Original Article

Cholera Outbreak Associated with Contaminated Water Sources in Paddy Fields, Mandla District, Madhya Pradesh, India

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Abstract

Background: Mandla District in Madhya Pradesh, India, reported a suspected cholera outbreak from Ghughri subdistrict on August 18, 2016. **Objective:** We investigated to determine risk factors and recommend control and prevention measures. **Methods:** We defined a case as >3 loose stools in 24 h in a Ghughri resident between July 20 and August 19, 2016. We identified cases by passive surveillance in health facilities and by a house-to-house survey in 28 highly affected villages. We conducted a 1:2 unmatched case–control study, collected stool samples for culture, and tested water sources for fecal contamination. **Results:** We identified 628 cases (61% female) from 96 villages; the median age was 27 years (range: 1 month–76 years). Illnesses began 7 days after rainfall with 259 (41%) hospitalizations and 14 (2%) deaths in people from remote villages who died before reaching a health facility; 12 (86%) worked in paddy fields. Illness was associated with drinking well water within paddy fields (odds ratio [OR] = 4.0, 95% confidence interval [CI] = 1.4–8.0) and not washing hands with soap after defecation (OR = 6.1, CI = 1.7–21). Of 34 stool cultures, 11 (34%) tested positive for *Vibrio cholerae* O1 Ogawa. We observed open defecation in affected villages around paddy fields. Of 16 tested water sources in paddy fields, eight (50%) were protected, but 100% had fecal contamination. **Conclusion:** We recommended education regarding pit latrine sanitation and safe water, especially in paddy fields, provision of oral rehydration solution in remote villages, and chlorine tablets for point-of-use treatment of drinking water.

Key words: Case-control studies, defecation, drinking water, sanitation, *Vibrio cholerae* O1

Introduction

Cholera, caused by *Vibrio cholerae,* is a severe acute diarrheal illness that can lead to sudden death if not treated. Every year there are an estimated 1–4 million cholera cases and 143,000 deaths from cholera worldwide.[1] Cholera commonly occurs in areas with poor access to safe water and improper sanitation. Case fatality rates (CFR) can be as high as 30%, but with proper and timely treatment, the CFR can be below 1%.[2,3]

Among all outbreaks reported in India, 26% are acute diarrheal disease (ADD); 6% of these are laboratory-confirmed cholera outbreaks.[4] However, this is likely an underestimation of cholera burden in India because of poor laboratory capacity at local levels to isolate etiological agents. Cholera is endemic in parts of the Indian subcontinent due to its vast coastlines, areas of poor sanitation, unsafe drinking water, and overcrowding. When cholera outbreaks are reported in India, the CFR is usually <1% because of prompt medical treatment.[3]

On August 18, 2016, the central surveillance unit (CSU), Integrated Disease Surveillance Programme in the National Centre for Disease Control, Delhi, received information from Madhya Pradesh State surveillance unit about a suspected

Access this article online

Quick Response Code:

Website: www.ijph.in

DOI: 10.4103/ijph.IJPH_1118_20

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Submitted: 07-Sep-2020 **Revised:** 01-Nov-2020
Accepted: 01-Dec-2020 **Published:** 29-Jan-2021

How to cite this article: Dutta BP, Kumar N, Meshram KC, Yadav R, Sodha SV, Gupta S. Cholera outbreak associated with contaminated water sources in paddy fields, Mandla District, Madhya Pradesh, India. Indian J Public Health 2021;65:S46-50.

cholera outbreak with multiple deaths in the Ghughri subdistrict of Mandla district, Madhya Pradesh. On August 19, a team from the CSU, including an India epidemic intelligence service (EIS) officer, joined the district investigation team to describe the epidemiological characteristics of the outbreak, determine risk factors, and to guide control and prevention measures.

