ORIGINAL RESEARCH

The Columbia University JOURNAL of GLOBAL HEALTH

Outbreak Investigation of Acute Diarrheal Disease (ADD) during a Religious Mass Gathering Associated with Drinking Contaminated Pipeline Water, Radhakund, Uttar Pradesh, India, October— November 2016

Sushma Choudhary[1], Rajesh Sahu[1], Samir V. Sodha[2], Tanzin Dikid[3], Chandra Shekhar Aggarwal[3], Ashok Kumar Pandey[4], Ekta Saroha[2], Shrinivas Venkatesh[3], Pradeep Khasnobis[3]

[1]National Centre for Disease Control, New Delhi, India, India Epidemic Intelligence Service Officer
[2]US Centers for Disease Control and Prevention, India
[3]National Centre for Disease Control, New Delhi, India
[4]Integrated Disease Surveillance Programme, Uttar Pradesh, India

ABSTRACT

Background: In 2015, there were >12 million acute diarrheal disease (ADD) cases with 1,216 deaths reported in India; 75,347 cases and 320 deaths were reported from Uttar Pradesh state. A suspected ADD outbreak was reported from Radhakund town, Uttar Pradesh (population = 11,488 as per census 2011) on November 11, 2016 during a religious festival with >10,000 pilgrims. We investigated to describe the epidemiology, identify risk factors and recommend preventive measures.

Methods: We defined a suspect case as ≥3 loose stools within 24 hours in anyone residing in Radhakund town between October 31 and November 11, 2016. We identified cases by reviewing hospital records and by house—to—house survey. We conducted a 1:2 unmatched case—control study using a structured questionnaire to identify risk factors. Stool for cultures were not collected by hospitals and no active cases were present during the investigation for testing. We assessed water supply and sanitation of the town and tested water samples for fecal contamination.

Results: We identified 339 cases (hospital records=273; house-to-house=66) ; 285 (84%) were pilgrims. Median age was 60 years (range 1—80 years), 69% female. There were 117 (35%) hospitalizations and two deaths. Symptoms were vomiting (94%), abdominal pain (23%), and fever (3%). Cases were clustered around areas receiving drinking water from pipeline A and peaked on 3 and 5 November 2016. Among 44 cases and 81 controls, only drinking water from pipeline A (aOR=9.6 [95% CI = 3.0—29.5]) and illiteracy (aOR=23.2 [95% CI = 5.9—91.0 were associated with illness in multivariate analysis. We observed sewage overflow from community toilets near tube-wells supplying pipeline A. Pipeline A is >40 years old with frequent cracks and leaks. Among four water samples from pipeline A, two were positive for *Vibrio cholerae*.

Conclusions: This was a point-source localized ADD outbreak, probably cholera, predominantly among pilgrims in Radhakund associated with drinking water from a pipeline contaminated with *Vibrio cholerae* Despite the limitation of pilgrims not being available for the analytical study, we were able to determine the likely source epidemiologically based on affected residents in the community. We recommended chlorination of water, relocation of public toilets away from tube—wells, repair of pipeline A, routine water surveillance and enhanced sanitation facilities for pilgrims.

KEY WORDS acute diarrheal disease, outbreak, Vibrio Cholerae, water—borne

Send correspondence to: SUSHMANIYATI@GMAIL.COM

INTRODUCTION

Acute diarrheal diseases (ADD) account for 1.7 billion illnesses every year globally,[1] accounting for 1.3 million deaths in 2015.[2] In 2016, there were an estimated 14 million diarrheal cases reported in India. Among 3,157 outbreaks reported in 2016 to India's Integrated Disease Surveillance Programme (IDSP), 821 (26%) were ADD outbreaks.[3] The Constitution of India defines the right to "pollution-free water" and the right of access to "safe drinking water" as a part of "Right to Life" under Article 21 of the.[4] Despite of it, 11% of the Indian population does not have access to safe drinking water and 52% lack access to improved sanitation facilities.[5]

The 74th Amendment in constitution devolves responsibility of water supply and sanitation to the local bodies/governments.[6] It empowers to develop and manage their own water supply and sanitation systems. Water supply in villages and small town constitutes of a centralized treatment plant or well, a network of pipes, gravity/pumping based distribution system from water source with needed water treatment to cater the small population.[7] Mass gatherings during religious rituals pose a unique public health challenge due to huge inflow of people into such limited resource settings. These gatherings lead to increased demand on existing services and resources, including for safe drinking water and sanitary facilities. Outbreaks of multiple diseases, including ADD, are often associated with these gatherings.[8] At the same time, overburdened water and sanitation departments' health systems may result in reduced outbreak detection and delayed response.

