A National Cholera Epidemic With High Case Fatality Rates—Kenya 2009

Anagha Loharikar,1,2 Elizabeth Briere,1,2 Maurice Ope,3 Daniel Langat,3 Ian Njeru,3 Lucy Gathigi,4 Lyndah Makayotto,4 Abdirizak M. Ismail,4 Martin Thurania,4 Ahmed Abade,4 Samuel Amwayi,4 Joe Oundo,4,5 Kevin M. De Cock,5 Robert F. Breiman,5 Tracy Ayers,2 Eric Mintz,2 and Ciara E. O’Reilly2

1Epidemic Intelligence Service, Office of Workforce and Career Development, and 2Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, Centers for Disease Control and Prevention, Atlanta, Georgia; 3Division of Disease Surveillance and Response, 4Kenya Field Epidemiology and Laboratory Training Program, Ministry of Public Health and Sanitation, and 5CDC–Kenya, Nairobi, Kenya

Background. Cholera remains endemic in sub-Saharan Africa. We characterized the 2009 cholera outbreaks in Kenya and evaluated the response.

Methods. We analyzed surveillance data and estimated case fatality rates (CFRs). Households in 2 districts, East Pokot (224 cases; CFR = 11.7%) and Turkana South (1493 cases; CFR = 1.0%), were surveyed. We randomly selected 15 villages and 8 households per village in each district. Healthcare workers at 27 health facilities (HFs) were surveyed in both districts.

Results. In 2009, cholera outbreaks caused a reported 11 425 cases and 264 deaths in Kenya. Data were available from 44 districts for 6893 (60%) cases. District CFRs ranged from 0% to 14.3%. Surveyed household respondents (n = 240) were aware of cholera (97.5%) and oral rehydration solution (ORS) (87.9%). Cholera deaths were reported more frequently from East Pokot (n = 120) than Turkana South (n = 120) households (20.7% vs. 12.3%). The average travel time to a HF was 31 hours in East Pokot compared with 2 hours in Turkana South. Fewer respondents in East Pokot (9.8%) than in Turkana South (33.9%) stated that ORS was available in their village. ORS or intravenous fluid shortages occurred in 20 (76.9%) surveyed HFs.

Conclusions. High CFRs in Kenya are related to healthcare access disparities, including availability of rehydration supplies.

Keywords. cholera; Kenya; outbreak; water; sanitation; nomadic/semi-pastoral.

Cholera is a watery diarrheal disease caused by the bacterium Vibrio cholerae. Without appropriate rehydration treatment, cholera can cause rapid, severe dehydration and death [1]. From 2001–2011, more than 2.4 million cases of cholera worldwide were reported to the World Health Organization (WHO), including almost 50 000 deaths [2–12]. Global case fatality rates (CFRs) varied from 1.3% to 4.0% annually. In sub-Saharan Africa, cholera CFRs are higher than in other regions, and cholera remains a leading cause of death from diarrhea [13, 14]. Cholera outbreaks have increased globally over the past decade [15], including large outbreaks in the past 5 years in Kenya, Zimbabwe, Nigeria, Cameroon, the Democratic Republic of Congo, Guinea, and Sierra Leone. Critical interventions during cholera outbreaks include life-saving treatment with oral rehydration solution (ORS) and intravenous fluids (IVF) and community-based prevention efforts [1]. In 2009–2010, Kenya experienced a large nationwide outbreak of cholera. The Centers for Disease Control and Prevention (CDC) assisted the Kenya Ministry of Public Health and Sanitation (MoPHS) to describe the epidemiology of cholera cases and evaluate cholera response efforts in northern Kenya’s Rift Valley Province, a region not typically endemic for cholera.

In this investigation, we characterized the epidemiology of the nationwide outbreak and conducted a rapid assessment of cholera awareness and management in...
the community and in health facilities (HFs) in 2 districts in Rift Valley Province. These districts were chosen for their distinct cholera case counts and CFRs during the outbreak, and characteristics were compared.