Materials and Methods

Case finding

We defined a case as >3 loose stools in 24 h in a resident of Ghughri subdistrict, Mandla District, Madhya Pradesh, between July 20 and August 19, 2016. Ghughri subdistrict includes 96 villages and has a population of 101,115 (2011 census). We conducted passive surveillance from outpatient and inpatient registers of the sole community health center (CHC) with available doctors in Ghughri subdistrict: Three primary health centers in the subdistrict were nonfunctional due to no doctor posted in the facilities. We also conducted active surveillance by house-to-house visits in the 28 most highly affected villages. We interviewed cases and family members of deceased cases regarding signs, symptoms, and clinical course. We conducted medical reviews of cases admitted to CHC Ghughri and also interviewed the physicians treating these cases about symptoms and treatment protocol.

Case–control study

We conducted an unmatched 1:2 case–control study to identify risk factors associated with the outbreak. Based on 95% confidence interval (CI), 80% power, estimated 50% exposure among controls, and an odds ratio (OR) of 3, we calculated a sample size of 50 cases and 100 controls. Cases were selected randomly, and controls were selected from the nearest neighbors of cases enrolled. We limited selection to one case per household. Controls were residents of Ghughri subdistrict, Mandla, Madhya Pradesh, who did not have >3 loose stools in 24 h between July 20 and August 9, 2016. Two controls per case were selected from the nearest two households of enrolled cases. We selected the first eligible person in the household that met the control criteria. We used a semi-structured questionnaire in the local language to collect demographic information, clinical history, drinking water sources, water storage, water treatment, and hygiene practices.

Laboratory investigation

We collected stool samples during August 15–23, 2016, from admitted cases at Ghughri CHC for the culture of common Gram-negative enteric pathogens such as *Shigella, Salmonella,* and *V. cholerae* followed by antibiotic susceptibility analysis at the Indian Council of Medical Research (ICMR) laboratory in Jabalpur, India.

Environmental investigation

We collected data on rainfall from July 5 to 20 for 2015 and 2016. In villages where deaths due to diarrhea were reported, we assessed drinking water sources, defecation practices, and toilet facilities and also tested water samples from different drinking water sources during August 15–23, 2016, for residual chlorine by orthotolidine test, fecal contamination by H_2S method, and *V. cholerae* by culture.

Data analysis

Data were summarized for frequencies, and ORs were calculated with 95% CIs using Epi Info 7.2 (Atlanta, United State of America).

Ethical considerations

The investigation was a public health response to an outbreak as a part of the India EIS Program, undertaken with the purpose to identify the source of spread for immediate control of outbreak, and intended for benefit of the community at large. Ethical approval is not applicable as a part of public health response. The investigation did not involve any human laboratory sample collection for research purpose, and there were no invasive investigations or medical interventions/experiments. All Government of India ethical principles and guidelines were adopted during the outbreak response: The investigation was aimed at achieving public good (beneficence) and collective welfare (solidarity); no harm was done to any individual (nonmaleficence); fair, honest, and transparent (accountability and transparency); and participants' data were de-identified before analysis (confidentiality).

Results

Descriptive epidemiology

We identified 628 cases (61% females) with a median age of 27 years (range: 1–76 years). There were 14 deaths for a 2% CFR. Among the deaths, 12 (86%) were female and the median age was 39 years (range: 8–65 years); 12 (86%) had a history of working in paddy fields. The outbreak started on July 30, 2016, and peaked on approximately August 8, 2016. Cases began declining from August 11, after chlorination of drinking water sources, and returned to preoutbreak levels on approximately August 28, after chlorine tablets were distributed and used in households across villages of Ghughri subdistrict [Figure 1].