In India, mass gatherings occur throughout the year for various religious practices. Every year, during the Kartik month of the Hindu calendar (October to November), there is a religious mass gathering for worship and holy bath in the town of Radhakund in the Mathura district, Uttar Pradesh state in India. Radhakund is located about 25 kilometers from the district headquarters with a population of 11,488 as per the 2011 India Census.[9] However, a population of pilgrims residing in the town during the Kartik month increases the total population to 25 to 30,000 every year. Radhakund is a town with its own water supply and sanitation system that was established with two borewells by local administrative body in 1978 when the town population was 3,825.[10] The existing water supply network was expanded with town expansion and is now supplied with five borewells through a network of pipelines.

On November 3, 2016, the community health center (CHC) of Radhakund reported an unusually high number of diarrhea cases during this religious mass gathering. As a local outbreak response, health camps were conducted on November 3 and 5, 2016 in affected areas of Radhakund. However, when more cases appeared, district health officials deployed the district rapid response team on November 7, 2016 and reported the ADD outbreak to the state surveillance unit. In response, the National Centre for Disease Control deployed two India Epidemic Intelligence Service officers to join the investigation. We investigated to describe the outbreak, identify risk factors and propose recommendations to prevent future outbreaks during such mass gatherings.

METHODS

Case Finding

We defined a case as any person of age ≥1 year residing in Radhakund with three or more loose stools within 24 hours between 31 October and 11 November 2016. We identified cases by reviewing out-patient and in-patient records from the Radhakund CHC and the two health camps. We conducted a house-to-house survey of Radhakund to search for cases and collected information on age, gender, place of residence, date of illness onset, symptoms and treatment history. Laboratory diagnosis of cases could not be done.

Case-Control Study

Based on leading hypotheses related to food, water and hygiene, an unmatched 1:2 case-control study among those residing in Radhakund from October 31 to November 5, 2016 was the most appropriate study design to test the hypotheses. Although pilgrims were not available at the time of data collection but considering that the exposures were similar, we enrolled all consenting cases identified through the house-to-house survey. To improve the power of the study, two unmatched controls for every case were selected through systematic random sampling of a sampling frame comprising the entire town of Radhakund. Based on an estimate of 50 available cases to enroll, we calculated a goal of selecting 100 controls. Based on this goal and household census data, we selected every twelfth house for control recruitment.

After obtaining informed consent, we administered structured questionnaires to cases and controls in Hindi, the local language. We collected information pertaining to illness and treatment (for case patients), food and water exposures (drinking water sources: pipeline A—D; water treatment: boiling, filtration, chlorination; consumption of pond water during holy bath) and hygiene practices. Individuals were excluded from being controls if they reported chronic diarrhea or were children younger than one year of age.

We calculated odds ratios (OR) with 95% confidence intervals (CI) for all suspected risk factors. For our multivariable logistic regression model, we included drinking water from any pipeline (without the individual pipelines) illiteracy, drinking filtered or boiled water at home and consumed prasad and all exposure-related variables with a p-value <0.20 in univariate analysis. Age and gender are known confounders in literature, and hence were considered for logistic regression.[11-13]

Borewell at home was considered a reference water source while calculating adjusted odds ratio for individual pipeline. We evaluated confounding and interaction among these factors. Data were entered and analyzed using Epi Info7.2.

Environmental Investigations

We assessed water sources, the water supply network and the sewerage in Radhakund. We gathered information regarding additional sanitary facilities either (temporary/mobile or permanent structure) made available during the mass gathering and general hygiene and sanitation of the town during the outbreak period. We also reviewed water pipeline repair records.

