Factors associated with cholera outbreaks, Nairobi County, July 2017: a case control study

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Abstract

Background

Cholera affects 1.3-4 million people globally and causes 21000-143,000 deaths annually. Nairobi County in Kenya reported cholera cases since April 2017. We investigated to identify associated factors and institute control measures.

Methods

We reviewed the line-list of patients admitted at the Kenyatta National referral Hospital, Nairobi and performed descriptive epidemiology. We carried out a frequency-matched case control study, using facility-based cases and community controls. We defined a case as acute onset of watery diarrhoea of at least >3 stools/24hours with or without vomiting in person of any age, admitted in Kenyatta National Hospital as from July 1st, 2017. We calculated odds ratios and their respective 95% confidence intervals. We also took water samples at water reservoirs, distribution and consumer points, and made observation on hygiene and sanitation conditions in the community.

Results

We reviewed 71 line-listed cases; median age 30 years (range 2-86 years); 45 (63%) were male. First case was admitted on 14th April 2017. Culture was performed on 44 cases, 30 (68%) was positive for *Vibrio cholerae*, biotype El-Tor, serotype Ogawa. There were 2 deaths (case fatality ratio 2.8%). Age-group ≥25 years was most affected. Drinking unchlorinated water (aOR 14.57, 95% CI 4.44-47.83), eating in public places (aOR 9.45, 95% CI 3.07-29.12) sourcing water from non-Nairobi city water company source (aOR 4.92, 95% CI 1.56-15.52) and having drank untreated water in the previous week before the outbreak (aOR 3.21, 95% CI 1.12-9.24) were independently associated with being a case in the outbreak. Out of 28 water samples, 4 (14%) had >180 coliforms/100mls; all were at consumer points.

Conclusion

Poor water quality and sanitation were responsible for this outbreak. We recommended adequate, clean water supply to unplanned settlements in Nairobi County, as well education of residents on water treatment at the household level.

Author summary

Cholera, a disease causing outbreaks in areas with low standards of hygiene and sanitation has afflicted humans for millennia. It is caused by a bacterium, *Vibrio Cholerae*, transmitted mainly through water contaminated by faecal matter. The resultant disease is acute watery diarrhoea, which causes death rapidly due to dehydration and shock. Virtually brought under control in the developed world due to improvements in hygiene, the disease still ravages many communities in low and middle income countries, as well as regions affected by conflict or natural disasters. In outbreak situations, rapid response in water treatment, sanitation improvement and setting up of cholera treatment centres for rehydration therapy reduces impact and saves lives. Long-term control can only be achieved through sustainable improvements in sanitation and standards of living. Case control studies in outbreak situations provide quick, actionable information to public health specialists during outbreak response. This study provides a cholera outbreak investigation in an urban informal settlement setting; the approach reported here can guide in outbreak investigations and response in similar settings globally.

Introduction

Cholera is an enteric infection caused by toxigenic *Vibrio cholerae* serogroup O1 and O139 [1]. Cholera is endemic in more than 50 countries globally and causes large epidemics in countries or regions facing complex emergencies including conflict, natural disasters like flooding or drought or massive displacement of persons [2]. It is estimated that every year, 1.3 billion people are at risk, 1.3 to 4 million get infected and 21000 to 143000 deaths occur globally [3]. Up to 90% of infected people continue shedding the bacterium up to 14 days without or with mild symptoms making cholera outbreaks difficult to control [4].

Most cholera outbreaks occur in areas with inadequate supply of potable water and poor sanitation facilities, especially during rainy seasons [5]. Other factors identified as risk factors in previous epidemiological studies done in Kenya include lack of knowledge about cholera, proximity to a large water body, living in a refugee camp and eating food outside the home [6-10]. A cross-district analysis of cholera occurrence also identified open defaecation as a risk factor [11].

