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Recurrent epidemic cholera with high mortality in Cameroon: persistent challenges 40 years into the seventh pandemic

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SUMMARY

Cameroon has experienced recurrent cholera epidemics with high mortality rates. In September 2009, epidemic cholera was detected in the Far North region of Cameroon and the reported case-fatality rate was 12%. We conducted village-, healthcare facility- and community-level surveys to investigate reasons for excess cholera mortality. Results of this investigation suggest that cholera patients who died were less likely to seek care, receive rehydration therapy and antibiotics at a healthcare facility, and tended to live further from healthcare facilities. Furthermore, use of oral rehydration salts at home was very low in both decedents and survivors. Despite the many challenges inherent to delivering care in Cameroon, practical measures could be taken to reduce cholera mortality in this region, including the timely provision of treatment supplies, training of healthcare workers, establishment of rehydration centres, and promotion of household water treatment and enhanced handwashing with soap.

Key words: Cholera, diarrhoea, *Vibrio cholerae*, water (safe).

INTRODUCTION

The seventh pandemic of cholera first reached West Africa in 1970 and has persisted as a public health problem in parts of Africa since that time. While the reported incidence of cholera has decreased significantly in Asia and Latin America over the past two decades, the incidence in sub-Saharan Africa has remained the same. In 2009, 98% of 221 226 cholera cases and 99% of 4946 cholera deaths reported to the World Health Organization (WHO) occurred in sub-Saharan Africa [1]. Rapid and vigorous oral or intravenous rehydration therapy is life-saving for patients with severe cholera infections; with prompt treatment the case-fatality rate (CFR, defined as the proportion of cholera cases which are fatal) can be reduced from 50% to <1%, even in makeshift, rural treatment centres [2, 3]. While the CFR for all parts of the world outside of Africa has been below 0·4% since 2002, the overall CFR for Africa in 2009 was

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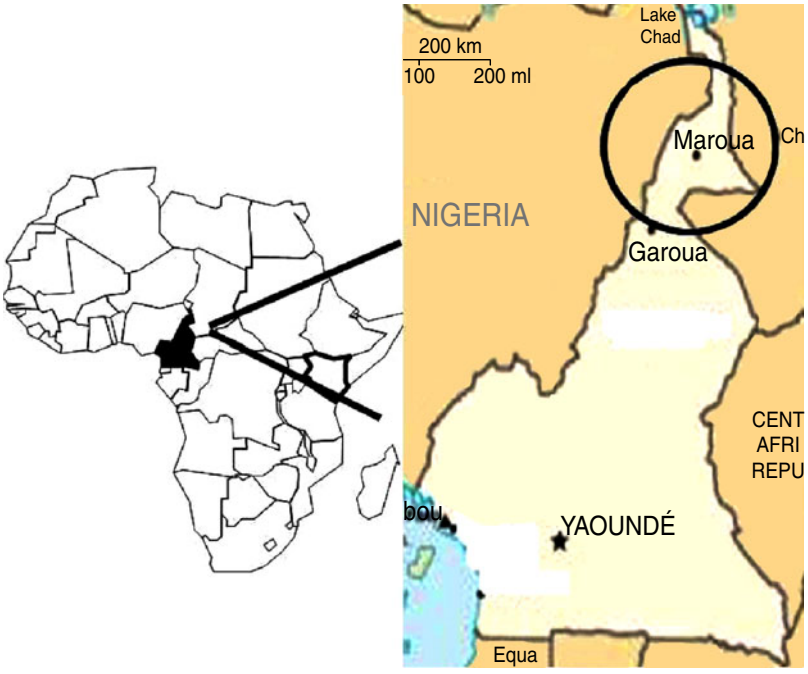

Fig. 1. [*colour online*]. *Left*: Map of Africa, with Cameroon highlighted in black. *Right*: Map of Cameroon with the Far North region circled.

2·3% [1, 4]. Based on studies in several countries, excess cholera mortality has been attributed to lack of access to treatment facilities, inadequate or delayed rehydration, and failure to seek care [5–9].

Cameroon, a country of 19 million people located in Central/West Africa (Fig. 1), has frequently experienced cholera epidemics, reporting cholera cases to WHO every year from 2000 to 2005 [4, 10]. Additionally, Cameroon has experienced excess cholera mortality with a mean reported CFR of 10·2% over the same time period [4].