We collected four water samples in sterile bottles: one from the religious pond, two from piped water supply (one each from the consumer end of pipeline A and from a hermitage supplied by pipeline D) and one from the overhead tank from where water is distributed through pipeline A. All the samples were sent to Sarojini Naidu Medical College, Agra for microbiological examination and were cultured for *Vibrio Cholerae*, *Escherichia Coli*, *Salmonella* and *Shigella*.

Ethical Considerations

Outbreak investigation was a public health response which was exempted from ethical review.

RESULTS

Descriptive Epidemiology

We identified 339 cases (69% females) between October 31 to November 11, 2016 with peaks on November 3 and 5, reflecting the dates when outreach treatment camps were conducted (Figure 1). There were no cases at the beginning of the mass gathering from October 17 to 30. Cases were reported from October 31, and a death also occurred the same day. Cases peaked on October 3 and 5, started declining from November 7 and no cases were reported after November 11. The median age was 60 years (range: 1 to 80 years) and 84% (285) were pilgrims. Among the cases 81% (273) were identified through hospital records and 19% (66) by house-to-house survey, 35% (117) of case patients were hospitalized and two died (case fatality rate <1%). Cases were clustered in colonies which were supplied drinking water by pipeline A (Figure 2).

Among the 66 cases with available data from the house-to-house survey, 100% had watery diarrhea, 94% had nausea or vomiting, 23% had abdominal cramps and 3% had fever. Health staff managed these 66 cases by treating with oral rehydration salt solution (66%), intravenous fluids (54%), injectable antibiotics (52%) and oral antibiotics (59%).

Case-Control Study

We included 49 cases that were available and willing to participate and 101 controls. Cases and controls were comparable for socio-demographic factors (Table 1). The median age of cases was 45 years old (range 1-80) and of control was 30 years old (range 6-34). Among different water sources, only drinking tap water from pipeline A (adjusted OR=9.5); among all other risk factors, only illiteracy (adjusted OR=23) was associated with the illness (Table 2).

Environmental Investigations

Pilgrims resided in Radhakund in the same colonies where locals lived and shared the same water supply with the locals. Water is supplied to Radhakund from five tube wells by pumping through a network of pipelines. Tube well A is located approximately 100 meters from the public toilet. Pipeline from tube well A1 and A2 join to form pipeline A (Figure 2). Pipeline A goes through an overhead tank and is approximately 40 years old with a history of frequent repairs. Water is pumped to overhead tank, chlorinated there and supplied through gravity. Tube well B, C and D were located 5-6 kilometers away from public toilets. Pipelines connected from them were comparatively new and supply water without treatment through pumping. Few houses have their own private tube wells.

Additional water sources made available during the mass gathering were supplied via two water filtration plants (one government and one private) having a cumulative capacity of 5000 liters per day which was below the average daily need of approximately 100,000 liters. There were reports of unofficial vendors providing water of questionable sources and quality to help fill this gap. There was no water quality monitoring mechanism or chlorination in the town. No special arrangements for water quality monitoring were made available during the mass gathering.

There was also no central sewage disposal system. Sewage from most household septic tanks overflowed into community drains. The old pipeline A was repaired 69 times during the last 12 months and passed along these community drains at some places. Only one public toilet and three mobile toilets were provided to meet population needs during the mass gathering. Water samples collected from the overhead tank and consumer end of pipeline A tested positive for *Vibrio cholerae*. No gut pathogen or coliforms were isolated from the other two samples collected from religious pond and one of the hermitages supplied by pipeline other than A, where pilgrims were residing.

Control Measures

After the outbreak onset, the town council stopped the piped water supply and cleaned the overhead tank on November 6, 2016. Chlorine tablets were distributed, and public announcements were made to consume water after treatment. Cases declined after these interventions (Figure 1). After outbreak control, chlorine realizing and mixing devices known as dozers were installed on all the five borewells.