Increase in acute watery diarrhoea cases, confirmed to be cholera by culture, was reported in Nairobi County from April 2017 through the Integrated Disease Surveillance and Reporting (IDSR) system. Sporadic cases were reported in May and early June but an upsurge was observed in late June and July 2017. The epicentre of the outbreak was unplanned settlements from the Eastern suburbs of the city; however, cases were also reported in high end hotels and restaurants. Most of the cases were admitted at Kenyatta National Referral Hospital, since an ongoing nurses' industrial action had paralyzed tier one, two and three facilities [12]. The Ministry of Health (MoH) deployed a team comprising of the Disease Surveillance and Response Unit (DSRU), the Kenya Field Epidemiology and Laboratory Training Programme (FELTP), Nairobi County Department of Health, National Public Health Laboratory (NPHL) and the Ministry of Water (MoW) to identify the associated factors and institute control.

Methods

Investigation setting

This investigation was carried out during July 24-28, 2017 in various locations in Nairobi County including the Kenyatta National Hospital (KNH) where most patients were admitted for care and five sub-counties: Embakasi South, Embakasi East, Embakasi West, Mathare and Starehe **(Figure 1)**. These were the sub-counties from which the cases originated from. Nairobi County has an estimated population of 3.5 million residents as of 2016 and 6.5 million with the suburbs included. Approximately 2.5 million of these live in unplanned settlements [13]. The city is divided into 17 sub-Counties, with 12 of them having reported cholera cases during the period Since May 2017.

Retrospective review

We reviewed the cholera line list from KNH up to July 16, 2017. The variables contained in the line list included Sub County of origin, residence (village/estate), age, sex, date of onset/admission/discharge, laboratory status and patient outcome. We conducted descriptive analysis of the updated and consolidated line list, describing the outbreak in terms of place of origin, time of symptoms onset and personal attributes like age and sex.

Case control

We then carried out a frequency matched case control study using facility cases from KNH and community controls from the most affected sub-counties. Cases were matched to controls using age groups (2-4, 5-14, 15-24, >24) years on a ratio of one case to two controls. Two years is the cut-off for cholera case definition in areas with active outbreaks as per the IDSR guidelines [14].

Case definition

We included both probable and confirmed cases in our investigation. A probable case

was defined as acute onset of watery diarrhoea of at least >3 stools/24hours with or without vomiting in a person ≥2 years, admitted in Kenyatta National Hospital as from July 1st, 2017. A confirmed case was culture positive.

Controls were defined as absence of diarrhoea in the preceding 30 days in any randomly selected person of the same age group as a particular case and came from the same Nairobi Sub-counties as cases. We administered verbal screening for symptom and admission questions to any control prior to enrolment into the study.

Inclusion criteria- Those who met the case/control definition and consented verbally to the study.

Sample Size Calculation

Assumptions

We made the following assumptions while calculating the sample size for the study: Power 80%, 21.6% prevalence of exposure for hand washing before meals among controls [15] to detect a least an exposure odds ratio of 3.0, desired two-sided confidence intervals of 95% and a case: control ratio of 1:2. A minimum sample size of 132 (44 cases and 88 controls) was calculated using the Fleiss method [16].

Selection of cases

Cases appearing in the consolidated KNH line list since July 1st, 2017 and still admitted in the hospital were eligible for inclusion in the study. The admission register in cholera treatment ward served as the sampling frame. We used simple random sampling to select the cases, and administered a structured questionnaire through face to face interview. Verbal consent was sought from the cases and legal guardians in case of a minor.

129 **Selection of Controls**

130 For each case we selected two population controls, distributed into five sub-counties.
131 The sub-counties were selected on the basis of the number of cases reported, with the three with
132 the most number of cases and two with the least number of cases. We visited the selected sub-
133 counties, and used the administrative offices of the Sub-counties at as our starting point.
134 Spinning a bottle to choose direction of proceeding, we selected every fifth household for
135 selection of controls. In areas where the direction was interrupted by infrastructural installations
136 like roads or industrial complexes, we spun the bottle a repeat time, to cover the expanse of the
137 unplanned settlements. The resident Community Health Volunteers guided us on the
138 demarcation of various households, due to the high population density in the settlements. We
139 administered a structured questionnaire similar to the one for cases on the demographics and
140 risk factor sections, but without clinical details section. Before the interview, controls were
141 screened for cholera-like symptom history, including diarrhoea, vomiting, abdominal pains, and
142 cholera case in the household, in the previous one month.

