern	Kathiani, Mavoko, Machakos Town
Mwala	Mwala	Machakos	Eastern	Mwala
Yatta	Yatta	Machakos	Eastern	Yatta, Masinga
Kangundo	Kangundo	Machakos	Eastern	Kangundo, Matungulu
Makueni	Makueni	Makueni	Eastern	Kaiti, Makueni
	Mbooni	Makueni	Eastern	Mbooni
Kibwezi	Kibwezi	Makueni	Eastern	Kibwezi West, Kibwezi East
Nzaui	Nzaui	Makueni	Eastern	Nzaui
Garissa	Garissa	Garissa	North Eastern	Garissa Township, Balambala
Lagdera	Lagdera	Garissa	North Eastern	Lagdera, Dadaab
Fafi	Fafi	Garissa	North Eastern	Fafi
Ijara	Ijara	Garissa	North Eastern	Ijara
Wajir	Wajir South	Wajir	North Eastern	Wajir South
	Wajir North	Wajir	North Eastern	Wajir North
	Wajir East	Wajir	North Eastern	Wajir East, Tarbaj
	Wajir West	Wajir	North Eastern	Wajir West, Eldas
Mandera	Mandera Central	Mandera	North Eastern	Mandera North, Mandera South
	Mandera East	Mandera	North Eastern	Mandera East, Lafey
	Mandera West	Mandera	North Eastern	Mandera West, Banissa
Siaya	Siaya	Siaya	Nyanza	Ugenya, Ugunja, Alego Usongo, Gem
Bondo	Bondo	Siaya	Nyanza	Bondo
Rarieda	Rarieda	Siaya	Nyanza	Rarieda
Kisumu	Kisumu East	Kisumu	Nyanza	Kisumu East, Kisumu Central
	Kisumu West	Kisumu	Nyanza	Kisumu West, Seme
Nyando	Nyando	Kisumu	Nyanza	Nyando, Muhoroni, Nyakach

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Homa Bay	Homa Bay	Homa Bay	Nyanza	Homa Bay Town, Ndhiwa, Rangwe
Suba	Suba	Homa Bay	Nyanza	Suba North, Suba South
Rachuonyo	Rachuonyo	Homa Bay	Nyanza	Kasipul, Kabondo Kasipul, Karachuonyo
Migori	Migori	Migori	Nyanza	Suna East, Suna West, Nyatike
Rongo	Rongo	Migori	Nyanza	Rongo, Awendo, Uriri
Kuria West	Kuria West	Migori	Nyanza	Kuria West
Kuria East	Kuria East	Migori	Nyanza	Kuria East
Kisii Central	Kisii Central	Kisii	Nyanza	Kitutu Chache North, Kitutu Chache South
Kisii South	Kisii South	Kisii	Nyanza	Bonchari
Masaba	Masaba	Kisii	Nyanza	Nyaribari Masaba, Nyaribari Chache
Gucha	Gucha	Kisii	Nyanza	Bomachoge Borabu, Bobasi, Bomachoge Chache
	Gucha South	Kisii	Nyanza	South Mugirango
Nyamira	Nyamira	Nyamira	Nyanza	West Mugirango, North Mugirango
Manga	Manga	Nyamira	Nyanza	Kitutu Masaba
Borabu	Borabu	Nyamira	Nyanza	Borabu
Turkana	Turkana Central	Turkana	Rift Valley	Turkana Central, Loima
	Turkana North	Turkana	Rift Valley	Turkana North, Turkana West
	Turkana South	Turkana	Rift Valley	Turkana South, Turkana East
West Pokot	West Pokot	West Pokot	Rift Valley	Kapenguria, Pokot South
Pokot North	Pokot North	West Pokot	Rift Valley	Kacheliba
Pokot Central	Pokot Central	West Pokot	Rift Valley	Sigor
Samburu Central	Samburu Central	Samburu	Rift Valley	Samburu West
Samburu East	Samburu East	Samburu	Rift Valley	Samburu East
Samburu North	Samburu North	Samburu	Rift Valley	Samburu North
Trans Nzoia West	Trans Nzoia West	Trans Nzoia	Rift Valley	Saboti, Kiminini
Trans Nzoia East	Trans Nzoia East	Trans Nzoia	Rift Valley	Cherangany
Kwanza	Kwanza	Trans Nzoia	Rift Valley	Kwanza, Endebess