DISCUSSION

This was a large point source ADD outbreak mostly among pilgrims during a religious mass gathering in Radhakund, Uttar Pradesh with *Vibrio cholerae* as the possible etiology. Illness was associated with illiteracy and consumption of water from a contaminated pipeline with water samples yielding *Vibrio cholerae*. Lack of administrative preparedness inadequately planning for water, sanitation, and hygiene during the mass gathering likely contributed to this outbreak.

Illiteracy was identified as risk factor in our study. Our finding is consistent with the finding of prevalence, patterns and predictors of diarrhea study. The study calculated expected increase in prevalence of diarrhea with every unit increase in illiteracy.[14]

Illiteracy is found associated with illness most likely due to the fact that education is expected to enhance household health and sanitation practices, can increase awareness about disease transmission and prevention methods. It also encourages changes in behavior at the household level.[15-16]

Our study had a limitation in that we could not interview a representative sample of pilgrim case—patients due to their non-availability at the time of interview. We might have underestimated the burden as many of the pilgrims who would have visited health facilities outside Radhakund could not be captured in our data. Through record review we tried to collect information on clinical presentation of pilgrims hospitalized in Radhakund. Although during the case-control study we could not collect data from pilgrims, our descriptive results indicate that all persons who lived (pilgrims or residents) in areas that received drinking water from pipeline A were at risk of diarrhea. Therefore, the living status (pilgrim or residents) does not distorts the association between the exposure and the outcome. Probably, a high number of pilgrims were affected because there were more pilgrams than there were residents.

There may have been recall bias regarding reporting of water consumption and sources. However, we investigated and observed the water supply source location with respect to the houses and subsequently were able to successfully identify the contaminated pipeline epidemiologically.

Radhakund in Mathura is known for its religious tourism mainly undertaken by elderly persons, particularly widows. During the mass gathering, demand for safe water increased, but with insufficient supply available, operators provided water of undetermined quality. Our findings are similar to the multidrug-resistant shigellosis outbreak reported after the annual meeting of the Rainbow family in Nantahala National Forest, NC, USA, due to inadequate sanitation of stream water used for drinking purpose.[17] During the religious mass gathering in Radhakund, fecal-contaminated drinking water with inadequate sanitation was supplied, which lead to acute diarrheal illness in pilgrims. In addition, an insufficient number of toilets were available to meet the needs of the huge influx of people. Overburdening an already old sanitation system may have led to cross contamination of drinking water sources and increased risk for waterborne diseases.

Due to limited laboratory capacity at the CHC and district headquarters, a confirmatory diagnosis could not be established. All the cases were managed on a presumptive basis. Laboratory capacity needs to be strengthened at the district level to ensure timely and accurate diagnosis of outbreak prone diseases, especially during mass gatherings. Rapid diagnostic test kits can be used in future mass gathering events to facilitate laboratory confirmation and prevent spread of diseases.[18] Despite the limited laboratory capacity, environmental water samples from the epidemiologically implicated pipeline and its overhead tank source yielded *Vibrio cholerae*.

In addition to the water samples, other factors support our finding that this outbreak was due to contamination of pipeline A. We observed clustering of cases in houses supplied by pipeline A and consumption of drinking water from pipeline A was significantly associated with illness. Proximity of public toilets to the tube well A_1, which supplied the overhead tank for pipeline A, was a public health hazard. Sewage overflow from the public toilet and its seepage into earth when negative pressure was created during the pumping of tube well A for water supply may have led to contamination of pipeline A. An outbreak with a contaminated water source identified is consistent with other cholera outbreaks in India.[19—22]

This outbreak underscores the importance of prior planning and preparedness for mass gatherings. Mass gatherings at sporting events such as London 2012 Olympic and Paralympic Games and religious events such as Hajj 2012 demonstrate the need for comprehensive planning, rapid detection and effective management.[23—26] In India for the 2013 Kumbh Mela in Allahabad, Uttar Pradesh, 46 protected bore wells with chlorination were attached; tanks and piped potable water through 20,000 taps were provided to reduce the chance of water contamination. Similarly, 35,000 toilets were constructed, ranging from designated open defecation fields to simple pit latrines to bio-digester toilets.[26] However, in Radhakund such preparation was lacking for this mass gathering. As water and sanitation resources became overwhelmed, the population became vulnerable for a waterborne outbreak. In addition to preparedness for water and sanitation, setting up temporary field hospitals or health camps for early management of epidemic prone diseases could have minimized the morbidity and mortality of the outbreak.