143 **Environmental testing**

144 We collected water samples for testing from the Nairobi city water company pipeline
145 system and households, using sterile containers. For the water company system, the testing was
146 done at the water treatment sites/ reservoirs, during piping and selected consumer points.
147 Samples were also collected from conveniently selected control households, from the affected
148 sub-counties, as well as from some public establishments like schools in the affected sub-
149 counties. Analysis of the samples was undertaken at the NPHL. General bacteriological analysis
150 through the most probable number (MPN) was used to estimate faecal coliform count. Levels of
151 residual chlorine were measured using automated colorimetry and physical conductivity tests
152 done [17].

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Data management

Data obtained was entered into a computer database, cleaned and analysed. Measures of central tendency and dispersion for continuous variables and proportions for categorical variables were calculated. We calculated odds of various exposures among the cases and controls and corresponding odds ratios (OR). Factors with a P-value of ≤0.15 [18] at bivariate analysis were included in unconditional logistic regression model, using the forward selection approach. A confidence interval excluding the null value of OR significant in the final model. During logistic regression, the matching variable (age group) was maintained in the model till the end of the analysis.

Ethical considerations

Informed consent was obtained orally from all study participants and recorded in the interview questionnaire; written consent was difficult because the study was conducted during emergency outbreak response. Confidentiality of the information from the participants was maintained at all times. We did not collect any personal identification information, the questionnaires were kept in a locked cabinet during data entry and the computer database created protected by a password, accessible only to the principal investigator. This being a public health emergency response, we did not seek approval of the investigation from an independent research and ethics committee. However, approval was sought from the Ministry of Health and permission to conduct the investigation from the County Government of Nairobi Department of Health.

Results

Retrospective review

The consolidated line list had 71 cases as at July 16, 2017. The median age was 30 years (Inter-quartile range 12.5); 45 (63%) were males. A total of 44 cases had culture done; 30

(68%) were positive. There were 2 deaths, case fatality rate 2.8%. Age group above 25 years was the most affected **(Table 1)**.The three Embakasi Sub-Counties (East, West and South) had the highest number of cases at 25 (36%). The first cholera case was admitted to KNH on April 14, 2017; sporadic cases were admitted in May 2017. Several peaks were observed in late June and early July 2017 **(Figure 2)**.

Case control findings

Mean age was 30.9 years±9.0 years for cases and 28.8 years±9.0 years for controls; 31 (71%) of cases and 30 (33%) of controls were male. Thirty-five cases (80%) and 55 (60%) controls had completed secondary education **(Table 2)**. Most of the cases had presented with watery diarrhoea (98%) and vomiting (80%). The median hospitalization period for the cases was 3 days, range 2-5 days. Only 19 (43%) of the cases sought care within 6 hours initial symptoms.

Bivariate analysis

Cases had 10 times higher odds of using unchlorinated water (OR 10.31, 95% CI 3.96-26.89), nine times higher odds of taking meals at public eating places (OR 8.97, 95% CI 3.52-22.30) and not washing hands after toilet (OR 8.91, 95% CI 2.46-39.62) at bivariate analysis. **(Table 3).**

Multivariate analysis

After controlling for confounders, drinking unchlorinated water (aOR 14.57, 95% CI 4.44-47.83), taking meals at public eating places (aOR 9.45, 95% CI 3.07-29.12) and sourcing drinking water from non-city water company sources (aOR 4.92, 95% CI 1.56-15.52) were independently associated with being a case in the outbreak **(Table 3).**

Water testing and environmental findings

Out of 28 water samples, four (14%) had >180 coliforms/100ml of water; from a restaurant, secondary school kitchen, residential apartments and a public water point. Of the 17

samples that underwent conductivity and residual chlorine testing, all had between 0.4-1.2 ppm (recommended range 0.2-5.0) of residual chlorine and 74.3-87.0µS/cm (recommend range 0-800) on conductivity levels.