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Baringo Central	Baringo Central	Baringo	Rift Valley	Baringo Central, Baringo South
Baringo North	Baringo North	Baringo	Rift Valley	Baringo North
East Pokot	East Pokot	Baringo	Rift Valley	Tiaty
Koibatek	Koibatek	Baringo	Rift Valley	Mogotio, Eldama Ravine
Eldoret West	Eldoret West	Uasin Gishu	Rift Valley	Soy, Turbo
Eldoret East	Eldoret East	Uasin Gishu	Rift Valley	Moiben, Ainabkoi
Wareng	Wareng	Uasin Gishu	Rift Valley	Kapseret, Kesses
Marakwet	Marakwet	Elgeyo-Marakwet	Rift Valley	Marakwet East, Marakwet West
Keiyo	Keiyo	Elgeyo-Marakwet	Rift Valley	Keiyo North, Keiyo South
Nandi North	Nandi North	Nandi	Rift Valley	Mosop
Nandi Central	Nandi Central	Nandi	Rift Valley	Chesumei, Emgwen
Nandi East	Nandi East	Nandi	Rift Valley	Nandi Hills
Nandi South	Nandi South	Nandi	Rift Valley	Aldai
Tinderet	Tinderet	Nandi	Rift Valley	Tinderet
Laikipia North	Laikipia North	Laikipia	Rift Valley	Laikipia North
Laikipia East	Laikipia East	Laikipia	Rift Valley	Laikipia East
Laikipia West	Laikipia West	Laikipia	Rift Valley	Laikipia West
Nakuru	Nakuru	Nakuru	Rift Valley	Rongai, Nakuru Town West, Nakuru Town East
Nakuru North	Nakuru North	Nakuru	Rift Valley	Subukia, Bahati
Naivasha	Naivasha	Nakuru	Rift Valley	Naivasha, Gilgil
Molo	Molo	Nakuru	Rift Valley	Molo, Njoro, Kuresoi South, Kuresoi North
Narok North	Narok North	Narok	Rift Valley	Narok North, Narok East
Narok South	Narok South	Narok	Rift Valley	Narok South, Narok West
Trans Mara	Trans Mara	Narok	Rift Valley	Kilgoris, Emurua Dikirr
Kajiado Central	Kajiado Central	Kajiado	Rift Valley	Kajiado Central, Kajiado East
Loitoktok	Loitoktok	Kajiado	Rift Valley	Kajiado South
Kericho	Kericho	Kericho	Rift Valley	Ainamoi, Belgut, Sigowet/Soin

137 DISTRICTS FOR REGRESSION ANALYSIS	158 DISTRICTS IN 2009 CENSUS	COUNTY	PROVINCE	CONSTITUENCY
Kipkelion	Kipkelion	Kericho	Rift Valley	Kipkelion East, Kipkelion West
Buret	Buret	Bomet	Rift Valley	Konoin, Bureti
Sotik	Sotik	Bomet	Rift Valley	Sotik
Bomet	Bomet	Bomet	Rift Valley	Chepalungu, Bomet East, Bomet Central
Kajiado North	Kajiado North	Kajiado	Rift Valley	Kajiado North, Kajiado West
Kakamega Central	Kakamega Central	Kakamega	Western	Lurambi, Navakholo
Kakamega South	Kakamega South	Kakamega	Western	Ikolomani
Kakamega North	Kakamega North	Kakamega	Western	Malava
Kakamega East	Kakamega East	Kakamega	Western	Shinyalu
Lugari	Lugari	Kakamega	Western	Lugari, Likuyani
Vihiga	Vihiga	Vihiga	Western	Vihiga, Sabatia
Emuhaya	Emuhaya	Vihiga	Western	Luanda, Emuhaya
Hamisi	Hamisi	Vihiga	Western	Hamisi
Mumias	Mumias	Kakamega	Western	Mumias East, Mumias West, Matungu
Butere	Butere	Kakamega	Western	Butere, Khwisero
Bungoma	Bungoma South	Bungoma	Western	Bumula, Kanduyi
	Bungoma East	Bungoma	Western	Webuye East, Webuye West
Bungoma North	Bungoma North	Bungoma	Western	Kimilili, Tongaren
Bungoma West	Bungoma West	Bungoma	Western	Sirisia, Kabuchai
Mt Elgon	Mt Elgon	Bungoma	Western	Mt Elgon
Busia	Busia	Busia	Western	Nambale, Matayos, Butula
Teso	Teso North	Busia	Western	Teso North
	Teso South	Busia	Western	Teso South
Samia	Samia	Busia	Western	Funyula
Bunyala	Bunyala	Busia	Western	Budalangi

APPENDIX B: KEY INFORMANT INTERVIEW GUIDE

Introduction

The purpose of this interview is to learn about the successes and challenges of cholera prevention and control in Kenya from your perspective. Eleven professionals with expertise in cholera prevention and control in Kenya will participate in the interviews. The interview will take about 45 minutes. The interview will be completely confidential, and your name will not be connected to your responses in any way. Any information that you provide will be released only as group summaries. With your permission I would like to record our interview. Tape recordings and transcriptions of the interview will be stored in a secure location and destroyed upon completion of this study. Do you have any questions about the research study or the interview before we begin? May I record the interview?