Cases were reported from 62/96 (65%) villages in the subdistrict [Figure 2]. Among 614 cases treated at the Ghughri CHC, 259 (41%) were hospitalized. All cases (100%) presented

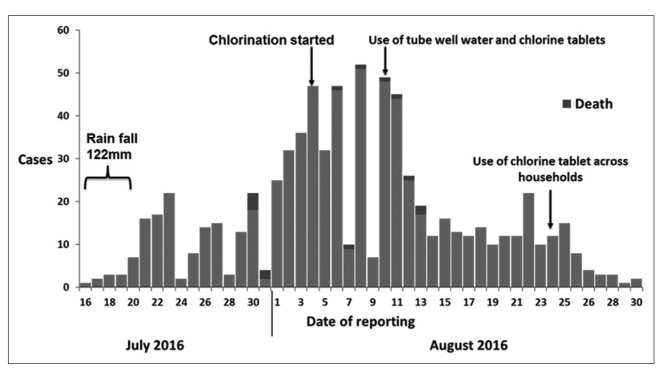

Figure 1: Diarrheal disease cases by date of reporting, Ghughri Sub-district, Mandla District, Madhya Pradesh, July 20 to August 19, 2016 (n = 628).

with acute watery diarrhea, 273 (44%) with vomiting, and 60 (10%) with fever. All 355 (100%) of outpatients were treated with oral rehydration solution (ORS) and doxycycline, and all 259 (100%) inpatients were treated with intravenous fluids and antibiotics (doxycycline, ceftriaxone, and metronidazole) as per the treatment protocol developed by the district. All 614 (100%) cases who received treatment at the Ghughri CHC recovered. All of the 14 deaths were from remote, hard-to-reach areas (10–30 km from Ghughri CHC) who were unable to reach a health facility for medical treatment.

Risk factors for the outbreak

Among 50 cases and 100 controls, illness was significantly associated with drinking water from wells within paddy fields (OR = 4.0, 95% CI = 1.3–8.1) and not washing hands with soap after defecation (OR = 6.1, 95% CI = 1.8–21.2) [Table 1]. Reported open defecation practices, taking water out of storage pot with a glass without a handle, or not washing hands before eating were not significantly associated with the illness.

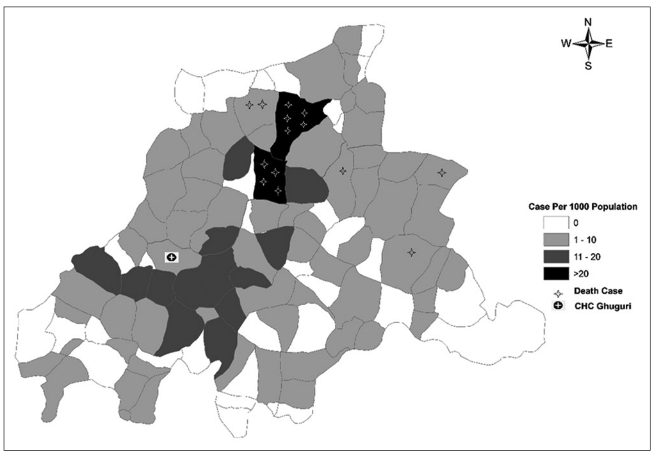

Figure 2: Distribution of acute diarrheal disease cases by village, Ghughri Subdistrict, Mandla District, Madhya Pradesh, July 20 to August 19, 2016 (*n* = 628).

Laboratory investigation

Of the 34 patients who submitted a stool sample, 11 (32%) were positive for *V. cholerae* O1 Ogawa. All isolates were susceptible to tetracycline, ceftriaxone, meropenem, doxycycline, amikacin, and norfloxacin and resistant to cotrimoxazole. There was no growth for *Salmonella* or *Shigella*.

Environmental investigation

The villages were sparsely populated and spread across hilly terrain. Drinking water sources included tube wells, open dug wells, and puddles. Paddy field work is predominantly done by women in this season, and they consume open dug well water within paddy fields; there is no other drinking water source in the paddy fields. Villagers reported an overflow of drinking water sources due to heavy rain 7 days before the outbreak. The rainwater flooded the area with open wells and consequently completely filled the wells. Tube wells were also submerged in the flooded water. The Ghughri Meteorological Department reported 122 mm of rainfall in 2016 between July 5 and 20, compared with 44 mm in 2015.