Discussion

Our investigation found use of untreated drinking water and taking meals away from home as risk factors in this outbreak in a major urban setting. Association with taking meals at public eating establishments was also a finding during the investigation of protracted outbreaks in Kenya in 2014-2016 [10] and is important in prevention of future urban food-borne outbreaks. Majority of urban residents take at least one meal daily away from their households highlighting importance of safe public eating places. Some of the water samples at consumer points were contaminated.

Cholera outbreaks have affected various counties in Kenya since December 2014 [19]. Water and sanitation is a major factor in cholera transmission in most outbreaks globally [20]. The current outbreak affected relatively younger individuals and males more than females. Males are likely to consume different types of meals regarded as 'high risk' outside the home during occupational ventures, hence predisposing them to higher risk of contracting food borne diseases [21]. The case fatality of 3% for the patients admitted at the referral facility (KNH) is unexpectedly high, with CFR expected to be less than 1% if proper treatment is instituted promptly [22]. This can be explained by several contextual realities affecting both the Nairobi County and National public health system at the time. Nurses were in the middle of an industrial action, therefore all the public dispensaries and health centres were non-functional. Since these usually serve as the avenues for setting up Cholera Treatment Centres (CTC), the resultant effect was delayed proper management and late referral to the national referral hospital. Peaks of cases in June and July were as a result of outbreaks during mass gathering of people on various occasions [23].

On risk factor analysis, using untreated water and taking meals in public eating places were noted as important exposures associated with being a case in the outbreak. Since the epicentre of this outbreak was from informal settlements in the city, contaminated water as well as unhygienic eating places, especially serving casual labourers in the adjacent industries were likely avenues for disease transmission. The affected sub counties boarder the Nairobi city industrial complex, where many young men work as casual labourers and eat from food vendors, a recognized ecological risk factor for the disease [24]. Majority of the residents were getting water that is illegally piped in unhygienic environment, especially in open sewer trenches. Failure to undertake domestic treatment of this water before use is therefore a major point of exposure to many waterborne diseases.

The water sampled from the city water company at holding reservoirs and distribution networks had adequate residual chlorination and conduction levels. Therefore contamination of the four samples likely occurred downstream during transmission to households. This could be caused by illegal connections into the distribution network. Contaminated water is the main vehicle of cholera transmission worldwide and offers opportunities for disease control [25].

We found several gaps in response to the outbreak. First, the initial cases were not fully investigated till the peaks in June and July occurred; this was a lost opportunity since promptly investigating and instituting control measures reduces extent, scope and possibility of propagation of outbreaks [26]. No cholera treatment centres (CTCs) were set up in the affected Sub-counties; patients had to be ferried to the referral facility likely aiding disease transmission. The best practice would have been to treat cholera at the sites of the outbreak. The nurses' strike reduced the effectiveness of the response, and likely contributed to the protracted course of the outbreak. Provision of water to most informal settlements in Nairobi is inadequate; water vendors and illegal connections fill in the gap but expose residents to unpotable water for human consumption.

Cholera control and prevention can be achieved in various ways. Of these, water, sanitation and hygiene improvement are the most effective, with water treatment preventing up to 90% of water borne diseases [27]. Cholera vaccination has only been effective in outbreak situations when offered together with provision of safe water and improving environmental hygiene [28]. Primary prevention in form of sanitizing the environment and provision of safe water are also effective against cholera and other water and food borne diseases.

Our investigation had limitations**.** The sampling of the water was not random, as advised by the WHO [29] therefore may not be representative to the water in use in the settlements from which the cases and controls came from. We also did not manage to tests the water samples for *Cholerae vibrio*, nor did we associate the contaminated water samples with the exact origin of the cases.