On 10 September 2009, suspected cholera cases were reported from the Far North region of Cameroon (Fig. 1). Stool specimens from these cases yielded toxigenic *Vibrio cholerae* O1, biotype El Tor, serotype Ogawa, resistant to trimethoprim/sulfamethaxole, sulfonamides, and nalidixic acid, susceptible to tetracycline, and with intermediate susceptibility to ampicillin and chloramphenicol [11]. On molecular analysis of the strain, the DNA sequence showed a single nucleotide polymorphism variant of the *ctxB* gene, similar to the Orissa variant identified in India in 2007 [11, 12]. By 7 December, 2009, cholera cases had been reported from 10 of the 28 districts of the Far North region, nine of the 13 districts in the North region, and in neighboring areas of Nigeria. A total of 717 cholera cases (380 in the Far North, 337 in the North) and 85 deaths (44 in the Far North, 41 in the North) had been reported, for a national CFR of 11·9% (Fig. 2). In December 2009, we conducted an investigation of excess mortality in the Far North region of Cameroon.

METHODS

Location of investigation

Our investigation took place in the Far North region; only districts that reported at least one cholera case and one cholera death from the same village were included in the investigation (Fig. 3).

Village chief survey

After obtaining permission from self-identified village chiefs, the chiefs were interviewed with a standard questionnaire to obtain village-level information. We asked about village characteristics such as size, socioeconomic status, education, access to healthcare facilities, cellular phone coverage and water sources.

Healthcare facility survey

In each study district, we conducted an assessment of healthcare facilities that had treated at least one cholera patient since the start of the epidemic. At each

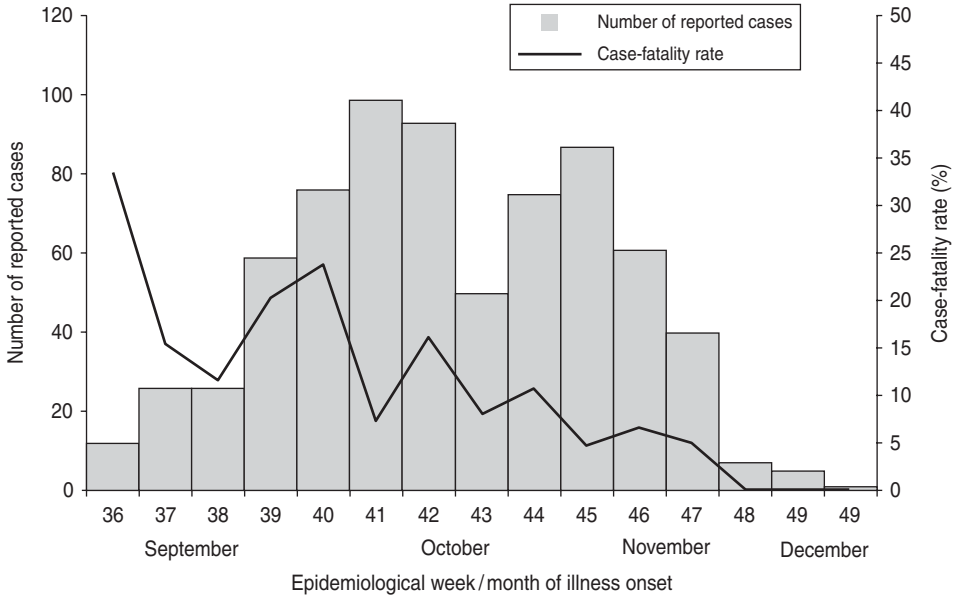

Fig. 2. Reported cholera cases and case-fatality rate by epidemiological week of illness onset for the North and Far North regions, Cameroon, 2009.

healthcare facility, we interviewed healthcare workers (HCWs) who were present at the time of our visit regarding cholera knowledge, attitudes and practices. We also gathered facility-level information and reviewed medical records of cholera patients, abstracting available data on symptom onset, date of arrival, date of departure, and treatment received, for the period from 1 September 2009 to the day of the interview.