A systematic and thorough epidemiologic investigation was critical in identifying the risk factors for illness when pilgrims who were mostly affected could not be interviewed. Pilgrims resided in Radhakund in the same colonies where locals lived and shared the same water supply with the locals. Despite of our limitation of not enrolling a significant proportion of pilgrims in our study, results are still valid. This investigation led to evidence-based recommendations for acute diarrheal disease prevention and control measures during mass gatherings.

Our investigation had limitations. we could not collect clinical samples to confirm etiology as there were no active cases when we stated epidemiological investigation.

This outbreak highlights the need for advanced planning for mass gatherings with respect to public health surveillance, sufficient supply of safe drinking water and sanitation facilities, in particular with a predicted increase in temporary population size and establishment of temporary health posts at prominent tourist places. Risk assessment throughout the period of mass gathering should be done. It includes continuous assessment of public health surveillance, health-care system and community adaptation to changes in population dynamics.[27-29]

Mass gatherings offer opportunities for health promotion activities on a large scale that can affect hundreds of attendings similar to that done during Athens Olympics in 2004.[30] Health education can be provided on hand hygiene and sanitary practices and interventions like use of chlorinated tablets, boiling water beforehand for drinking and mobile public toilets can be placed at potential sites of population gatherings.

APPENDIX: TABLES & FIGURES

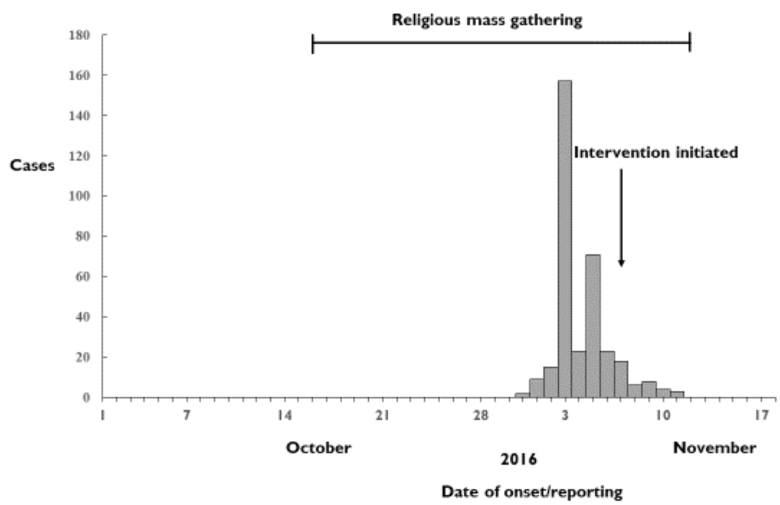

FIGURE 1. DISTRIBUTION OF CASES BY DATE OF ONSET OR REPORTING* TO HEALTH FACILITY, RADHAKUND, UTTAR PRADESH, INDIA, OCTOBER—NOVEMBER 2016 (N=339)

*Date of onset was collected from cases interviewed and date of reporting was collected from health facility records