Public health action

We supported the Nairobi County Department of Health (CDoH) in setting up and operationalizing CTCs in the two most affected sub-counties, as well as health education and provision of water treatment supplies. We also trained the Community Health Volunteers on first aid and quick response when assisting cholera victims as well as the Sub-County disease surveillance coordinators on proper data capture, management and timely transmission to the DSRU. The communities were sensitized on cholera symptoms, importance of prompt seeking of care if the disease is suspected, importance of water, sanitation and hygiene (WASH) practices and various methods of water treatment.

Conclusion

We confirmed that this cholera outbreak, with epicentres in several informal settlements in Nairobi, was associated with taking untreated water and eating meals at public eating places. Long term control requires investment in improving clean water supply to the informal

283 settlements, in adequate amounts, throughout the year.

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Table 1: Attack rates for different age groups and sex, cholera outbreak in Nairobi County, July 2017

Age	Age group	Number of cases	Total population	Attack rate (per 100,000 population
	<4 years	2	407988	0.49
	5-14	6	564906	1.06
	15-24	7	753209	0.93
	≥25	56	1412266	4.00
Sex	Male	45	1605230	2.80
	Female	26	1533139	1.70

Table 2: Sociodemographic characteristics of the study participants

Variable	Cases (n=44)	Controls (n=92)
Age (mean years, SD)	30.9 (9.0)	28.3 (9.0)
Sex		
Male	31 (70.5)	30 (32.6)
Female	13 (29.5)	62 (67.4)
Religion		
Christianity	43 (97.7)	89 (96.7)
Islam	1 (2.3)	3 (3.3)
Occupation		
Business person	10 (22.7)	29 (31.5)
Employed/self employed	21 (47.7)	16 (48.9)
House wife	0 (0.0)	16 (17.4)
Student/pupil	5 (11.4)	7 (7.6)
Unemployed	1 (2.3)	11 (12.0)
Unskilled labor/casual	6 (13.6)	5 (5.4)
Missing	1 (2.3)	8 (8.7)
Period of stay in current residence		
< 3 months	4 (9.1)	4 (4.4)
> 1 year	33 (75.0)	71 (77.2)
3 - 6 months	4 (9.1)	9 (9.8)
6 - 12 months	3 (6.8)	8 (8.7)
Education status		
None/Madrasa	0 (0.0)	3 (3.3)
Primary complete	8 (18.2)	31 (33.7)
Primary incomplete	1 (2.3)	3 (3.3)
Secondary complete	13 (29.6)	47 (51.1)
Tertiary	22 (50.0)	8 (8.7)

Table 3: Bivariate and multivariate analysis of factors associated with cholera outbreak, Nairobi County, July 2017

Exposure variable	Cases n (%)	Controls n (%)	Crude OR (95 % CI)	aOR
Not Treating drinking water				
Yes	21 (47.7)	19(20.7)	3.51 (1.61-7.63)	NA
No	23 (52.3)	73 (79.3)	Ref	
Drinking water from Borehole				
Yes	6 (13.6)	1 (1.1)	14.37 (1.63-667.91)	NA
No	38 (86.4)	91 (98.9)	Ref	
Drinking water from non-municipal supplies				
Yes	20 (45.5)	12 (13.0)	5.56 (2.38-12.98)	4.92 (1.56-15.52)
No	24 (54.5)	80 (87.0)	Ref	
Storing drinking water in uncovered container				
Yes	10 (22.7)	4 (4.4)	6.47 (1.70-29.74)	NA
No	34 (77.3)	88 (95.6)	Ref	
Drinking untreated water in previous week				
Yes	32 (74.4)	39 (52.0)	2.69 (1.18-6.10)	3.21 (1.12-9.24)
No	11 (25.6)	36 (48.0)	Ref	
Not chlorinating water before drinking				
Yes	38 (86.4)	35 (38.0)	10.31 (3.96-26.89)	14.57 (4.44-47.83)
No	6 (13.6)	57 (62.0)	Ref	
Not Washing hands before eating				
Yes	10 (22.7)	3 (3.3)	8.53 (2.0-50.22)	NA
No	34 (77.3)	87 (96.7)	Ref	
Not Washing hands after visit to toilet				
Yes	13 (29.6)	4 (4.5)	8.91 (2.46-39.62)	NA
No	31 (70.4)	85 (95.5)	Ref	
Eating away from home				
Yes	37 (84.1)	31 (37.3)	8.87 (3.52-22.30)	9.45 (3.07-29.12)
No	7 (15.9)	52 (62.7)	Ref	