Assessment of cholera case definition

At the time of our evaluation, the Cameroon Ministry of Health (MOH) defined a suspect cholera case as an individual with acute, watery diarrhoea (10–100 unobstructed, involuntary stools per day), dehydration, and anuria (from the MOH, *Guide de Prise en Charge des Maladies à Potentiel Épidémique et affections Prioritaires au Cameroun*, 2009 edition). The WHO case definition for suspected cholera in an area experiencing epidemic cholera is acute, watery diarrhoea ($\geqslant$3 stools in a 24-h period) in any person aged $\geqslant$5 years [13]. To determine the impact of the WHO cholera case definition on the CFR in Cameroon, we reviewed admission log books at all study hospitals, abstracted information for all patients who met the WHO cholera case definition but were not reported on the MOH cholera line-list, added these patients to the denominator of reported cholera cases, and recalculated the CFR.

Case-control study

We conducted a case-control study, using the 19 November 2009 MOH line-list to select cases and controls. The MOH line-list is compiled by the Regional Delegate from information from each district medical officer and includes cases reported from healthcare facilities. If a person dies in a village, the district medical officer may perform a verbal autopsy to determine the presumed cause of death. If an adult dies from diarrhoea, especially during a recognized cholera epidemic, this death would be attributed to cholera and would be reported on the MOH surveillance line-list. We defined a case (hereafter referred to as a 'decedent') as death from suspected cholera in any person aged $\geqslant$5 years that lived in a study village. Controls (hereafter referred to as 'survivors') included any person aged $\geqslant$5 years that survived a cholera-like illness and lived in a study village. We attempted to interview all cases and controls in study villages.

A standardized questionnaire was developed in English, translated into French and then administered in the local language by local field workers who had been trained on the meaning of each question and had piloted the questionnaire in a non-study village. From 25 November to 2 December, 2009, field workers interviewed relatives of decedents, and cholera survivors (or, in some cases, a survivor's relative) to collect information about the presence of cholera signs and symptoms, chronic conditions (including

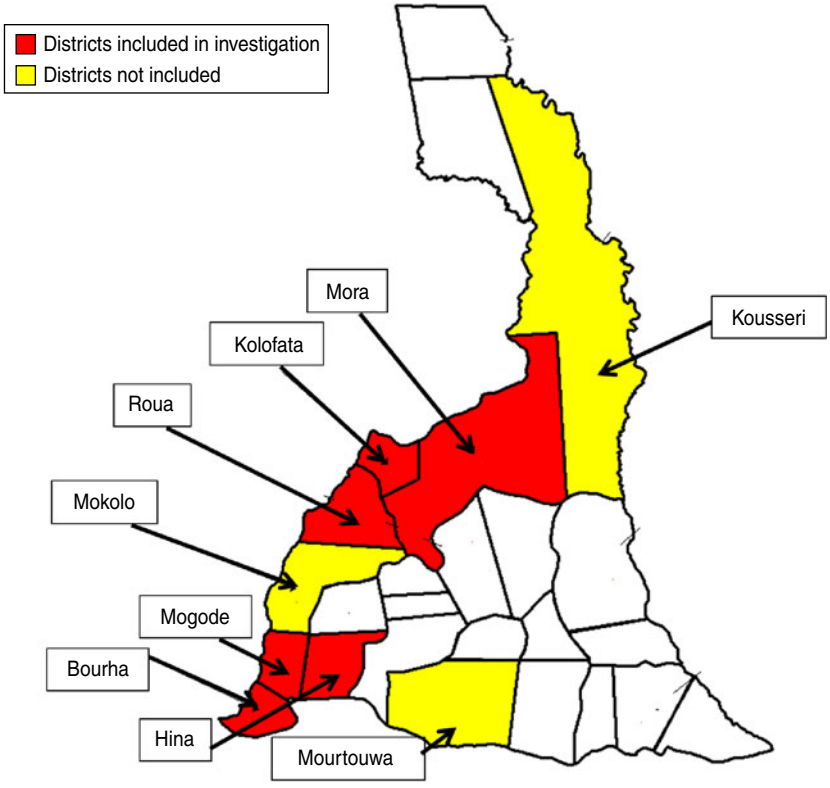

Fig. 3. [*colour online*]. Geographical distribution of healthcare districts with and without reported cholera, and by inclusion in the investigation, Far North region, Cameroon, 2009.