METHODS

Epidemiology
District-level acute watery diarrhea/cholera surveillance data were compiled from data collected under the MoPHS reporting mechanisms to create a national overview of cholera in Kenya during 2009. The surveillance case definition for reporting a suspected case of *V. cholerae* was illness in a patient aged ≥2 years with acute watery diarrhea, with or without vomiting [16]. A national listing of acute watery diarrhea/cholera cases reported to the MoPHS from 1 January 2009 to 19 December 2009 was created in Microsoft Excel 2003 (Microsoft Corporation, Redmond, Washington). National-, provincial-, and district-level epidemic curves were constructed, and epidemiologic data available from MoPHS were analyzed.

Investigation in Rift Valley Province
We conducted a community and HF survey in 2 districts of Rift Valley Province: East Pokot and Turkana South. This province was selected because this northern, semiarid region is not typically impacted by endemic cholera. After considering security and logistical issues, these districts were selected because MoPHS data indicated that one had a high CFR and one had a low CFR. Reported deaths/cases (CFR) were 26/224 (11.7%) in East Pokot and 16/1493 (1.0%) in Turkana South. We sought to identify differences in response efforts among these districts with regard to community awareness and prevention efforts, healthcare access, and treatment in HFs. The HF survey, conducted in a sample of HFs in these 2 districts, assessed healthcare worker (HCW) knowledge of cholera clinical case management guidelines [16].

COMMUNITY ASSESSMENT

Population
Both districts are rural and located in remote areas of northern Kenya; the population is nomadic or semipastoral (Supplementary Figure 1). Households in both districts are often multiunit with 1 husband, multiple wives, and many children living in small twig huts.

Sampling Selection
A list of villages was generated in East Pokot and Turkana South districts, due to the transient fluctuations in village locations depending on community movements. In East Pokot, a list of currently existing villages was compiled during the field investigation 3 days before the survey launch date. In Turkana South, a current list of villages was available from the district. Villages that met the following criteria were included for possible selection: secure during the study period (due to ongoing community conflicts); feasible to reach using an all-terrain vehicle; and village confirmed to currently have community members in residence (due to nomadic nature of the population). Among the 37 villages in East Pokot and 16 villages in Turkana South meeting these criteria, 15 were randomly selected in each district. Using the “spin the bottle” method, 8 households per village were randomly selected from the center of the village or the area closest to the main road, if the village did not have an obvious central location.

Data Collection
The respondent for the household was the person in the home responsible for caring for sick family members, water collection, or both. Household respondents were surveyed using a standard questionnaire, administered by trained enumerators in the local language (Pokot or Turkana). Household stored drinking water was also tested for residual chlorine using the N, N-diethyl-p-phenylenediamine colorimetric method (Hach Free and Total Chlorine kits; Hach Co., Loveland, Colorado), as an objective measure of chlorine use for water treatment.

VILLAGE-LEVEL SURVEY OF CHOLERA TREATMENT MEDICATIONS

We surveyed a convenience sample of village shops (kiosks/chemists) in both districts to examine availability of ORS and other medications used to treat diarrheal diseases. Wherever possible, all village shops were visited. If not feasible due to logistical constraints, a convenience sample of those nearest to a road was selected. We surveyed village shop owners using a standardized form, administered by trained enumerators in the local language (Pokot or Turkana).

HCW CASE MANAGEMENT EVALUATION

Population
The case management survey was conducted in a random sample of government, private, and faith-based HFs, including dispensaries, village health centers, subdistrict hospitals, district hospitals, and provincial hospitals. All HCWs (patient attendants, nurses, clinical officers, and medical officers) responsible for treatment of diarrheal illness in the selected HF, including within the emergency department, outpatient department, adult and pediatric inpatient wards, and cholera ward, on the day of the visit were interviewed.

Sampling Selection
A list of all government, private, and faith-based HFs currently operating in each district was obtained from the district public health officer. HFs that were nonoperational or inaccessible due
to security concerns were excluded. The district hospital and/or subdistrict hospital were included from each district. An additional 14 HFs per district were randomly selected from the census of eligible HFs.