Ref: reference group, NA: not included in logistic regression, OR: odds ratio, aOR: adjusted odds ratio

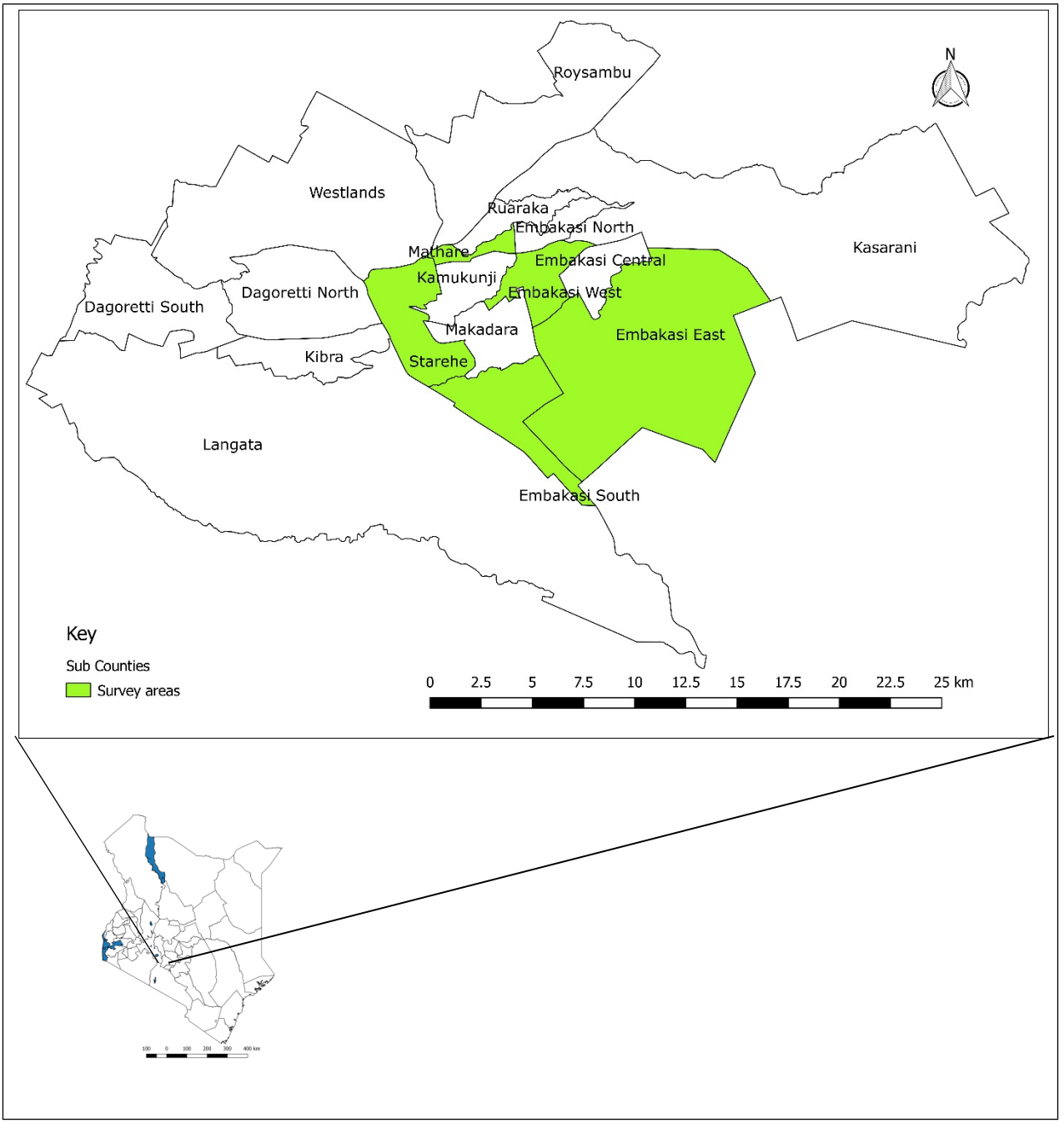

Figure 1: Map of Nairobi County, showing the study sites (Sub-counties affected by the Cholera outbreak) highlighted in green. (Maps produced using QGIS, a free and open source Geographic