HIV, cancer, tuberculosis), care-seeking practices, and care received. Field workers observed materials used to construct the walls, floor and roof of the dwelling; drinking water collection and storage practices; and tested stored water for residual free chlorine using the DPD (*N*,*N* diethyl-*p*-phenylene diamine) method (La Motte, USA) as an objective measure of water treatment.

Statistical analysis

Statistical analysis of the data was performed using SAS version 9.3 survey procedures (SAS Institute Inc., USA). Descriptive frequencies were calculated for village-level and healthcare facility-level data. The variance estimates were adjusted for cluster correlation within villages using the Taylor series (linearization) method. As data from the continuous variables were not normally distributed, square root transformations were performed to allow for comparisons using the survey design-adjusted regression models. Risk factors for cholera mortality were explored, adjusting for survey design, using logistic regression. Due to the small sample size, formal multivariate model selection could not be performed; therefore, we explored risk factors independently in separate models. Because age is a known confounder in mortality studies, we present age-category adjusted odds ratios (aORs) and 95% confidence intervals (CIs) for each risk factor.

Ethical considerations

This investigation did not require formal ethical review because it was in response to a request by the MOH for assistance in a public health emergency. Due to low literacy levels, investigators obtained verbal consent from all participants. Personal identifiers were removed from databases.

RESULTS

Village chief survey

Chiefs of 14 villages and one sub-quarter chief were interviewed. The median number of persons living in the 15* study villages (as estimated by the village

* The denominator is 15 because 14 village chiefs and 1 sub-quarter chief were interviewed.

chief) was 1573 persons (range 350–20 000) (Table 1). The predominant religion was Christian in nine (60%) villages, Muslim in four (27%) villages, and Animist in two (13%) villages. Nine (60%) villages had cell phone coverage and six (40%) had electricity in any part of the village. Twelve (80%) villages had at least one primary school and eight (53%) had a shop or market. An 'improved' water source† was present in eight (53%) villages and the median number of wells per village was seven (range 1–36). Six (40%) villages had a healthcare centre within 5 km. Traditional practitioners were present in 11 (73%) villages with a median of five per village (range 0–50).

Table 1. *Village-level characteristics (N = 15); cholera mortality investigation, Far North region, Cameroon, 2009*

Village characteristic, median (range)		
Village size (persons)	1573	(350–20 000)
No. of traditional practitioners/ village	5	(0–50)
No. of wells	7	(1–36)
No. of boreholes	2	(0–8)
Distance to healthcare centre (km)	6	(0·8–15)
Religious predominance, *n* (%)		
Christian	9	(60)
Muslim	4	(27)
Animist	2	(13)
Socioeconomic indicators, *n* (%)		
At least half own a bike	10	(67)
At least half own a radio	9	(60)
At least half own a motorcycle	7	(47)
At least half own a mobile phone	6	(40)
Anyone owns a television*	8	(53)
Anyone owns a car	8	(53)
Remoteness, *n* (%)		
Church or mosque present in village	14	(93)
Electricity in village	6	(40)
Shops/market in village	8	(53)
Cell phone coverage in village	9	(60)
Primary school in village	12	(80)
Improved water source in village	8	(53)
Half the adults can read	4	(27)
Access to medical care, *n* (%)		
Healthcare centre <5 km*	6	(40)
Healthcare centre $\geqslant 5$ km*	8	(53)
Traditional practitioner in village*	11	(73)
Able to obtain oral rehydration salts	9	(60)

* More than 5% of data missing.

Healthcare facility survey

We interviewed 57 HCWs in 21 healthcare centres in the six districts under investigation. The 21 facilities had a median of seven beds per facility (range 0–100 beds) and had seen a median of 1036 patients (range 199–5815 patients) in the 80 days before our survey, including a median of 14 cholera patients (range 1–56). Medical doctors were on staff in five (24%) facilities; 20 facilities (95%) were open 7 days per week and 16 (76%) were open 24 h per day. Cholera management posters were observed in two (10%) facilities.

Among 57 HCWs who were interviewed in 21 healthcare facilities, 53 (93%) were male, 51 (89%) had heard of cholera, 47 (82%) correctly identified a severely dehydrated patient after listening to a case presentation, 25 (44%) reported receiving training in cholera management before the epidemic, and 29 (51%) received cholera training after the start of the epidemic. The median expected cholera CFR reported by the HCWs was 3% (range 0–50%). Of 57 HCWs, 13 (23%) said they had run out of necessary supplies while treating a cholera patient.