Data Collection
A standardized survey was administered, in English or Swahili, by trained enumerators to assess HCWs knowledge of cholera transmission and prevention, physical signs and treatment of dehydration, hygiene, and treatment practices such as the administration of IVF and ORS. All questions assessing cholera case management were based on the MoPHS Guidelines on Cholera Control handbook [17]. The survey also evaluated the availability of appropriate cholera treatment supplies in HFs; the respondent for supply questions was the nurse in charge at each HF.

DATA MANAGEMENT AND ANALYSIS
All data were entered into a Microsoft Access 2003 (Microsoft Corporation, Redmond, Washington) database. Data preparation and frequencies were performed using SAS version 9.3 (SAS Institute, Cary, North Carolina), and descriptive comparisons were made.

INFORMED CONSENT
The Kenya MoPHS and CDC considered this outbreak investigation to be a nonresearch public health response activity. Therefore, it was not subject to institutional review board review requirements. Nevertheless, verbal informed consent was obtained from survey respondents.

RESULTS

Epidemiology
A total of 11,425 cases of cholera were reported from the district level to the Kenya MoPHS in 2009 (Figure 1) [2–12]. Surveillance data, including date of illness onset, were available for 6893 (60%) cases in 44 districts (Supplementary Figure 2). The national cholera epidemic curve shows peaks in cases occurring during March and April, June, and October and November 2009 (Figure 2). Cholera occurred across all 8 provinces in 2009 (Supplementary Figure 3); however, data at the national level from Central province and large areas of Rift Valley Province were incomplete and thus not representative. The dates of illness onset among cases by province and district suggest that cholera appeared first in Nyanza Province, followed by Western, Eastern, North Eastern, Rift Valley, Coast, and finally Nairobi Province.

Of the 6605 cases with gender information available, 50% were female. The median age of the 5625 cases with age information was 20 years (range: 2–90 years). The percentage of cases in each age group was as follows, in years: <5 (14%), 5–9 (15%), 10–14 (12%), 15–19 (9%), 20–24 (9%), 25–29 (10%), 30–34 (7%), 35–39 (6%), 40–44 (5%), 45–49 (3%), 50–54 (3%), 55–59 (2%), and >60 years (5%).

Of 4548 (66%) cases with outcome information, 111 cholera deaths were reported, for an overall CRF of 2.4%. CFRs varied

![Figure 1](https://academic.oup.com/jid/article-abstract/208/suppl_1/S69/833896/download?download=true)
by district from 0% to 14.3%. Stool culture was completed on specimens from 868 (13%) of 6,893 cases with acute watery diarrhea/cholera and yielded *V. cholerae* in 512 (59%) specimens tested.

**COMMUNITY KNOWLEDGE, ATTITUDES, AND PRACTICES STUDY**

A total of 240 households were surveyed in East Pokot (*n* = 120) and Turkana South (*n* = 120) districts during January 2010. The outbreak was not ongoing in these locations at the time of the survey.

**Demographics, Education, and Socioeconomic Background**

In total, 191 (80%) of 240 respondents were female (73% in East Pokot and 87% in Turkana South). The primary source of income for 84% of households in East Pokot was herding animals, primarily goats, compared with 27% in Turkana South. Respondents in both districts were similar with regard to age, household size, literacy, and formal schooling (Table 1).

**Water Sources, Water Availability, and Water Treatment**

Households in both East Pokot (48%) and Turkana South (41%) most frequently identified shallow hand-dug wells in dry riverbeds as their current source for water (Supplementary Figure 4). However, more Turkana South respondents reported having a protected water source than those in East Pokot, 41% and 3%, respectively. In East Pokot, 100 (84%) respondents compared with 63 (53%) respondents from Turkana South stated water was not readily available at times during 2009 (Table 2).