Opening

1. What roles and responsibilities have you had related to cholera prevention and control?
2. How long have you been involved in activities related to cholera prevention and control?
    a. *[Probe] How long overall and how long in Kenya specifically?*

Topic Area 1: Interventions

I would like to ask you about interventions that have been implemented in Kenya to prevent or control cholera.

3. What interventions do you think have been particularly effective in preventing or controlling cholera in Kenya?
    a. *[Probe] What contributed to their effectiveness?*
4. What information is available for evaluating the effectiveness of interventions?
5. What new interventions, if any, do you think should be implemented in Kenya and why?

5a. Are you familiar with oral cholera vaccines and WHO's stockpile?

5b. Has there been consideration of using this vaccine in Kenya, and do you see any barriers to implementation?

Topic Area 2: Policies and strategies

I now have a few questions about policies and strategies related to cholera prevention and control. These may be policies and strategies specific to cholera, or they may be broader public health policies and strategies.

6. What policies or strategies have contributed to successful prevention and control of cholera in Kenya?
    a. *[Probe] Kenyan government policies or strategies, these may be national, regional, or local*
    b. *[Probe] Other policies or strategies, these may be international or organization-specific*
    c. *[Probe] How does the policy or strategy contribute to success?*
7. What weaknesses do you see in existing policies and strategies or their implementation?
8. What suggestions do you have for improving cholera prevention and control through policy and strategy formulation?

Topic Area 3: Data for decision-making

I would like to ask you about the availability of data for decision-making.

9. What data is available to decision makers to enable informed decisions on cholera prevention and control strategies?
10. What data is lacking for informed decision-making?

Topic Area 4: Communication and coordination

I would like to ask you some questions about communication and mechanisms of coordination among organizations engaged in cholera prevention and control in Kenya.

11. How does your organization communicate with other organizations that are involved in cholera prevention and control activities?
    a. *[Probe] What structures exist for communication and coordination?*
12. What challenges have you seen with respect to communication and coordination among organizations?
13. What suggestions do you have for improving communication and coordination among organizations?

Topic Area 5: Multi-sectoral Cholera Prevention and Control Plan

16. Are you familiar with the Multi-sectoral Cholera Prevention and Control Plan developed by the Ministry of Health with stakeholders?

    If YES, proceed to the next question, if NO, proceed to the next section.
17. What has been achieved by this plan?
18. What challenges exist in implementing this plan?
19. What suggestions do you have for improving implementation of this plan?

Topic Area 6: Devolution

Given that responsibility for health, water, and sanitation services has been devolved to county governments, I would like to ask you a few questions about the implications of devolution with respect to cholera.

20. What opportunities does devolution present for improving cholera prevention and control?

21. What challenges does devolution present to cholera prevention and control?

Closing

We are nearing the close of the interview, but I would like to give you an opportunity to talk about any other successes and challenges of cholera prevention and control in Kenya that we have not already covered.

22. Is there anything else you would like to tell me about cholera prevention and control?

Thank you very much for your time

APPENDIX C: RECRUITMENT LETTER FOR KEY INFORMANT INTERVIEWS

Dear [*insert participant's name*],

My name is Gretchen Cowman, and I am a doctoral candidate at the University of North Carolina in the Gillings School of Global Public Health. I am requesting your participation in a study I am conducting on cholera prevention and control in Kenya. I will be interviewing professionals with expertise in this field. Your participation in the study would involve discussing your opinions on the successes and challenges of cholera prevention and control in Kenya and any recommendations that you may have for improvement. The interview would take place at a time and location convenient for you and will last about 45 minutes.

Background
Kenya experienced widespread cholera outbreaks in 1997-1999 and in 2008-2010. The disease is endemic in Kenya and presents a continuing public health challenge. Few cases of cholera have been reported in Kenya since 2011. This may reflect success in cholera prevention and control efforts, or it may be the result of other factors.