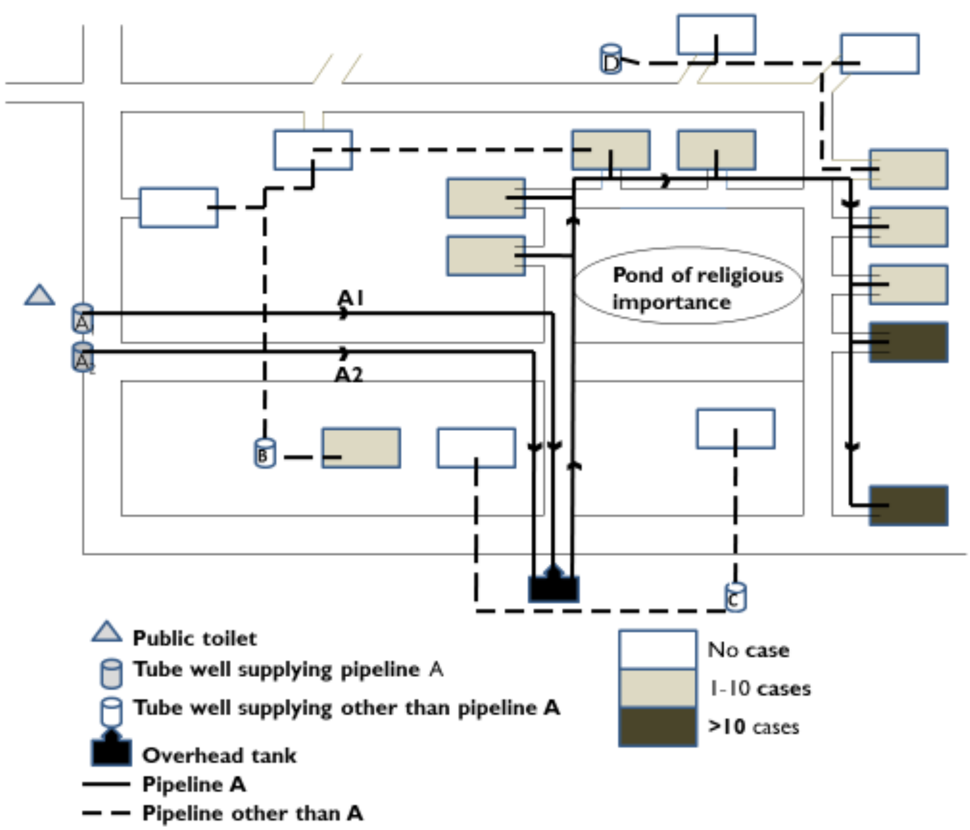

FIGURE 2. DISTRIBUTION OF ACUTE DIARRHEAL DISEASE CASES BY WATER SUPPLY PIPELINES, BY RADHAKUND, UTTAR PRADESH, INDIA, OCTOBER TO NOVEMBER 2016 (N= 121)

TABLE 1. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF CASES AND CONTROLS, RADHAKUND, UTTAR PRADESH, INDIA, OCTOBER TO NOVEMBER 2016 (N=150)

Characteristic	Cases (n=49) n	**Controls** (n=101) n	Cases (n=49) %	**Controls** (n=101) %	OR	(95% CI)
Age >=40 years	25	50	51	50	1.1	(0.5—2.1)
Female	28	53	57	53	1.2	(0.6—2.4)
Highest level of education						
No formal education	19	26	39	26	1	ref
Less than Primary	12	10	25	10	0.6	(0.2—1.7)
Primary completed	11	23	22	23	1.5	(0.6—3.8)
Secondary completed	6	18	12	18	2.2	(0.7—6.6)
Higher secondary completed	1	13	2	13	9.5	(1.1—79.0)
Graduate and above	0	11	0	11	8.9	(1.1—74.1)
Occupation						
Laborer	2	3	4	3	1	ref
Skilled worker	9	9	18	9	0.2	(0.0—1.3)
Student	23	29	47	29	0.3	(0.0—1.4)
Office worker	0	2	0	2	0.9	(0.1—12.2)
Homemaker	13	45	27	45	0.8	(0.1—4.0)
Agriculture worker	0	6	0	6	2.1	(0.2—24.6)
Shopkeeper	1	3	2	3	0.7	(0.0—10.2)
Others	1	4	2	4	0.9	0.1—12.9
Type of family						
Nuclear*	26	63	53	62	1	ref
Joint†	20	31	41	30	0.6	(0.3—1.3)
Three generation‡	3	7	6	7	1.1	(4.0)

ref: reference level
*a couple and their dependent children
†family in which members of a unilineal descent group live together with their spouses and offspring in one homestead
‡families represented by grandparent, parent and grandchild

TABLE 2. RISK FACTORS AMONG CASES AND CONTROLS IN ACUTE DIARRHEAL DISEASE OUTBREAK, RADHAKUND, UTTAR PRADESH, INDIA, OCTOBER TO NOVEMBER 2016 (N=150)

