

Field Investigation of an Acute Diarrhoeal Disease Outbreak in Sabzi Mandi, Urban Ludhiana, Punjab, India, June 2018

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ABSTRACT

Background: Acute diarrhoeal disease remains an important public-health problem, particularly where drinking-water systems are vulnerable to faecal contamination. In June 2018, an increase in cases of loose stools was reported from the Sabzi Mandi area of urban Ludhiana, Punjab. **Objectives:** To confirm and characterize the outbreak by time, place and person; identify potential risk factors and source of transmission; and recommend immediate and long-term control measures. **Methods:** A suspected case was defined as three or more loose stools within 24 hours in a resident of Geeta Colony, Bharti Colony or Aman Nagar during 3-30 June 2018. Active house-to-house and passive case searches were undertaken. A neighbourhood-matched 1:1 case-control study involving 35 cases and 35 controls was conducted. Stool specimens were tested for *Vibrio cholerae*, *Salmonella* and *Shigella*. Drinking-water samples were assessed for coliforms, faecal coliforms and residual chlorine. The water-distribution and sewerage systems were inspected. **Results:** Seventy-nine cases were identified among an estimated population of 7,500 (attack rate 10.5 per 1,000); 43 (54.4%) were female and the median age was 16 years (range 7 months-62 years). The highest age-specific attack rate occurred among children aged 0-5 years (55.2 per 1,000). Twenty-seven patients (34.2%) were hospitalized and two deaths were reported (case-fatality proportion 2.5%). No individual exposure in the matched case-control study reached statistical significance. All four stool samples were negative for *V. cholerae*, *Salmonella* and *Shigella*; however, sample transport was delayed. On 4 July, seven of eight water samples showed coliform/faecal-coliform contamination and residual chlorine was absent in all eight. One of two interconnected submersible pumps lacked a chlorine-dosing system; sewer overflow and a drinking-water pipeline leak were also documented. **Conclusion:** The outbreak was most consistent with faecal contamination of the piped drinking-water system. Environmental and water-quality findings were stronger than the household-level analytic findings. Rapid chlorination, repair of leaks, continued surveillance, safe-water messaging and routine water-quality monitoring were recommended.

Keywords: *acute diarrhoeal disease; outbreak investigation; drinking-water contamination; faecal coliform; matched case-control study; Ludhiana; India*

INTRODUCTION

Diarrhoeal diseases remain a substantial cause of preventable morbidity and mortality worldwide. The Global Burden of Disease 2015 analysis estimated approximately 1.31 million diarrhoeal deaths globally, with a disproportionate burden among young children [1]. The World Health Organization emphasizes that infectious diarrhoea is commonly transmitted through contaminated food or drinking-water and that safe water, sanitation and hygiene are central to prevention [2].

Urban outbreaks may occur even where piped-water systems are available. Intermittent supply, inadequate chlorination, negative pressure within damaged pipelines, cross-connections with sewer lines and

unsafe household storage can permit faecal contamination. Investigations from India have repeatedly demonstrated associations between acute gastroenteritis or cholera and contaminated municipal or community water supplies [3-6].

On 18 June 2018, five cases of loose stools from the Sabzi Mandi area of urban Ludhiana were reported by the emergency medical officer of Civil Hospital, Ludhiana to the District Surveillance Unit. The district initiated house-to-house surveillance from 18 to 20 June. A field epidemiological investigation was subsequently undertaken from 25 June to confirm the outbreak, describe its epidemiology, evaluate risk factors and identify control measures.

Objectives

- To confirm the occurrence of an acute diarrhoeal disease outbreak in the affected area.
- To describe the outbreak in terms of time, place and person.
- To determine possible risk factors and the likely source of transmission.
- To recommend measures to control the ongoing outbreak and prevent similar outbreaks.

MATERIALS AND METHODS

Study design and setting

A field outbreak investigation was conducted in Geeta Colony, Bharti Colony and Aman Nagar, collectively located in the Sabzi Mandi area of urban Ludhiana district, Punjab, India. The population of the affected area was approximately 7,500. The investigation included descriptive epidemiology, active and passive case finding, a neighbourhood-matched case-control study, laboratory testing and environmental assessment.

Confirmation of the outbreak

Acute diarrhoeal disease data from the Integrated Disease Surveillance Programme (IDSP) P-form for epidemiological weeks 22-25 of 2018 were compared with the corresponding weeks during 2015-2017 for the reporting unit serving the Sabzi Mandi area. Key-informant interviews were conducted with Accredited Social Health Activists, Auxiliary Nurse Midwives, private doctors, the medical officer of the urban primary health centre, informal/unqualified practitioners and selected cases.