We observed wide scale open defecation practices. None of the houses had a toilet in the six villages we visited. There was one community toilet present in one village, but it was not in use. Among 25 drinking water samples tested from six village open wells, five paddy field open wells, and seven puddles, all samples were positive for the presence of fecal coliforms. Among the seven tube well samples in villages, two were contaminated with fecal coliforms. There was no residual chlorine found in any water sample tested. *V. cholerae* was not isolated from any water sample.

Public health action

Ambulances were provided in inaccessible areas for early treatment and transportation of patients to the nearest

Table 1: Risk factors for acute diarrheal disease, Ghughri subdistrict, Mandla District, Madhya Pradesh, India, July to August 2016 (*n*=150)

	Cases (*n*=50), *n* (%)	Controls (*n*=100), *n* (%)	OR	95% CI
Drinking water source within paddy field				
Paddy field dug wells‡	32 (64)	31 (31)	4.0	1.9-8.1
Drinking water sources at home				
Village dug wells‡	13 (26)	26 (26)	1.0	0.5-2.2
Tube wells§	32 (64)	65 (65)	1.0	0.5-2.2
Puddles‖	5 (10)	9 (9)	1.12	0.4-3.6
Hygiene				
Did not wash hands with soap after defecation	47 (94)	72 (72)	6.1	1.8-21.2
Open defecation	43 (86)	82 (82)	1.3	0.6-3.5
Did not wash hands before eating	3 (6)	6 (6)	1.0	0.2-4.2
Water storage and treatment				
Wide neck water storage container	29 (58)	66 (66)	0.7	0.4-1.4
Uncovered storage of drinking water	12 (24)	27 (27)	0.9	0.4-1.9
Did not treat water before drinking	46 (92)	84 (84)	2.2	0.7-6.9

‡Paddy field dug wells/village dug wells=Holes in the ground dug by shovel to collect water, §Tube wells=A well made by driving a tube into the earth to a stratum that bears water, ‖Puddles=A small pool of rainwater on the ground. OR: Odds ratio, CI: Confidence interval

hospital. The district supplied water filters to households in hard-to-reach areas in Ghughri subdistrict. ORS packets, chlorine tablets, soap, and educational leaflets for hygiene and sanitation were distributed to each household in Ghughri subdistrict. It was recommended that villagers do not defecate near drinking water sources until the construction of pit latrines was completed with government support. More than 500 field health workers were engaged for community education.

Discussion

We investigated a large cholera outbreak associated with drinking open dug well water within paddy fields. Rain water runoff in open defecation areas likely contaminated unprotected overflowing open drinking water sources in and around paddy fields. Poor access to health facilities staffed by doctors in hard-to-reach areas contributed to mortality. In the analytical study, approximately two-thirds of case-patients drank water from the open dug wells within paddy fields. The exposure rate was higher, but it may have been underreported because of recall bias. An estimated 84% of case-patients worked in paddy fields. Most of those who did not work in paddy fields had a relative working in paddy fields. Cross-contamination probably occurred due to poor sanitation behaviors such as not washing hand after defecation, which was also significantly associated with illness. However, we are unable to completely explain the association between poor hand washing after defecation and illness. This could be a result of confounding from other unidentified factors related to open defecation in paddy fields.