Almost all (95%) Turkana South respondents reported “treating” their drinking water to make it safe to drink compared with few (10%) East Pokot respondents. A higher percentage of Turkana South respondents (77%) compared with East Pokot respondents (29%) reported receiving free water treatment or hygiene products in the past 6 months. Of those who received products, most (82%) reported receiving Aquatabs. More than half (53%) of Turkana South households had Aquatabs that were observed in the home as compared with 8% of East Pokot households. Free chlorine residual was detected in stored drinking water in 24% of households in Turkana South compared with 19% of households in East Pokot.

**Table 1. Demographic Characteristics of Households Surveyed in East Pokot and Turkana South Districts, Kenya, 2010**

<table>
<thead>
<tr>
<th>Demographic Characteristic</th>
<th>Total N = 240 (%)</th>
<th>East Pokot N = 120 (%)</th>
<th>Turkana South N = 120 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>191 (80)</td>
<td>87 (73)</td>
<td>104 (87)</td>
</tr>
<tr>
<td>Mean age in years (range)</td>
<td>40 (15–100)</td>
<td>43 (20–100)</td>
<td>40.4 (15–86)</td>
</tr>
<tr>
<td>Mean number of people in household</td>
<td>7 (1–21)</td>
<td>7 (1–21)</td>
<td>6 (2–14)</td>
</tr>
<tr>
<td>Self-reported literacy</td>
<td>29 (12)</td>
<td>13 (11)</td>
<td>16 (13)</td>
</tr>
<tr>
<td>No formal schooling</td>
<td>206 (87)</td>
<td>103 (87)</td>
<td>103 (87)</td>
</tr>
<tr>
<td>Primary income through herding</td>
<td>133 (56)</td>
<td>100 (84)</td>
<td>33 (27)</td>
</tr>
</tbody>
</table>
Knowledge of Cholera, Cholera Management, and Public Health Messaging

Although most (80%) respondents in both districts knew that cholera caused watery diarrhea, knowledge of the etiology and prevention of cholera differed. In East Pokot 53% of respondents indicated that drinking bad water caused cholera compared with 81% of Turkana South respondents; 21% of East Pokot respondents indicated that cholera could be prevented by boiling or treating water compared with 70% of Turkana South respondents (Supplementary Table 1). Methods reported for cholera treatment in East Pokot and Turkana South, respectively, included appropriate responses, including homemade sugar–salt solution (20% vs. 68%), increase liquid intake (17% vs. 28%), ORS (0% vs. 23%), and seeking care at a hospital (3% vs. 18%), and less appropriate responses, including home remedy (herbs, ant hills, animal slaughter; 34% vs. 0%) and no known treatment (21% vs. 11%).

Only 49 (41%) respondents in East Pokot compared with 112 (93%) respondents in Turkana South had heard of cholera in their village. Of these, 4% in East Pokot compared with 81% in Turkana South heard from a village chief/community meeting, and 24% in East Pokot compared with 47% in Turkana South heard from a HCW. Most respondents in East Pokot who had knowledge of the cholera outbreak heard from family (37%) or neighbors (50%; Supplementary Table 1).

Experience With Cholera in 2009, Access to Healthcare, and ORS Availability

Twenty-nine (24%) respondents in East Pokot reported cholera in their family compared with 57 (48%) in Turkana South (Table 3). Of these, 6 (21%) in East Pokot and 7 (13%) in Turkana South reported death from cholera in their family. The mean number of hours to travel to a HF for households was 31 hours in East Pokot (range: <1–168 hours) and 2 hours in Turkana South (range: <1–6 hours). Overall, 17 (14%) respondents in East Pokot compared with 46 (38%) in Turkana South stated they sought care for a family member with cholera at a HF in the past 6 months. Ten (10%) respondents in East Pokot compared with 37 (34%) in Turkana South stated that ORS is available in their village. Of households surveyed, 2% in East Pokot compared with 13% in Turkana South had ORS sachets in the home (Table 3).