The aim of this study is to describe specific successes and challenges of cholera prevention and control in Kenya identified by experts operating in both the governmental and non-governmental sectors in the country. Topics of particular interest in this study include: cholera interventions, policies and strategies, data for decision-making, communication and coordination, Kenya's 5-year Multi-sectoral Cholera Prevention and Control Plan, and implications of devolution. The goal is to produce information that will be useful to the Government of Kenya and its partners in establishing or strengthening policies and programs that effectively prevent and control cholera.

Disclosure and Protection of Your Privacy
I am a Public Health Advisor with the U.S. Centers for Disease Control and Prevention (CDC) in Nairobi, Kenya. Although the doctoral research I am conducting is not a CDC-funded activity, the results may be used to inform CDC strategy for supporting the Government of Kenya in cholera prevention and control efforts.

The interview will be completely confidential, and your name will not be connected to your responses in any way. Any information that you provide will be released only as group summaries. Information from the interview will be stored in a secure location and destroyed upon completion of this study. In order to establish credibility of the study I would like to list the names of participants in the final report. Your consent to being listed in the final report is completely voluntary, and you may choose to remain anonymous.

Thank you for considering participation in this study. Please confirm if you are willing to participate. Feel free to contact me at gcowman@live.unc.edu or +254 722 721 781 if you have any questions.

Sincerely,
Gretchen Cowman, MSPH, P.E.

APPENDIX D: INFORMED CONSENT FORM

Consent to participate in the research study
University of North Carolina – Chapel Hill

KEMRI Non-SSC 438 / UNC IRB Study No. 13-3399
Consent Form Version Date: May 5, 2014
Title of study: Cholera Prevention and Control in Kenya
Principal Investigator: Gretchen Cowman
Study Contact Telephone Number: +254 722 721 781
Study Contact email: gcowman@live.unc.edu
KEMRI ERC Contact: The Secretary, KEMRI Ethics Review Committee, P.O. Box 54840-00200, Nairobi, Kenya; Telephone numbers 020-2722541, 0722205901, 0733400003; Email address ercadmin@kemri.org
UNC-Chapel Hill Contact: Department of Health Policy and Management; Telephone number 001-919-966-9756; Faculty Advisor: Harsha Thirumurthy, PhD
Funding Source and/or Sponsor: None

What are some general things you should know about research studies?
You are being asked to take part in a research study. To join the study is voluntary.
You may refuse to join, or you may withdraw your consent to be in the study, for any reason, at any time, without penalty.

Research studies are designed to obtain new knowledge. This new information may help people in the future. You may not receive any direct benefit from being in the research study. There also may be risks to being in research studies.

Details about this study are discussed below. It is important that you understand this information so that you can make an informed choice about being in this research study. You will be given a copy of this consent form. You should ask the researchers named above, or staff members who may assist them, any questions you have about this study at any time.

What is the purpose of this study?
The purpose of this research study is to learn about the successes and challenges of cholera prevention and control in Kenya. The information will be used to assist the Government of Kenya and its partners in establishing or strengthening policies and programs that effectively prevent and control cholera. You are being asked to participate in the study because you have professional expertise in cholera prevention and control in Kenya.

How many people will be interviewed for this study?
If you decide to be interviewed for this study, you will be one of approximately 9 people interviewed for this research study.

How long will your part in this study last?
If you decide to be interviewed for this study, you will be asked to meet in-person or by telephone for a 45-minute interview. If you agree, you may also be contacted by e-mail or telephone to address follow up questions or clarifications if needed.

What will happen if you take part in the study?
- You will participate in a 45-minute interview. This is a one-time event, although the researcher may contact you again for clarification of comments made during the interview.
- The interview will be conducted in-person or over the telephone at your convenience.
- The interview will be audio recorded with your permission. You may refuse to answer any question, and you may ask to have the audio recorder turned off at any time.

What are the possible benefits from being in this study?
You may benefit from this study by discovering practical solutions for improving cholera prevention and control in Kenya. The final report from the study will be shared with all participants. It is anticipated that the study will generate information that will be useful to the Government of Kenya and its partners in designing effective prevention and control strategies and programs.

What are the possible risks or discomforts involved from being in this study?
This study is of minimal risk to participants. You will not be pressured to disclose any information that you feel could potentially bring harm to yourself. As with any activity that involves collection of information from individuals, there is a risk of breach of privacy or confidentiality of information. This risk will be minimized by strict adherence to procedures for protecting privacy.

How will your privacy be protected?
The following measures are in place to protect your privacy:
- Your name will not be connected to your responses in any way. Any information that you provide will be released only as group summaries.
- The principal investigator listed on the first page of this form is the only person who will have access to information that links individual participants to the responses from their interviews. Identifying information will be securely stored in a separate location from the information that you provide during the interview.
- Audio recordings, transcripts, and notes will be encrypted and stored on a password-protected computer in a secure location. All data will be destroyed upon completion of the study.