	Cases (n=49)	**Controls (n=101)**	**OR**	**(95% CI)**	**Adjusted OR**	**(95% CI)**
Risk Factor	**n**	**n**	**%**	**%**		
Age>=40years	25	50	51	50	1.1	(0.5—2.1)
Gender(Female)	28	53	57	53	1.1	(0.6—2.3)
Illiteracy	25	17	51	17	5.1	(2.4—11.1)
Drinking water source**						
Tap water from pipeline A	39	19	80	19	16.9	(7.1—39.6)
Tap water from pipeline B	2	9	4	9	0.4	(0.1—2.1)
Tap water from pipeline C	2	7	4	7	0.6	(0.1—2.9)
Tap water from pipeline D	3	40	6	40	0.1	(0.0—0.3)
Borewell at home	1	21	2	21	0.1	(0.0—0.6)
Bottled water	3	5	4	5	1.2	(0.3—5.5)
Filtered or boiled drinking water at home	2	12	4	12	0.3	(0.0—1.5)
Washed hands after defecation	44	99	90	98	0.2	(0.0—0.9)
Consumed food in *bhandar**	19	40	38	39	1.0	(0.5—1.9)
Consumed *prasad*†	6	31	11	31	0.3	(0.0—1.5)

Logistic regression analysis was done with variables age, gender, illiteracy, , borewell at home and drinking filtered or boiled water at home and consumed prasad
#Borewell at home is taken as reference water source while calculating adjusted odds ratio for individual pipeline
**Drinking water from any pipeline was not considered in logistic regression analysis
*large communal meal
†religious food offering

REFERENCES

1. Global Disease Detection Stories: Coordinated Outbreak Response Puts Diarrhea on the Run | Division of Global Health Protection | Global Health | CDC [Internet]. [cited 2018 Aug 30]. Available from: https://www.cdc.gov/globalhealth/healthprotection/gdd/stories/india—_diarrhea_on_run.html
2. Estimates of global, regional, and national morbidity, mortality, and etiologies of diarrheal diseases: a systematic analysis for the Global Burden of Disease Study 2015 — The Lancet Infectious Diseases [Internet]. [cited 2018 Aug 30]. Available from: https://www.thelancet.com/journals/laninf/article/PIIS1473—3099(17)30276—1/fulltext