VILLAGE-LEVEL SURVEY OF CHOLERA TREATMENT MEDICATIONS

During the village survey of availability of cholera treatment medications in local shops, we surveyed 35 kiosks/chemist shops in East Pokot and 50 in Turkana South. Fewer than a quarter of all kiosks/chemists surveyed had any of the supplies asked about. Overall, only 3 (3.5%) had ORS, 10 (11.8%) had doxycycline, 4 (4.7%) had tetracycline, and 3 (3.5%) had ciprofloxacin.

HCW CASE MANAGEMENT EVALUATION

Enrollment and Demographics

Thirteen of the HFs selected in East Pokot had staff present on the day of the survey; 21 HCWs were surveyed. In Turkana

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Table 2. Water Sources, Water Availability, and Water Treatment of Households Surveyed in East Pokot and Turkana South Districts, Kenya, in 2010

<table>
<thead>
<tr>
<th>Water Sources, Water Availability, and Water Treatment</th>
<th>Total N = 240* (%)</th>
<th>East Pokot N = 120* (%)</th>
<th>Turkana South N = 120* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Current water source</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shallow well/hand-dug well</td>
<td>106 (45)</td>
<td>57 (48)</td>
<td>49 (41)</td>
</tr>
<tr>
<td>Open deep well</td>
<td>13 (5)</td>
<td>0 (0)</td>
<td>13 (11)</td>
</tr>
<tr>
<td>River</td>
<td>50 (21)</td>
<td>43 (36)</td>
<td>7 (6)</td>
</tr>
<tr>
<td>Borehole</td>
<td>33 (14)</td>
<td>3 (3)</td>
<td>30 (25)</td>
</tr>
<tr>
<td>Piped water to house</td>
<td>2 (1)</td>
<td>0 (0)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Community tap</td>
<td>17 (7)</td>
<td>0 (0)</td>
<td>17 (14)</td>
</tr>
<tr>
<td>Water vendor</td>
<td>1 (0)</td>
<td>1 (1)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dam</td>
<td>11 (5)</td>
<td>11 (9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Protected source</td>
<td>52 (22)</td>
<td>3 (3)</td>
<td>49 (41)</td>
</tr>
<tr>
<td>Unprotected source</td>
<td>185 (78)</td>
<td>115 (97)</td>
<td>70 (59)</td>
</tr>
<tr>
<td><strong>Water not available during times in the year</strong></td>
<td>n = 163 (68)</td>
<td>n = 100 (84)</td>
<td>n = 63 (53)</td>
</tr>
<tr>
<td>One mo during year</td>
<td>5 (3)</td>
<td>1 (1)</td>
<td>4 (6)</td>
</tr>
<tr>
<td>Between 1 and 3 mo during year</td>
<td>29 (18)</td>
<td>12 (12)</td>
<td>17 (27)</td>
</tr>
<tr>
<td>Between 3 and 6 mo during year</td>
<td>93 (57)</td>
<td>67 (67)</td>
<td>26 (41)</td>
</tr>
<tr>
<td>More than 6 mo during year</td>
<td>28 (17)</td>
<td>18 (18)</td>
<td>10 (16)</td>
</tr>
<tr>
<td><strong>Water treatment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported “treating” drinking water to make it safe</td>
<td>123 (52)</td>
<td>12 (10)</td>
<td>111 (95)</td>
</tr>
<tr>
<td>Received water treatment/ hygiene product for free in past 6 mo</td>
<td>126 (53)</td>
<td>34 (29)</td>
<td>93 (77)</td>
</tr>
<tr>
<td><strong>Received water treatment product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WaterGuard</td>
<td>6 (5)</td>
<td>1 (1)</td>
<td>5 (5)</td>
</tr>
<tr>
<td>PuR</td>
<td>50 (39)</td>
<td>0 (0)</td>
<td>50 (54)</td>
</tr>
<tr>
<td>Aquatabs/chlorine tabs</td>
<td>103 (82)</td>
<td>23 (68)</td>
<td>80 (87)</td>
</tr>
<tr>
<td>Jerrycan</td>
<td>13 (10)</td>
<td>4 (12)</td>
<td>9 (10)</td>
</tr>
<tr>
<td>Bucket</td>
<td>1 (1)</td>
<td>1 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td><strong>Products observed at home (purchased or received free)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WaterGuard</td>
<td>7 (3)</td>
<td>0 (0)</td>
<td>7 (6)</td>
</tr>
<tr>
<td>PuR</td>
<td>43 (18)</td>
<td>0 (0)</td>
<td>43 (36)</td>
</tr>
<tr>
<td>Aquatabs</td>
<td>72 (30)</td>
<td>9 (3)</td>
<td>63 (53)</td>
</tr>
<tr>
<td>Own none</td>
<td>95 (40)</td>
<td>70 (58)</td>
<td>25 (21)</td>
</tr>
<tr>
<td>Residual chlorine test positive</td>
<td>52 (22)</td>
<td>23 (19)</td>
<td>29 (24)</td>
</tr>
</tbody>
</table>