Although every effort will be made to keep research records private, there may be times when federal or state law requires the disclosure of such records, including personal information. This is very unlikely, but if disclosure is ever required, UNC-Chapel Hill will take steps allowable by law to protect the privacy of personal information. In some cases, your information in this research study could be reviewed by representatives of the University, research sponsors, or government agencies for purposes such as quality control or safety.

To contribute to the credibility of this study, the researcher would like to list names and affiliations of participants in the final report. Your name will not be linked in any way to your responses. Consenting to having your name listed in the report is completely voluntary, and you may choose to remain anonymous.

May your name be listed in the report?

_____ YES, it is OK to list my name in the report.
_____ NO, do not list my name in the report.

In order to ensure accurate recording of your responses, the researcher would like to audio record the interview.

May the researcher audio record the interview?

_____ YES, it is OK to audio record the interview.
_____ NO, it is not OK to audio record the interview.

Will you receive anything for being in this study?
You will not receive anything for taking part in this study.

Will it cost you anything to be in this study?
Other than your time, there will be no costs for participating in the study.

What if you have questions about this study?
You have the right to ask, and have answered, any questions you may have about this study. If you have questions, or concerns, you **may contact the Principal Investigator at +254 722 721 781.**

What if you have questions about your rights as a research participant?
All research with human volunteers is reviewed by a committee that works to protect your rights and welfare. If you have questions or concerns about your rights as a research participant you may contact, anonymously if you wish, **the KEMRI ERC: The Secretary, KEMRI Ethics Review Committee, P.O. Box 54840-00200, Nairobi, Kenya; Telephone numbers 020-2722541, 0722205901, 0733400003; Email address ercadmin@kemri.org**. You may also contact the University of North Carolina Institutional Review Board at 001-919-966-3113 or by email to IRB_subjects@unc.edu.

Title of study: Cholera Prevention and Control in Kenya
Principal Investigator: Gretchen Cowman

Participant's Agreement:

I have read the information provided above. I have asked all the questions I have at this time. I voluntarily agree to participate in this research study.

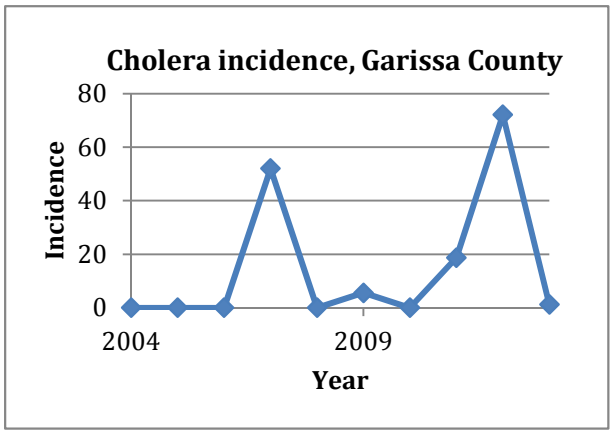
_____ _____
Signature of research participant Date

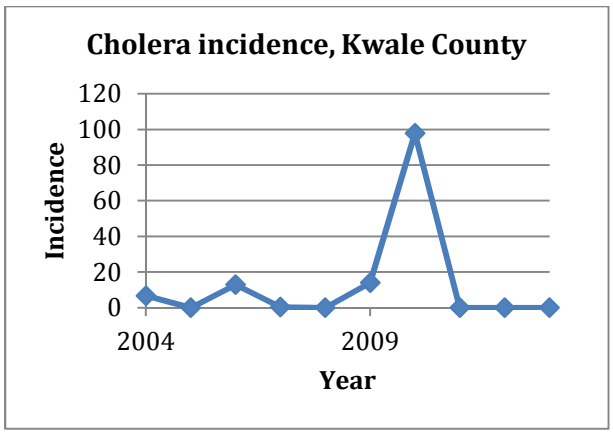
_____
Printed name of research participant

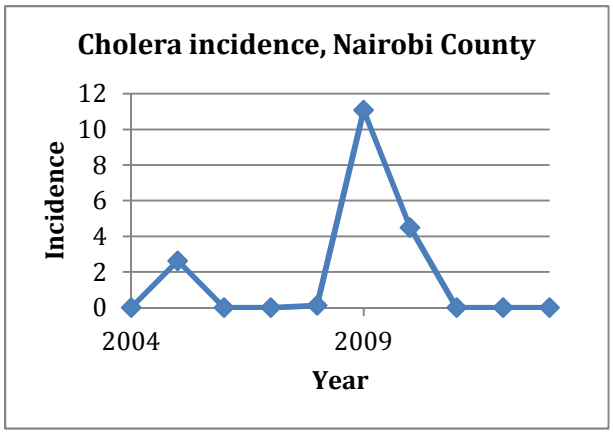
_____ _____
Signature of person obtaining consent Date