Historically, higher CFRs are a result of limited access to proper health care of vulnerable populations and underpreparedness of health-care systems.[3] In 2016, CFRs higher than 5% were reported in Niger, Zimbabwe, and Congo, while the overall global CFR was 1.8%.[4] A CFR of 9%, with 10 deaths among 114 cases in a 2010 Western Kenya cholera outbreak, was due to poor case management, inadequate skills among health staff, weaknesses in the surveillance system, and poor management support.[5] These causes were consistent with the findings during a cholera outbreak in Zimbabwe in 2008, with a CFR of 4.5%, with 4282 deaths among 95,531 reported cholera cases, where inappropriate cholera case management with inadequate use of oral rehydration therapy, inappropriate use of antibiotics, and a shortage of experienced health-care professionals were contributing factors.[6] In this outbreak, we found a CFR of 2%, which was lower than recent outbreaks in African settings but higher than expected for India. Due to the hilly terrain in this geographic area, there was poor access to health facilities. Moreover, heavy rain had damaged footpaths in the area. The inability to access care probably contributed to the deaths; all the patients died before receiving any medical care.

We found that most cases in this cholera outbreak were women. Numerous studies and outbreaks in Indonesia, South Africa, the United Kingdom, the United States of America, Canada, Bangladesh, and Kenya have found the predominance of cholera and other diarrheal diseases in women.[7-11] The reasons for the gender disparities are unclear; there is no known biological explanation for the predominance of cholera and other diarrheal diseases among women. Therefore, behavior seems likely to play a role, perhaps through increased occupational exposure.[12] In this outbreak, most deaths were among female paddy field workers. Conventionally, in Mandla district, males work in paddy fields during paddy preparation, while females take over during planting and weeding. This outbreak was during weeding and planting season when females usually work and coincided with the heavy rains. As women field workers generally do not take clean drinking water to the fields, they drank the open well water that was contaminated with fecal material.

Due to limited laboratory capacity in India, isolation of a causative pathogen in ADD outbreaks is challenging.[13] The lack of laboratory capacity negatively affects ADDs surveillance, etiological confirmation, and delays response time. In a 2010 Haiti cholera outbreak, a CFR of 4.6% during the initial days of the outbreak was due to the inability to quickly identify cholera as the causative agent; it took nearly 17 days to confirm the cholera outbreak and respond appropriately.[14] A cholera outbreak, which started in July 2009, spread throughout lowland Papua New Guinea with 15,500 cases and 493 reported deaths (CFR 3.2%).[15] Delays in diagnosis due to limited laboratory diagnostic capacity delayed the public health response and facilitated the spread of *V. cholerae*.[15] Similar limited laboratory capacity exists in India; we were only able to effectively isolate *V. cholerae* and determine antimicrobial sensitivity profiles during our investigation because our team included a microbiologist and access to a referral diagnostic laboratory. The microbiologist ensured adequate collection and transportation of stool and water samples to the ICMR laboratory in Jabalpur. We also had onsite support from the ICMR laboratory for logistics and immediate processing of samples to isolate the causative pathogen on an urgent basis. Because of the timely laboratory confirmation, effective treatment and control mechanisms were quickly implemented to minimize morbidity and mortality.

Our investigation was subject to limitations. We could not collect stool samples from all cases including those who died. We might have missed cases in remote hilly villages with sparse populations as the house-to-house case search was conducted in selected villages based on the residence of cases visiting the health facility. Furthermore, there might have been recall bias among the cases and controls concerning exposures, and information bias about hygienic practices as respondents might have tried to give socially desirable answers.