* For some items, N may vary by small numbers.
South, 14 of the selected HFs had staff present on the day of the survey; 22 HCWs were surveyed. In East Pokot, 24% of HCWs were patient attendants, 57% were nurses, 14% were clinical officers, and 1 (5%) was a laboratory technician. In Turkana South, 55% were patient attendants, 41% were nurses, and 1 (5%) was a clinical officer. In East Pokot and Turkana South, 15 (71%) and 10 (46%) HCWs reported having completed formal clinical training, respectively. Five (24%) and 3 (14%) HCWs had received no formal training or only on-the-job-training in East Pokot and Turkana South, respectively.

Cholera Knowledge and Treatment Practices
Most HCWs in East Pokot (95%) and Turkana South (100%) correctly identified a case of severe dehydration. All HCWs in East Pokot and 19 (86%) HCWs in Turkana South knew that giving IVF with or without ORS was the correct management of a cholera patient with severe dehydration. Ten (48%) and 12 (63%) HCWs in East Pokot and Turkana South, respectively, identified Ringer’s Lactate solution as the IVF of choice for an adult cholera patient with severe dehydration (Table 4). Seventeen (81%) HCWs in East Pokot and 13 (59%) HCWs in Turkana South knew that ORS alone was the correct management of a cholera patient with some dehydration. In East Pokot and Turkana South, 15 (71%) and 19 (86%) HCWs, respectively, knew cholera patients with no dehydration should receive ORS to take home.

Nineteen (91%) HCWs in East Pokot and 21 (100%) HCWs in Turkana South incorrectly stated that all cholera patients should receive oral antibiotics, regardless of dehydration level. All HCWs in East Pokot and Turkana South reported that doxycycline is used to treat adult patients with severe cholera, when indicated. Fourteen (67%) HCWs in East Pokot and 18 (82%) HCWs in Turkana South correctly reported using erythromycin for pediatric patients with severe cholera.

Availability of HF Treatment Supplies and Laboratory Capacity
Among HFs, 7 of 13 (54%) in East Pokot and 4 of 14 (29%) in Turkana South had confirmed stocks of all cholera management supplies (ORS, IVF, intravenous [IV] needles, IV tubing, and doxycycline) at the time of the interview. Eight (62%) and 12 (86%) HFs experienced stockouts of 1 or more of these supplies in 2009 in East Pokot and Turkana South, respectively (Supplementary Table 2).

DISCUSSION
In 2009, every province in Kenya experienced cholera outbreaks. This country-wide outbreak resulted in > 11 000 suspected cases

Table 4. Knowledge of Cholera and Cholera Treatment Practices Among HCWs in East Pokot and Turkana South Districts, Kenya, in 2010