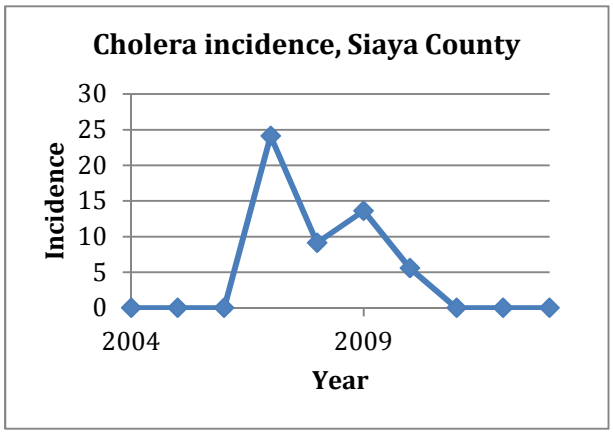
_____
Printed name of person obtaining consent

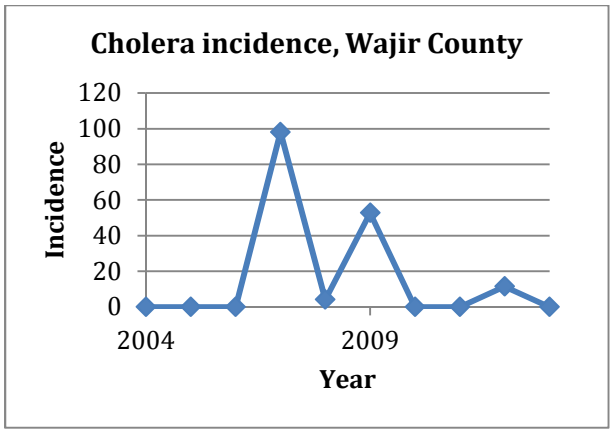
APPENDIX E: TRENDS IN CHOLERA INCIDENCE IN SELECTED COUNTIES OF KENYA, 2004-2013