Case definition and case finding

A suspected case was defined as three or more loose stools within 24 hours in a resident of Geeta Colony, Bharti Colony or Aman Nagar with onset between 3 and 30 June 2018. Active case finding was performed through house-to-house survey using a structured data-capture tool that recorded demographic characteristics, symptoms, date of illness onset, treatment history and hospitalization. Passive surveillance was strengthened through local public and private providers and community health workers.

Matched case-control study

Based on descriptive findings and hypothesis-generating interviews, a 1:1 matched case-control study was undertaken. Cases and controls were matched by neighbourhood. Households with cases were selected randomly from the line list; when more

than one case occurred in a household, one was selected randomly. A control was a resident of the same study area without three or more loose stools within 24 hours during the study period. The immediate neighbouring household was approached using a prespecified sequence, and one eligible control was selected when multiple controls were available.

Laboratory investigation

Stool samples were collected in sterile containers and sent to Christian Medical College, Ludhiana. Hanging-drop microscopy was performed for *Vibrio cholerae* and cultures were performed for *V. cholerae*, *Salmonella* and *Shigella*. Drinking-water samples were collected on 19 June and 4 July 2018 and sent to the State Public Health Laboratory, Chandigarh for coliform/faecal-coliform testing and assessment of free residual chlorine.

Environmental investigation

The drinking-water distribution and sewerage systems were inspected for potential routes of contamination. Water sources, chlorination arrangements, interconnections, sewer overflow and visible leakage of drinking-water pipelines were documented.

Statistical analysis

Data were entered and summarized in Microsoft Excel. Frequencies, proportions, median age and attack rates were calculated. Matched odds ratios (mORs) with 95% confidence intervals (CIs) were calculated using Epi Info 7. An exposure was considered statistically significant when the 95% CI for the matched odds ratio excluded 1.0.

RESULTS

Outbreak confirmation and descriptive epidemiology

No acute diarrhoeal disease cases were reported through the relevant IDSP reporting unit during the corresponding epidemiological weeks of 2015-2017, whereas 10, 9, 9 and 57 cases were reported in epidemiological weeks 22, 23, 24 and 25 of 2018, respectively. Key informants also reported a noticeable increase in loose-stool illness from mid-June.

A total of 79 cases were identified through active and passive case search. Forty-three (54.4%) were female and 36 (45.6%) were male. Median age was 16 years (range 7 months-62 years). The overall attack rate was 10.5 per 1,000 population. The sex-specific attack rate was 11.9 per 1,000 among females and 9.3 per 1,000 among males. Twenty-seven cases (34.2%) were hospitalized. Two deaths were reported, corresponding to a case-fatality proportion of 2.5%.

Table 1. Age-specific distribution and attack rates among identified cases (N=79)

Age group (years)	Cases, n	Population	Attack rate /1,000
0-5	29	525	55.2
6-10	6	551	10.9
11-15	4	534	7.5
>15	40	5890	6.8
Total	79	7500	10.5

Health-seeking behaviour

Private doctors were the most frequently consulted providers (36.7%), followed by government doctors (29.1%) and informal/unqualified practitioners (27.8%). Fifteen of the patients who sought government care and 12 of those who sought private care were hospitalized.

Table 2. Health-seeking behaviour among cases (N=79)

Health-care provider	Cases, n (%)	Hospitalized, n
Government doctor	23 (29.1)	15
Private doctor	29 (36.7)	12
Informal/unqualified practitioner	22 (27.8)	0
Self-medication	4 (5.1)	0
None	1 (1.3)	0

Matched case-control study

Seventy participants were enrolled as 35 neighbourhood-matched case-control pairs. The median age of cases was 9 years (range 10 months-60 years) and that of controls was 7 years (range 8 months-52 years). None of the investigated household, socioeconomic or water-related exposures reached statistical significance in the matched analysis. Several estimates had wide confidence intervals, indicating limited precision.

Table 3. Selected matched case-control findings (35 pairs)

Exposure / characteristic	Matched OR	95% CI
Respondent/mother illiterate	0.86	0.29-2.55
Head of family employed as labourer	0.40	0.13-1.28
Monthly income <₹5,000	0.40	0.13-1.44
Upper floor residence	3.00	0.61-14.86
Motor used for pumping pipeline water	0.40	0.08-2.06
Eating raw fruit outside home	0.80	0.21-2.98
Buying ice from market	0.50	0.09-2.73
Household treatment of drinking-water	2.60	0.93-7.29
Covered water-storage container	5.00	0.58-42.79
Narrow outlet of water container	1.80	0.60-5.37
No hand contact during water retrieval	1.30	0.29-5.96
Soap present in kitchen	7.00	0.86-56.89

Laboratory findings

Four stool specimens were examined. Hanging-drop microscopy was negative in all four, and cultures did not yield *V. cholerae*, *Salmonella* or *Shigella*. The investigation noted that stool specimens were not transported to the laboratory within two hours of collection, which could have reduced pathogen recovery.