<table>
<thead>
<tr>
<th>Level of Knowledge</th>
<th>East Pokot n = 21 (%)</th>
<th>Turkana South n = 22 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of correct World Health Organization cholera case definition: Acute watery diarrhea in a person &gt; 2 years in an area where there is an outbreak of cholera</td>
<td>1 (5)</td>
<td>2 (9)</td>
</tr>
<tr>
<td>Correctly identify case of severe dehydration</td>
<td>20 (95)</td>
<td>22 (100)</td>
</tr>
<tr>
<td>Know Ringer’s solution is the correct IVF to treat severe dehydration</td>
<td>10 (48)</td>
<td>12 (63)</td>
</tr>
<tr>
<td>In an adult</td>
<td>11 (52)</td>
<td>13 (59)</td>
</tr>
<tr>
<td>Know correct management of a patient with:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe dehydration (IVF ± ORS)</td>
<td>21 (100)</td>
<td>19 (86)</td>
</tr>
<tr>
<td>Some dehydration (ORS only)</td>
<td>17 (81)</td>
<td>13 (59)</td>
</tr>
<tr>
<td>No dehydration (ORS to take home)</td>
<td>15 (71)</td>
<td>19 (86)</td>
</tr>
<tr>
<td>Know correct use of ORS for a nonvomiting patient</td>
<td>16 (76)</td>
<td>13 (62)</td>
</tr>
<tr>
<td>Know correct use of antibiotics for cholera patients</td>
<td>1 (5)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Adult cholera patient (treatment with doxycycline)</td>
<td>21 (100)</td>
<td>22 (100)</td>
</tr>
<tr>
<td>Pediatric cholera patient (erythromycin)</td>
<td>14 (67)</td>
<td>18 (82)</td>
</tr>
</tbody>
</table>

Abbreviations: IVF, intravenous fluid; ORS, oral rehydration solution.
of cholera, more than the sum of all suspected cases reported from 1999 to 2008 [2–10, 18]. Genetic analyses of *V. cholerae* isolates from various sites suggest that this multifocal outbreak was caused by the simultaneous emergence of several distinct but related lineages of *V. cholerae*, perhaps facilitated by environmental factors around the country [19]. The semiarid regions of northern Kenya, which typically have minimal cholera burden, experienced high case counts and CFRs. This investigation underscores the impact the 2009 outbreaks had nationally, as well as the important challenges the country faced with response efforts. Numerous prior cholera investigations have highlighted risks of transmission, high mortality rates, and poor access to care in dense urban environments and areas of conflict that have resulted in displaced persons living in densely populated refugee camps [20–26]. Our investigation showed that populations in remote, rural regions of Kenya had poor access to healthcare, to supplies for cholera treatment, and to information about cholera prevention and treatment, similar to populations in remote rural areas during cholera outbreaks in Latin America and sub-Saharan Africa in the 1990s [15, 27]. Nomadic populations within Kenya are at particular risk because migration, including movement across national borders, often keeps them beyond the reach of public health messages and far from HFVs operated by local government or nongovernmental organizations (NGOs) [28]. These deficiencies likely contributed to cholera case fatality rates far above what can be attained when appropriate treatment can be delivered in a timely manner, as also noted in northern Cameroon [29].

From the community evaluation, we observed differences between 2 neighboring districts. Foremost, East Pokot had limited water availability during 2009, resulting in greater use of shallow hand-dug wells as the primary source of drinking water [30, 31]. Prevention and control of cholera and other waterborne diseases requires access to improved water sources and to point-of-use household water treatment products where water quality cannot otherwise be assured [14, 32]. The community assessment also demonstrated interesting beliefs and practices among nomadic populations (Supplementary Table 1), which underscore the need for tailored, culturally sensitive public health messaging for at-risk populations. In addition, it would be useful to collect this information in other settings as it may aid with better targeted health promotion messages, as well as general diarrheal disease prevention messages, outside of the outbreak setting.

Populations in East Pokot had less access to HFVs and to cholera prevention supplies in the community compared with those in Turkana South. This difference is likely related to differences in population density and to a greater and more permanent NGO presence in Turkana South. Transportation and logistical challenges were observed in both districts, but much more so in East Pokot. In some instances, supplies (eg, 20-L water storage containers or ceramic water filters) provided by the MoPHS and partners arrived at the local level, but due to lack of appropriate local transportation, these items did not reach households in remote areas. Poor access to healthcare and prevention supplies in East Pokot compared with Turkana South likely contributed to higher CFRs in this district [27], in addition to limited knowledge of cholera prevention and treatment. The low percentage of kiosks/chemists with ORS for sale in both districts likely contributed to deaths, as patients without access to ORS are unable to prevent progression to severe dehydration [27, 33].