3. National Centre for Disease Control (NCDC) [Internet]. [cited 2018 Aug 30]. Available from: http://www.ncdc.gov.in/
4. Water Management – Law And Policy In India [Internet]. [cited 2020 Jan 8]. Available from: http://www.legalserviceindia.com/article/l420-Water-Management.html
5. India.pdf [Internet]. [cited 2018 Aug 31]. Available from: http://rchiips.org/NFHS/pdf/NFHS4/India.pdf
6. Water Rights and the 'New' Water Laws in India - Google Search [Internet]. [cited 2020 Jan 10]. Available from: https://www.google.com/search?
7. BASICS OF WATER SUPPLY SYSTEM. :65.
8. Gautret P, Steffen R. Communicable diseases as health risks at mass gatherings other than Hajj: what is the evidence? International Journal of Infectious Diseases. 2016 Jun 1;47:46–52.
9. Mellou K, Katsioulis A, Potamiti-Komi M, Pournaras S, Kyritsi M, Katsiaflaka A, et al. A large waterborne gastroenteritis outbreak in central Greece, March 2012: challenges for the investigation and management. Epidemiol Infect. 2014 Jan;142(1):40–50.
10. POPULATION GROWTH OF ULBs IN UTTAR PRADESH (1901-2001) S - Google Search [Internet]. [cited 2020 Jan 8]. Available from: https://www.google.com/search?
11. Jager KJ, Zoccali C, Macleod A, Dekker FW. Confounding: what it is and how to deal with it. Kidney Int. 2008 Feb;73(3):256–60.
12. Ratnaike RN. Diarrhea and aging. Journal of Postgraduate Medicine. 1999 Apr 1;45(2):60.
13. Groenwold RHH, Klungel OH, Grobbee DE, Hoes AW. Selection of confounding variables should not be based on observed associations with exposure. Eur J Epidemiol. 2011 Aug;26(8):589–93.
14. Nilima, Kamath A, Shetty K, Unnikrishnan B, Kaushik S, Rai SN. Prevalence, patterns, and predictors of diarrhea: a spatial-temporal comprehensive evaluation in India. BMC Public Health. 2018 Nov 23;18(1):1288.
15. Joseph N, Suvarna P, Hariharan Bharadwaj S, Dhanush KS, Raeesa F, Mohamed Jasir KK, et al. Prevalence, risk factors and treatment practices in diarrheal diseases in south India. Environ Health Prev Med. 2016 Jul;21(4):248–57.
16. Aziz FAA, Ahmad NA, Razak MAA, Omar M, Kasim NM, Yusof M, et al. Prevalence of and factors associated with diarrheal diseases among children under five in Malaysia: a cross-sectional study 2016. BMC Public Health [Internet]. 2018 Dec 11 [cited 2020 Jan 7];18. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6288967/
17. Abubakar I, Gautret P, Brunette GW, Blumberg L, Johnson D, Poumerol G, et al. Global perspectives for prevention of infectious diseases associated with mass gatherings. Lancet Infect Dis. 2012 Jan;12(1):66–74.
18. Census of India: Search Details [Internet]. [cited 2018 Aug 31]. Available from: http://www.censusindia.gov.in/pca/Searchdata.aspx
19. David S, Roy N. Public health perspectives from the biggest human mass gathering on earth: Kumbh Mela, India. Int J Infect Dis. 2016 Jun;47:42–5.
20. Mukherjee R, Halder D, Saha S, Shyamali R, Subhranshu C, Ramakrishnan R, et al. Five Pond—centred Outbreaks of Cholera in Villages of West Bengal, India: Evidence for Focused Interventions. J Health Popul Nutr. 2011 Oct;29(5):421–8.
21. Hamner S, Tripathi A, Mishra RK, Bouskill N, Broadaway SC, Pyle BH, et al. The role of water use patterns and sewage pollution in incidence of water—borne/enteric diseases along the Ganges river in Varanasi, India. Int J Environ Health Res. 2006 Apr;16(2):113–32.
22. Sur D, Dutta P, Nair GB, Bhattacharya SK. Severe cholera outbreak following floods in a northern district of West Bengal. Indian J Med Res. 2000 Nov;112:178–82.
23. Das A, Manickam P, Hutin Y, Pal BB, Chhotray GP, Kar SK, et al. An Outbreak of Cholera Associated with an Unprotected Well in Parbatia, Orissa, Eastern India. J Health Popul Nutr. 2009 Oct;27(5):646–51.
24. McCloskey B, Endericks T, Catchpole M, Zambon M, McLauchlin J, Shetty N, et al. London 2012 Olympic and Paralympic Games: public health surveillance and epidemiology. Lancet. 2014 Jun 14;383(9934):2083–9.
25. Smallwood CAH, Arbuthnott KG, Banczak—Mysiak B, Borodina M, Coutinho AP, Payne—Hallström L, et al. Euro 2012 European Football Championship Finals: planning for a health legacy. Lancet. 2014 Jun 14;383(9934):2090–7.
26. Vortmann M, Balsari S, Holman SR, Greenough PG. Water, Sanitation, and Hygiene at the World's Largest Mass Gathering. Curr Infect Dis Rep. 2015 Feb;17(2):461.
27. Nsoesie EO, Kluberg SA, Mekaru SR, Majumder MS, Khan K, Hay SI, et al. New Digital Technologies for the Surveillance of Infectious Diseases at Mass Gathering Events. Clin Microbiol Infect. 2015 Feb;21(2):134–40.
28. Memish ZA, Zumla A, Alhakeem RF, Assiri A, Turkestani A, Al Harby KD, et al. Hajj: infectious disease surveillance and control. Lancet. 2014 Jun 14;383(9934):2073–82.
29. Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events - The Lancet [Internet]. [cited 2019 Nov 19]. Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)30501-X/fulltext
30. Mass gatherings and public health: the experience of the Athens 2004 Olympic Games. :402.