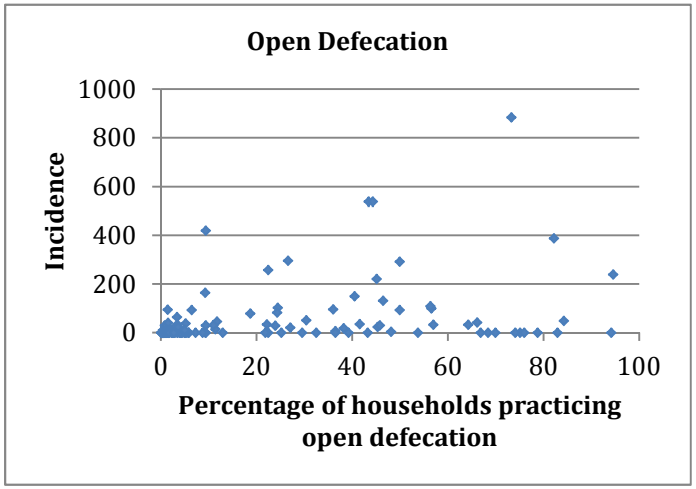


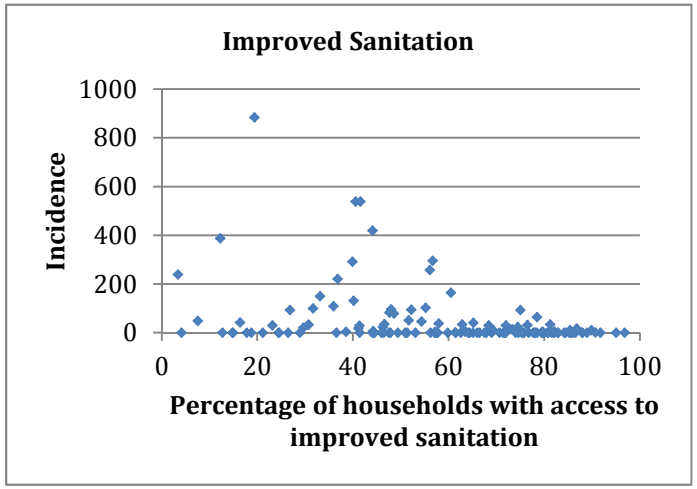


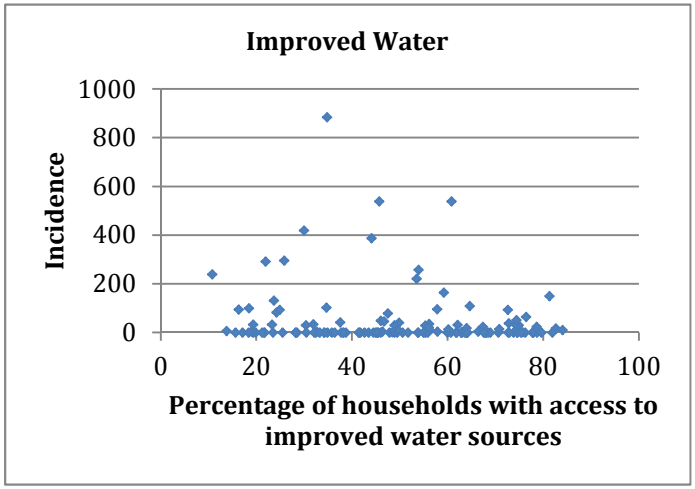
Description: Cholera incidence per 100,000 people in counties reporting cholera in 4 or 5 years during the period 2004-2013.

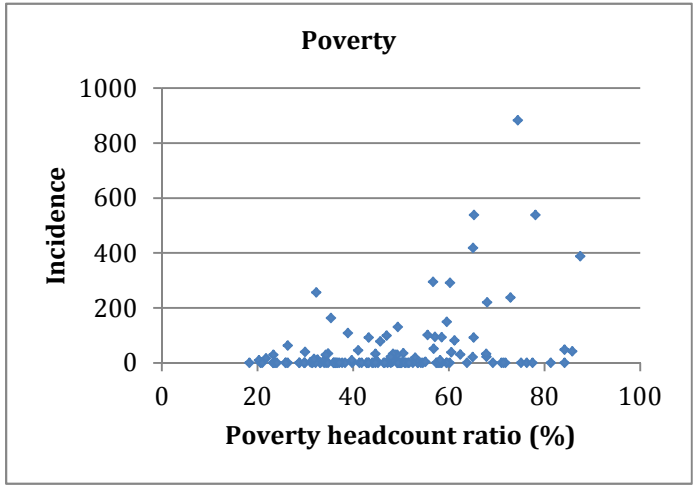
APPENDIX F: SCATTERPLOTS OF CUMULATIVE CHOLERA INCIDENCE VERSUS DEVELOPMENT AND DEMOGRAPHIC INDICATORS