Table 4. Stool laboratory findings

Test	Positive / tested
Hanging-drop microscopy for <i>V. cholerae</i>	0 / 4
Culture for <i>V. cholerae</i> , <i>Salmonella</i> and <i>Shigella</i>	0 / 4

Five water samples were collected on 19 June. A second set of eight samples was collected on 4 July. In the second round, seven of eight samples demonstrated coliform/faecal-coliform contamination, while free residual chlorine was absent in all eight samples. Contamination was detected in water from the second source, households in the case area and households in the non-case area; one source sample met the reported coliform criterion.

Table 5. Summary of the second-round water-quality testing (4 July 2018)

Sampling location	No. sampled	Coliform result	Faecal coliform	Residual chlorine
Source 1	1	<10 E. coli/100 mL	Absent	Nil
Source 2	1	>10 E. coli/100 mL	Present	Nil
Case-area households	4	>10 E. coli/100 mL	Present	Nil
Non-case-area households	2	>10 E. coli/100 mL	Present	Nil

Environmental findings

The affected area received piped water from two submersible pumps, each reportedly approximately 600 feet deep. There was no overhead or underground storage reservoir. A chlorine-dosing system was installed on only one of the two pumps, while the distribution from both pumps was interconnected. Residents commonly reported intermittent changes in water quality before illness. Two overflowing sewer drains were observed in Geeta Colony on 28 June. A leak in a tributary of the main drinking-water pipeline was identified on 2 July and repaired on the same day.

DISCUSSION

This field investigation documented an acute diarrhoeal disease outbreak affecting three adjacent urban neighbourhoods in Ludhiana during June 2018. The clustering of illness in time, the overall attack rate of 10.5 per 1,000, the marked excess risk among children aged 0-5 years, and the sudden increase above the preceding surveillance baseline supported the conclusion that a true outbreak had occurred.

The strongest evidence concerning the likely source came from the water-quality and environmental investigations. Seven of eight water samples collected on 4 July demonstrated coliform/faecal-coliform contamination and none had detectable residual chlorine. The distribution network was supplied by two interconnected submersible pumps, but only one had a chlorine-dosing system. In addition, sewer overflow and a leak in the drinking-water pipeline were documented. These findings provide a plausible mechanism for faecal contamination of the piped supply, especially during periods of intermittent pressure or after rainfall.

Similar mechanisms have been reported in other Indian outbreaks. Bhunia et al. described an urban cholera outbreak in West Bengal in which cases clustered near leaking water pipelines; exclusive municipal-water consumption was strongly associated with illness, and water samples showed faecal contamination and poor chlorination [3]. Taneja et al. demonstrated a close relationship between faecal contamination of drinking-water supplies in and around Chandigarh and acute gastroenteritis [4]. More recent Indian field investigations have likewise implicated unsafe water sources and inadequate sanitation in cholera transmission [5,6].

The age-specific attack rate was highest among children younger than five years (55.2 per 1,000), approximately five times the rate in children aged 6-10

years and more than eight times that observed in persons older than 15 years. Young children are particularly vulnerable to diarrhoeal illness because of greater susceptibility to dehydration, dependence on caregivers for food and water hygiene, and frequent environmental exposure. The WHO continues to identify diarrhoeal disease as a leading cause of childhood morbidity and mortality and emphasizes safe water and sanitation as core preventive measures [2].

The matched case-control study did not identify a statistically significant household-level risk factor. This does not exclude a common waterborne source. Because cases and controls were matched by neighbourhood, both groups were likely to share the same municipal water network, potentially reducing exposure contrast. The small number of matched pairs also resulted in wide confidence intervals. Thus, the lack of statistical association at household level should be interpreted alongside the environmental findings rather than in isolation.