Most HCWs could correctly identify the symptoms of severe dehydration and knew that IVF is the recommended treatment; however, the recommended type of IVF was often misidentified [34]. Rehydration with inappropriate IVF may lead to electrolyte imbalances and other complications [35]. Overuse of IVF was evident, increasing the risk of complications from fluid overload and depleting supplies. Antibiotic overuse may also be a problem in HFVs. Until recently, standard guidelines by WHO and other organizations recommended that antibiotics be reserved for treatment of patients with severe cholera [36]. The advent of the new El Tor variant strain [37], which appears to cause a greater proportion of rapidly progressive, severe cholera than typical El Tor strains, has led to recommendations that antibiotic treatment also be used for patients with moderate illness who have begun IV hydration [38]. Injudicious use of antibiotics for chemoprophylaxis or for treatment of patients with mild illness can lead to antimicrobial resistance and deplete supplies that may be lifesaving for patients with more severe cholera.

Considerable opportunities exist for targeted interventions to improve cholera prevention and control at the district, provincial, and national levels. Ensuring availability of commodities for diarrheal disease management such as low-osmolality ORS and IV fluids through better inventory control will enhance cholera response efforts and may reduce CFRs. Universal access to ORS and community education is imperative, as it can aid in management of childhood diarrheal disease at the household/community level [39, 40]. Scientific evaluations of any interventions implemented in this area, including those mentioned above, will help document their success and inform changes to maximize their health impact and allow for more efficient scale-up in this unique social and environmental context.

Access to adequate healthcare poses a major challenge for rural, remote areas of the country. Creative alternatives to the traditional model of healthcare, such as mobile rehydration units or scaling up the community HCW model, must be considered [41, 42]. Many HFVs were staffed primarily with patient attendants who had little or no formal education; attracting trained health professionals to work in these remote areas is challenging and will require improved living conditions and adequate compensation.

Although only 1 WHO-prequalified oral cholera vaccine was available in very limited supply when this outbreak occurred, a new, less expensive oral cholera vaccine from a different manufacturer has since been prequalified. WHO now recommends

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that cholera vaccine be considered for use in endemic areas and for preemptive use in populations at risk of cholera and for re-active use during cholera epidemics [12]. In the future, oral cholera vaccines may help prevent morbidity and mortality due to cholera in areas such as Turkana and Pokot, while longer-term improvements in access to healthcare, safe drinking water, sanitation, and hygiene are made.

There were limitations to the surveillance data reported, as the large, persistent outbreak overwhelmed the surveillance system and inundated those in the districts and provinces as well as those at the national level with data. This report describes epidemiologic data available through 19 December 2009 and acknowledges that data from some districts and provinces are incomplete. More accurate counts of cholera cases and deaths can be achieved through active surveillance; however, this was not possible in such a large area and over such a prolonged period [43].

The community and HCW surveys were conducted in only 2 districts in northern Kenya, which may not represent other communities in Rift Valley Province or in other provinces. We relied primarily on district public health officials and other partners to list the villages within each district eligible for inclusion in the surveys. Although our comparison of the 2 districts, 1 with high CFR and 1 with low CFR, highlighted differences, it does not prove a causal association, as our small sample size and constrained sampling method precluded statistical inferences.

This outbreak, yet again, highlights that cholera is still with us and that it inequitably affects the poor, underprivileged, and less educated who have limited access to healthcare and resources [13, 14]. We are reminded of the fundamental problems with availability and safety of water and sanitation in sub-Saharan Africa. These areas should be a focus of all policymakers in the global community, including ministries of finance, government, and health, in order to minimize illness and deaths from preventable diarrheal diseases, including cholera.

Supplementary Data
Supplementary materials are available at The Journal of Infectious Diseases online (http://jid.oxfordjournals.org/). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyrighted. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

Notes
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