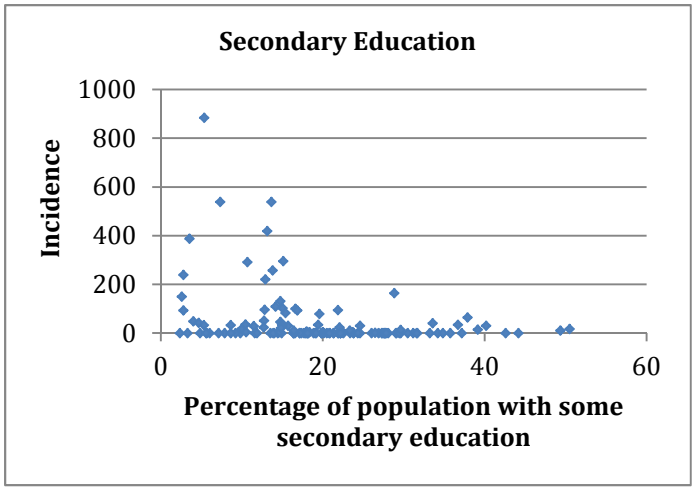
Kenya, 2008-2013, N=137 Districts

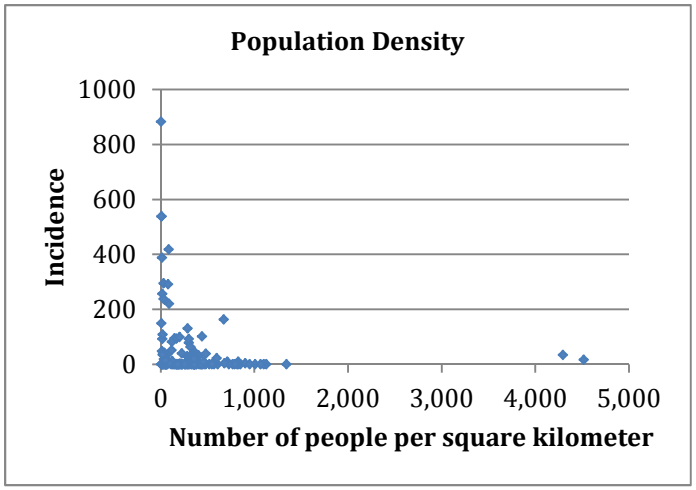


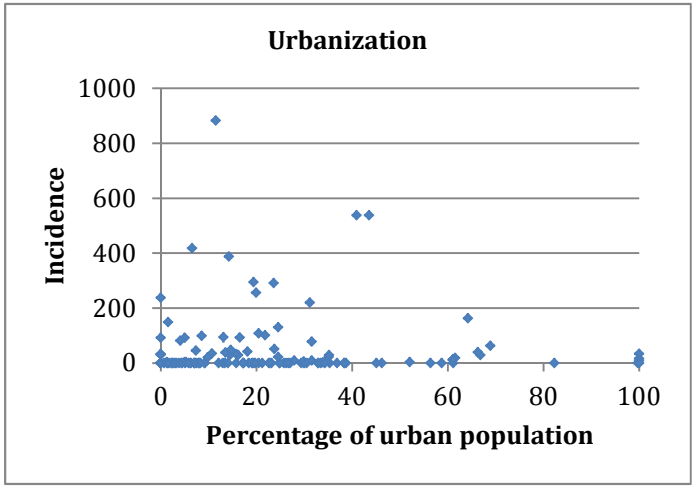


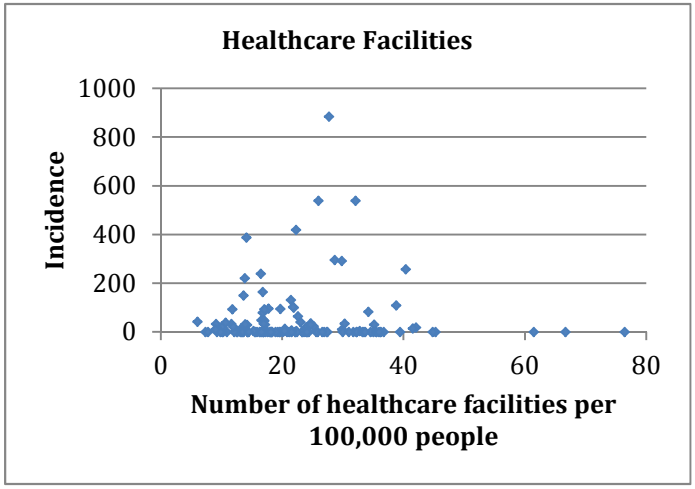





Secondary Education
Incidence
1000
800
600
400
200
0
0
20
40
60
Percentage of population with some secondary education


Population Density
Incidence
1000
800
600
400
200
0
0
1,000
2,000
3,000
4,000
5,000
Number of people per square kilometer


Urbanization
Incidence
1000
800
600
400
200
0
0
20
40
60
80
100
Percentage of urban population


Healthcare Facilities
Incidence
1000
800
600
400
200
0
0
20
40
60
80
Number of healthcare facilities per 100,000 people

APPENDIX G: LIST OF KEY INFORMANTS PARTICIPATING IN INTERVIEWS

Name	Title	Affiliation
Dr. Willis Akhwale	Director, Department of Disease Prevention & Control (former)	Ministry of Health
Dr. Jackson Kioko	Director of Preventive & Promotive Health Services and former Provincial Director of Public Health & Sanitation, Nyanza Province	Ministry of Health
Dr. James Kisia	Deputy Secretary General	Kenya Red Cross
Dr. John Logedi	Director of Health, Taita-Taveta County and former District Medical Superintendent, Kitui District	Taita-Taveta County and Ministry of Health (former)
Dr. Joel Montgomery	Director, Division of Global Health Protection	CDC Kenya
Dr. Ian Njeru	Head, Disease Surveillance & Response Unit	Ministry of Health
Mr. Charles Njuguna	National Professional Officer for Integrated Disease Surveillance & Response	WHO Kenya
Dr. Kepha Ombacho	Director, Public Health	Ministry of Health
Mr. Steven Ongaro	Nurse Expert	Medecins Sans Frontieres
Dr. S. K. Sharif	Director of Public Health & Sanitation (former)	Ministry of Health
Mr. Martin Worth	WASH Specialist	UNICEF Kenya

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