Assessment of cholera case definition

We reviewed the admission log books from 21 healthcare facilities and identified an additional 203 diarrhoea cases that met the WHO cholera case definition. When these additional cases were added to the denominator of suspected cholera cases in the Far North region, the CFR decreased from 11·6% to 7·5%.

Case-control investigation

Fourteen villages in six districts met the inclusion criteria. The MOH cholera line-list from these villages included 139 potential cholera survivors and 31 decedents; we enrolled 72 survivors and 25 decedents. Of 73 persons who were excluded, 46 did not live in the study village as indicated on the surveillance line-list, 12 were aged <5 years, five did not meet our case definition of cholera, and 10 could not be found.

The median age of decedents was 35 years (range 5–90, standard deviation 24 years) compared to 28 years (range 5–80, standard deviation 17 years) in survivors ($P = 0{\cdot}09$)‡. A higher percentage

† Improved water sources include boreholes, household connections, public standpipes, protected wells, rainwater collection, protected springs, as defined by WHO [14].

‡ Age was transformed to approximate normal distribution for statistical analysis using survey methods.

Table 2. *Demographic information, household observations, and water source, storage and treatment practices of cholera decedents and survivors; cholera morality investigation, Far North region, Cameroon, 2009* ($N=97$)

	Decedents ($N=25$)		Survivors ($N=72$)			
	n	(%)	*n*	(%)	aOR*	(95% CI)
Age >50 years	8	(32)	8	(11)	3·8†	(1·3–11·1)
Animist religion	11	(44)	12	(17)	3·0	(0·7–13·0)
Male	11	(44)	25	(35)	1·3	(0·4–4·1)
Married	14	(56)	40	(56)	1·1	(0·5–2·5)
Employed	7	(28)	20	(28)	0·7	(0·2–1·8)
Educational status						
No education	20	(80)	58	(81)	0·8	(0·2–2·9)
Literate‡	4	(16)	13	(18)	1·1	(0·2–5·2)
Household assets						
Bicycle ownership	10	(40)	34	(47)	1·0	(0·3–2·9)
Radio ownership	8	(32)	25	(35)	0·9	(0·4–2·2)
Motorcycle ownership	5	(20)	25	(35)	0·5	(0·1–1·6)
Mobile phone ownership	4	(16)	16	(22)	0·7	(0·2–2·5)
Television ownership	0	(0)	2	(3)	—	—
Household observations						
Thatched roof	20	(80)	34	(47)	4·2	(1·0–17·1)
Mud walls	24	(96)	62	(86)	3·6	(0·3–40·9)
Mud floors	24	(96)	63	(88)	3·2	(0·3–32·7)
Drinking water source, storage and treatment practices						
Improved water source§	6	(24)	12	(17)	1·8	(0·8–4·4)
Traditional clay pot	24	(96)	69	(96)	1·2	(0·2–9·4)
Vessel has a lid‡	21	(84)	51	(71)	1·4	(0·4–4·6)
Water obtained by dipping utensil	24	(96)	72	(100)	—	—
Has heard of water chlorination	20	(80)	50	(69)	1·8	(0·5–6·4)
Chlorinated water on day of interview	5	(20)	15	(21)	0·8	(0·3–2·0)
Positive chlorine residual	2	(8)	2	(3)	3·0	(1·4–6·3)

aOR, Adjusted odds ratio; CI, confidence interval.
* Indicates adjusted odds ratio (adjusted for age older than 50 years).
† Not adjusted odds ratio.
‡ More than 5% of data is missing
§ Improved water sources include boreholes, household connections, public standpipes, protected wells, rainwater collection, protected springs.

of decedents than survivors were aged >50 years (32% *vs.* 11%, OR 3·8, 95% CI 1·3–11·1) (Table 2). Belonging to age group >50 years was considered a confounder and included in the model; therefore aORs are reported. There were no significant differences in gender, marital status, education, literacy, employment, or household assets between decedents and survivors. Forty-four percent of decedents self-identified as having Animist beliefs compared to 17% of survivors (aOR 3·0, 95% CI0·7–13·0). Decedents were more likely than survivors to have a house with a thatched roof, an indicator of poverty (80% *vs.* 47%, aOR 4·2, 95% CI 1·0–17·1) (Table 2).