Information System, available at https://qgis.org/en/site/).

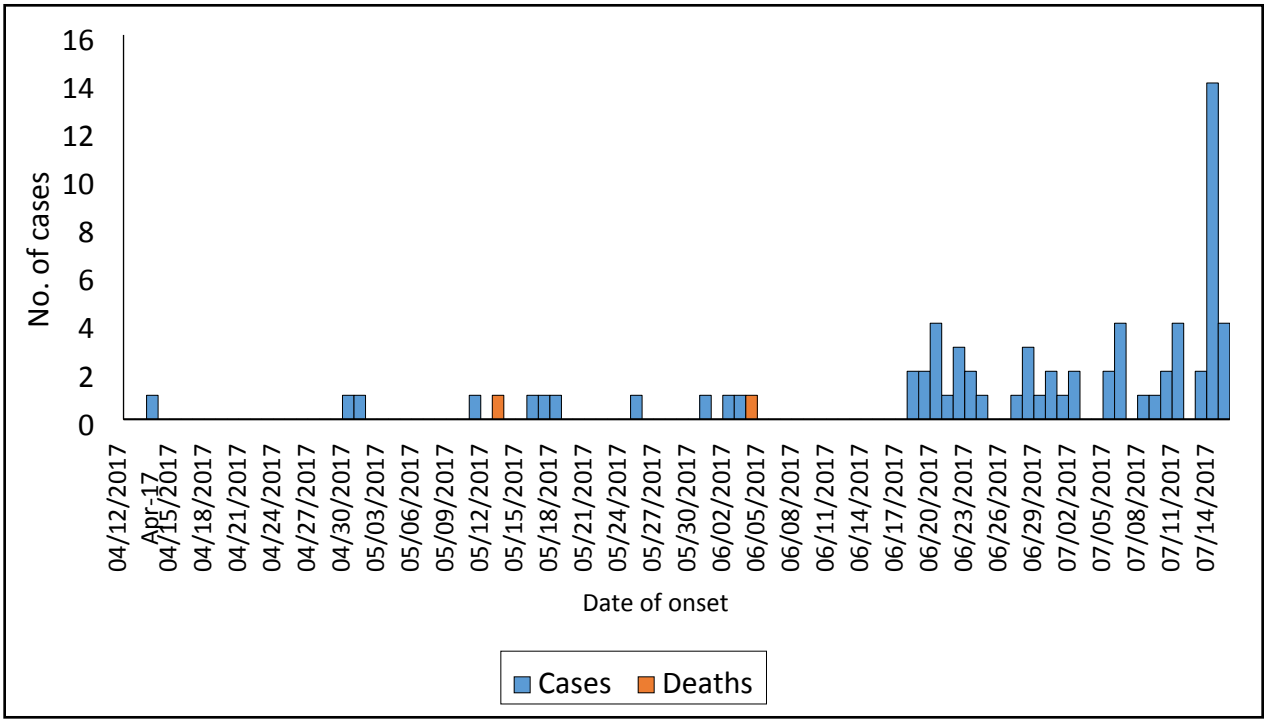

Figure 2: Epidemic curve, Cholera patients at Kenyatta National Hospital, July 2017 (N=71)

Supporting information files legends

S1: Article submission cover letter.

S2: Filled STROBE Checklist for a case control study.