Microbiological confirmation of a specific enteric pathogen was not achieved. All four stool samples were negative for *V. cholerae*, *Salmonella* and *Shigella*. However, the number of specimens was very small and transport exceeded the recommended short interval noted in the field report, potentially reducing culture yield. The absence of pathogen isolation therefore cannot rule out an infectious waterborne aetiology. In addition, viral and parasitic causes were not investigated. This is important because diagnostic yield depends strongly on the methods used. Sen et al. compared direct stool microscopy with concentration techniques and demonstrated improved detection of ova and cysts after concentration, highlighting the possibility that low-burden parasitic infections may be missed by limited direct examination [9]. Similarly, Rajput et al. evaluated viral causes of childhood diarrhoea using molecular and omics-based approaches and identified rotavirus, norovirus, astrovirus and adenovirus among symptomatic children, illustrating the additional aetiological information obtainable when viral molecular testing is incorporated [10]. Therefore, a broader diagnostic panel including appropriately transported bacterial cultures, parasitological concentration methods and viral molecular assays could have improved aetiological ascertainment in the present outbreak.

The outbreak investigation also illustrates the importance of routine water-safety management rather than reliance on reactive testing after illness is

detected. WHO guidance emphasizes systematic management of drinking-water risks from source to consumer [7]. In settings with interconnected pumps, intermittent distribution and pipelines running near drains or sewers, maintaining adequate chlorination and promptly repairing leaks are particularly important.

Public-health response and recommendations

Immediate response measures recommended during the investigation included continued active surveillance for 15 days after the last reported case, provision of chlorine tablets for household water treatment until reliable chlorination was restored, community information and education on boiling and safe storage of drinking-water, prompt referral of dehydrated patients, and timely collection and transport of stool specimens. For the water-supply system, installation of a chlorine-dosing pump at the unchlorinated source and active search and repair of pipeline leaks were recommended.

For long-term prevention, a routine water-quality surveillance system should monitor microbiological quality and adequate free residual chlorine at the consumer level. Water-distribution and sewerage infrastructure should be periodically inspected for leaks, cross-connections and overflow, and corrective action should be documented. These measures are consistent with the broader public-health role of surveillance systems such as IDSP in early outbreak detection and response [8].

Strengths

- The investigation combined active and passive surveillance with descriptive epidemiology, analytic epidemiology, laboratory testing and environmental assessment.
- Neighbourhood matching helped control for broad geographic and socioeconomic differences between cases and controls.
- Water-quality testing and direct inspection of the supply network provided objective environmental evidence relevant to the suspected source.
- The investigation translated findings into immediate operational recommendations for the health department and local government bodies.

Limitations

- Recall bias may have affected exposure histories reported by cases and controls.
- Only four stool specimens were tested, and delayed transport may have reduced microbiological yield; the specific aetiological agent could not be established.

- The 35 matched pairs provided limited statistical power, resulting in wide confidence intervals for several exposures.
- Neighbourhood matching may have reduced the ability to detect an association with a water source shared by both cases and controls.
- Water sampling was performed at limited time points, and the second round was conducted after rainfall and after some control actions, limiting direct reconstruction of water quality at the precise time of peak transmission.
- The investigation did not quantify a dose-response relationship between consumption of potentially contaminated water and illness.

Future Directions

Future outbreak investigations should incorporate timely collection and transport of clinical specimens, broader microbiological and molecular testing, systematic water-quality monitoring, and improved surveillance of drinking-water distribution systems to facilitate early detection and identification of waterborne outbreaks.

CONCLUSION

The June 2018 acute diarrhoeal disease outbreak in the Sabzi Mandi area of urban Ludhiana affected 79 residents and disproportionately involved children younger than five years. Although the matched case-control study did not identify a statistically significant individual risk factor and stool cultures were negative, the convergence of faecal contamination in drinking-water samples, absent residual chlorine, incomplete chlorination of interconnected water sources, sewer overflow and a documented pipeline leak strongly indicated contamination of the piped water system as the most likely source. Strengthening chlorination, water-quality surveillance, infrastructure maintenance and early diarrhoeal surveillance is essential to prevent recurrence.

Declarations

Funding

No specific funding.

Conflict of Interest

None.

Data Availability

The manuscript is based on data contained in the original field outbreak investigation report. Availability of the underlying line list and investigation records is subject to the responsible public-health authority.

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Author Contributions

The author contributed to the conception and design of the investigation, field investigation, data interpretation, drafting and critical revision of the manuscript, and approved the final version.

Abbreviations

IDSP-Integrated Disease Surveillance Programme
NVBDCP-National Vector Borne Disease Control Programme
OR-Odds Ratio
Mor-Matched Odds Ratio
CI-Confidence Interval
WHO-World Health Organization
GBD-Global Burden of Disease
CDC-Centers for Disease Control and Prevention
E. coli-*Escherichia coli*

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