No significant differences were found in water sources, water storage or water treatment practices, between decedents and survivors. A similar percentage of decedents and survivors used an improved water source (24% *vs.* 17%, aOR 1·8, 95% CI 0·8–4·4) and 96% stored household drinking water in a traditional (wide-mouthed) vessel, obtaining water by dipping a utensil into the vessel. While most decedents and survivors had heard of chlorination as a water treatment method (80% *vs.* 69%), about 20% of respondents in each group reported chlorinating water on the day of the interview (Table 2). Decedents' households were more likely than survivors' households to have detectable residual chlorine in stored water (8% *vs.* 3%, aOR 3·0, 95% CI 1·4–6·3).

Over 50% of decedents and survivors reported >12 stools in a 24-h period and >90% described

Table 3. *Percentage of decedents and survivors with clinical signs, symptoms and comorbidities; cholera mortality investigation, Far North region, Cameroon, 2009 (N = 97)*

	Decedents (*N* = 25)		Survivors (*N* = 72)			
	n	(%)	*N*	(%)	aOR*	(95% CI)
Quality/quantity of diarrhoea						
>12 stools per day	13	(52)	38	(53)	0·8	(0·3–2·4)
Like rice water†	23	(92)	70	(97)	—	—
Symptoms						
Vomiting	24	(96)	66	(92)	2·2	(0·4–10·7)
Extreme thirst	22	(88)	58	(81)	1·9	(0·5–7·1)
Body cramps†	16	(64)	49	(68)	1·3	(0·4–4·2)
Too tired to walk	20	(80)	57	(79)	0·9	(0·4–2·0)
Sunken eyes	23	(92)	66	(92)	1·9	(0·7–5·1)
Too tired to speak	16	(64)	51	(71)	0·6	(0·2–1·3)
Headache	11	(44)	48	(67)	0·4	(0·2–1·0)
Clinical comorbidities						
Pregnant (*N* = 49)	3	(27)	5	(13)	2·5‡	(0·4–16·0)
Any alcohol use (*N* = 70)	13	(68)	20	(40)	2·5	(0·8–8·0)
Daily alcohol use	8	(44)	11	(22)	2. 2	(0·8–8·7)
Drank alcohol on day of illness onset	2	(11)	3	(6)	2·9	(0·4–21·1)
Tuberculosis	1	(4)	0	(0)	—	—
Cancer	0	(0)	1	(1)	—	—
HIV	0	(0)	0	(0)	—	—

aOR, Adjusted odds ratio; CI, confidence interval.
* Odds ratio adjusted for age group older than 50 years.
† More than 5% of data is missing.
‡ Not age-adjusted odds ratio.

a 'rice water' appearance to the stool (Table 3). Decedents and survivors also frequently reported vomiting (96% *vs.* 92%), extreme thirst (88% *vs.* 81%), and body cramps (64% vs. 68%). There were no differences in the proportion of respondents for decedents and survivors who reported signs of severe dehydration (Table 3). Of women of childbearing age (*n* = 49), 27% of decedents, compared to 13% of survivors, were reported to be pregnant (OR 2·5, 95% CI 0·4–16·0). Of respondents aged >14 years (*n* = 70), 68% of decedents reported any alcohol use, compared to 40% of survivors (OR 2·5, 95% CI 0·8–8·0).

Overall, diarrhoea treatment with oral rehydration salts (ORS) at home was low in decedents (4%) and survivors (13%) (Table 4). A homemade sugar-salt solution (SSS) was used by 12% of decedents; however, no one reported using the correct ratio of sugar to salt. Sixteen percent of decedents and 7% of survivors reported using a traditional medicine at home after developing diarrhoea.