Conclusion

A systematic and thorough epidemiologic investigation was critical to identifying the source of water contamination. This investigation demonstrates the importance of being able to incorporate clinical, epidemiological, laboratory, and environmental data to describe an outbreak and to identify the risk factors for illness. This investigation led to evidence-based recommendations for cholera prevention and control measures, which ended the outbreak. Cholera remains a major public health problem in India that is likely underrecognized. We recommended strengthening surveillance of ADDs and enhancing laboratory capacity to isolate causative agents. As India continues to invest in building epidemiological and laboratory capacity, we expect improvements in evidence-based public health policies and practices to decrease ADDs in the population.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Ali M, Lopez AL, Ae You Y, Kim YE, Sah B, Maskery B, *et al.* The global burden of cholera. Bull World Health Organ 2012;90:209-18A.
2. Cholera Case Fatality Ratio (%). Global Health Observatory. World Health Organization. Available from: https://www.who.int/gho/epidemic_diseases/cholera/situation_trends_case_fatality_ratio/en/. [Last accessed on 2017 May 26].
3. World Health Organization. Cholera Case Fatality Rate – Situation and Trends. Global Health Observatory. World Health Organization. Available from: http://www.who.int/gho/epidemic_diseases/cholera/case_fatality_rate_text/en/. [Last accessed on 2017 May 26].
4. Weekly Outbreaks. Integrated Disease Surveillance Programme, National Centre for Disease Control. Directorate General of Health Services. Ministry of Health and Family Welfare. Government of India. Available from: http://www.idsp.nic.in/inde×4.php?lang=1&level=0&linkid=406&lid=3689. [Last accessed on 2017 May 26].
5. Onyango D, Karambu S, Abade A, Amwayi S, Omolo J. High case fatality cholera outbreak in Western Kenya, august 2010. Pan Afr Med J 2013;15:109.
6. Ahmed S, Bardhan PK, Iqbal A, Mazumder RN, Khan AI, Islam MS, *et al*. The 2008 cholera epidemic in Zimbabwe: Experience of the icddr, b team in the field. J Health Popul Nutr 2011;29:541-6.
7. Agtini MD, Soeharno R, Lesmana M, Punjabi NH, Simanjuntak C, Wangsasaputra F, *et al*. The burden of diarrhoea, shigellosis, and cholera in north Jakarta, Indonesia: Findings from 24 months surveillance. BMC Infect Dis 2005;5:89.
8. Archer BN, Cengimbo A, De Jong GM, Keddy KH, Smith AM, Sooka A, *et al*. Cholera Outbreak in South Africa: Preliminary Descriptive Epidemiology on Laboratory – Confirmed Cases, 15 November 2008 to 30 April 2009. In: National Institute for Communicable Diseases. Vol. 7. South Africa: Communicable Diseases Surveillance Bulletin; 2009. Available from: https://www.nicd.ac.za/assets/files/CommDisBullMay09_Vol0702.pdf. [Last accessed on 2020 Aug 16].
9. Scallan E, Majowicz SE, Hall G, Banerjee A, Bowman CL, Daly L, *et al*. Prevalence of diarrhoea in the community in Australia, Canada, Ireland, and the united states. Int J Epidemiol 2005;34:454-60.
10. Fauveau V, Koenig MA, Wojtyniak B. Excess female deaths among rural Bangladeshi children: An examinationof cause-specific mortality and morbidity. Int J Epidemiol 1991;20:729-35.
11. Tornheim JA, Manya AS, Oyando N, Kabaka S, O'Reilly CE, Breiman RF, *et al*. The epidemiology of hospitalization with diarrhea in rural Kenya: The utility of existing health facility data in developing countries. Int J Infect Dis 2010;14:e499-505.
12. UNICEF. Briefing Note: Strategy for Integratinga Gendered Response in Haiti's Cholera Epidemic. UNICEF: Haiti Child Protection Section/GBV Program; 2010. Available from: https://www.unicef.org/cholera/Chapter_8_case_management/29_Haiti_UNICEF_Briefing_Note_Gender_Cholera.pdf. [Last accessed on 2020 Aug 16].
13. Zuckerman JN, Rombo L, Fisch A. The true burden and risk of cholera: Implications for prevention and control. Lancet Infect Dis 2007;7:521-30.
14. Barzilay EJ, Schaad N, Magloire R, Mung KS, Boncy J, Dahourou GA, *et al*. Cholera surveillance during the haiti epidemic – The first 2 years. N Engl J Med 2013;368:599-609.
15. Greenhill A, Rosewell A, Kas M, Manning L, Latorre L, Siba P, *et al.* Improved laboratory capacity is required to respond better to future cholera outbreaks in Papua new guinea. Western Pac Surveill Response J 2012;3:30-2.


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