Decedents were less likely than survivors to seek any type of care (72% *vs.* 96%, aOR 0·2, 95% CI 0·0–0·8) or care at a healthcare facility (64% *vs.* 96%, aOR 0·1, 95% CI 0·0–0·5) (Table 4). Of those who sought care at a healthcare facility (*n* = 85), 31% of decedents had a transport time ⩽20 min, compared to 58% of survivors (aOR 0·4, 95% CI 0·1–1·1). Decedents that sought care at a healthcare facility were less likely than survivors to receive ORS (50% *vs.* 90%, aOR 0·1, 95% CI 0·0–0·4); intravenous fluids (50% *vs.* 77%, aOR 0·3, 95% CI 0·1–0·9); or antibiotics (50% *vs.* 80%, aOR 0·2, 95% CI 0·1–0·8). The median amount of time between symptom onset and death in decedents was 12 h (range 3–144 h). Of those who did not seek care outside the home (*n* = 12), the most frequently cited reasons included a lack of transportation and thinking they did not need medical care.

DISCUSSION

Results of this investigation suggest that cholera patients who died were less likely than survivors to seek care outside the home, and to receive rehydration therapy and antibiotics at a healthcare facility.

Table 4. *Medical treatment at home and at a healthcare facility and care-seeking behaviours, by cholera decedents and survivors; cholera mortality investigation, Far North region, Cameroon, 2009 (N = 97)*

	Decedents (*N* = 25)		Survivors (*N* = 72)			
	n	(%)	*n*	(%)	aOR*	(95% CI)
Treatments undertaken at home						
Oral rehydration salts	1	(4)	9	(13)	0·4	(0·0–3·5)
Sugar-salt solution	3	(12)	3	(4)	4·4	(0·7–26·0)
Traditional medicine	4	(16)	5	(7)	2·9	(0·9–9·0)
Care-seeking behaviour						
Sought any type of care	18	(72)	69	(96)	0·2	(0·0–0·8)
Visited a healthcare facility	16	(64)	69	(96)	0·1	(0·0–0·5)
Care received (*N* = *85*)	**(*N* = *16*)**		**(*N* = *69*)**			
Transport time ⩽20 min	5	(31)	40	(58)	0·4	(0·1–1·1)
Received oral rehydration salts†	8	(50)	62	(90)	0·1	(0·0–0·4)
Received intravenous fluids†	8	(50)	53	(77)	0·3	(0·1–0·9)
Received antibiotics	8	(50)	55	(80)	0·2	(0·1–0·8)

aOR, Adjusted odds ratio; CI, confidence interval.
* Odds ratio adjusted for age group older than 50 years.
† Indicates that more than 5% of data is missing.

For both decedents and survivors, use of ORS at home was very low. Inadequacies in rehydration therapy and care-seeking behaviour found in this investigation were consistent with results of previous studies in other settings [5–9]. We identified an increased risk of death from cholera in the older age groups. Although age could not be investigated as a continuous variable within models that accounted for sample design, exploration outside such models using the using Hosmer–Lemeshow goodness-of-fit test did indicate a positive linear relationship between mortality risk and age. The low literacy, poor transportation infrastructure, and inadequate coverage of safe water and sanitation infrastructure observed in this investigation are common conditions in countries predisposed to epidemic or endemic cholera and contribute to the challenge of preventing cholera morbidity and mortality. This constellation of findings highlights shortcomings in emergency and longer-term cholera prevention and control activities in sub-Saharan Africa that have persisted despite four decades of experience with the seventh cholera pandemic [4].

Findings of this investigation suggest several interventions that could help mitigate the high cholera CFR in Cameroon. Previous investigations in countries with similar conditions showed a rapid decrease in cholera CFRs to <1% through timely provision of treatment supplies and training of HCWs [6]. Educating the community on the importance of seeking immediate care for diarrhoea during a cholera epidemic is critical. The establishment of rehydration centres in rural areas has also been shown to reduce cholera mortality, probably by reducing transportation times during epidemics in other settings [3, 15]. In South Asia, the cholera CFR remains consistently below 1% in part because of widespread access to and aggressive use of ORS [16]; the benefit of ORS extends to prevention of diarrhoea-related mortality in children aged <5 years [17]. Training of traditional practitioners, who are more accessible to many rural populations in Cameroon, as ORS providers could increase access to rehydration therapy [18].

Although homemade SSS has been proposed as an alternative rehydration method for populations with poor access to ORS [19], in this investigation, use of SSS was rare and no respondents knew the correct recipe for SSS. Other investigations had similar observations [6, 20–22]. Ensuring widespread access to and training in proper preparation of prepackaged ORS may be a more effective use of scarce resources, and could help reverse a trend towards lower use of ORS for diarrhoeal disease treatment that has been observed in a number of countries [23]. By providing ORS in homes and educating the population to use ORS to treat severe diarrhoeal illness, even before a cholera epidemic is recognized, cholera mortality could be mitigated early in an epidemic.

The consumption of alcohol can lead to dehydration [24] and may compound dehydration from cholera. Additionally, alcohol intoxication during illness onset may impair care-seeking behaviours. Although we did not find a statistically significant association between alcohol use and death from cholera, this association was observed during a cholera outbreak in Guinea-Bissau in 1994 [8].

In addition to measures for the treatment and prevention of cholera mortality, attention to interventions that prevent cholera acquisition and transmission are also needed in Cameroon. Water storage in traditional, wide-mouthed clay pots, similar to those used by the majority of respondents in this investigation, increases the likelihood of water contamination and the attendant risk of diarrhoea [25–27]. Use of covered, narrow-mouthed containers can reduce this risk [28]. The infrequent use of household water treatment noted in this investigation combined with the use of unimproved water sources increases the risk of infection with waterborne diarrhoeal pathogens, including *V. cholerae* [29, 30]. Simple household interventions, including household water treatment and handwashing with soap, have been shown to reduce cholera risk during outbreaks [31, 32] and the risk of diarrhoea more generally [29, 33].

In this investigation, we found that the Cameroon MOH was using a suspect cholera case definition that, by excluding mild or moderate cases, was very specific, and limited to patients with very severe diarrhoea and dehydration, thus inflating the CFR. Applying the standard WHO cholera case definition decreased the CFR from 11·6% to 7·5%, which remains well above the target of $\leqslant$1% for cholera mortality. Since our investigation, Cameroon has adopted the WHO case definition, which not only provides a more accurate measure of outbreak magnitude and severity but also allows for comparisons between countries, and assists aid organizations in prioritizing response activities [34].

Another factor contributing to excess cholera mortality in this region of Cameroon may have been the epidemic strain ('Orissa strain'), which may be particularly virulent [11, 12], having caused severe outbreaks in Bangladesh [12, 35] and, more recently, in Haiti [36]. Further research is needed to understand the virulence factors of this strain. In the meantime, the fundamentals of cholera response, regardless of the epidemic strain, remain the same: distribution of adequate treatment supplies, HCW training, mass communication about cholera prevention measures (water treatment, proper sanitation practices, handwashing with soap, proper food preparation), and ensuring access to safe water and sanitation.

This investigation has several important limitations. First, findings could not be generalized to other regions of Cameroon because this investigation was limited to the Far North region. Nevertheless, many findings in our study have been found in other cholera mortality studies in different settings [5–9]. Second, the population of decedents and survivors was obtained from the MOH line-list and may not have been representative of all cholera-infected persons, especially cholera survivors with mild symptoms that did not seek care at a healthcare facility. Using the MOH line-list, however, did ensure that the severity of illness was comparable between decedents and survivors, as seen in Table 2. Third, because we had the unavoidable necessity of relying on responses of relatives of decedents, the data may have been subject to information bias; however, it is unknown which direction, if any, this bias may have changed our findings. Finally, our limited sample size probably reduced our ability to detect statistically significant associations between interventions and cholera mortality. Nevertheless, some of our findings, although not statistically significant, were biologically plausible, consistent with results of other studies on cholera mortality, and, therefore, merited mention [5–9].

Over the long term, control of epidemic cholera in Cameroon, and in other countries that experience recurrent outbreaks, will require sustained infrastructural improvement. The need for improved infrastructure is urgent; in 2010, Cameroon experienced another cholera epidemic with 10759 reported cholera cases and 657 deaths (CFR 6·1%) [37]. Fortunately, mitigation of epidemic cholera is possible. In the early 1990s, when the seventh pandemic of cholera reached Latin America, a concerted effort from United Nations agencies, development banks, and national governments resulted in large investments in drinking water, sanitation, and healthcare infrastructure leading to marked reductions in cholera morbidity and mortality by the following decade [1]. These investments had the collateral benefit of reducing illness from other enteric diseases, such as typhoid fever and hepatitis A, and reduced infant mortality [38]. This experience demonstrates the path to improved health for Cameroon and other cholera-affected countries.

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DECLARATION OF INTEREST

None.

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