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Original Research Article

Footprints to findings: insight into causality of an acute gastroenteritis outbreak in a closed community

Barinderjot Kaur*, Shabeena Tawar, Shafique Ahmed

Department of Community Medicine, Armed Forces Medical College, Pune, Maharashtra, India

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***Correspondence:**
Dr. Barinderjot Kaur,
E-mail: bjot26@gmail.com

ABSTRACT

Background: An investigation was initiated following an health intelligence alert which indicated a sporadic rise in cases of acute gastroenteritis (AGE) within an urban community located in western Maharashtra. This investigation sought to identify the origin and causal agents of the outbreak, as well as to establish and implement measures to control its spread.
Methods: A matched case-control study was conducted by taking 30 cases and 78 controls from that semi-urban residential area. Blood and stool culture samples of patients reporting to a primary health care facility were obtained using conventional culture techniques and polymerase chain reaction (PCR) kits. Epidemiological investigations comprised a review of surveillance data, filling of epidemiological case sheets, sanitary surveys, inspection of water supply and bacteriological surveillance of water and environmental engineering surveys.
Results: The crude attack rate was reported to be 7%. Laboratory tests revealed multiple pathogens, including *Pseudomonas*, diarrheagenic *E. coli*, and *Shigella*. Environmental assessments highlighted issues such as rusted and leaky water pipes, sewage pipeline problems and insufficient chlorination of the water supply.
Conclusions: A widespread outbreak of waterborne gastroenteritis occurred in this region due to contamination of drinking water. The contamination was caused by an improper connection between the sewage system and potable water pipelines. Recommended actions included repair of cross connections, improved treatment methods, adequate chlorination, regular inspections of the water supply and health education which significantly reduced the impact of outbreak.

Keywords: Acute gastroenteritis, Outbreak investigations, Pipeline, Surveillance

INTRODUCTION

Poor water quality poses a major threat to human health. Acute gastroenteritis (AGE) is prevalent across all age groups, with children being more commonly affected. According to the Centre for Disease Control and Prevention (CDC), the United States experiences over 350 million instances of acute gastroenteritis each year. Among these, 48 million are attributed to bacteria transmitted through food or water.[1,2] Inadequate water, sanitation and hygiene infrastructure are the main risk factors for enteric diseases in Central Asia. Various causative agents of AGE can be bacteria, virus and parasites.[3]

Despite global efforts to reduce enteric diseases, pathogens continue to cause significant morbidity and mortality, particularly in Asia and India.[4] Diarrhoeal diseases are widespread in India, primarily due to contaminated drinking water, underscoring the urgent need for enhanced sanitation and better hygiene measures to prevent outbreaks.[5,6]

Waterborne diseases, exacerbated by contaminated water, disproportionately affect children under five years of age,

lack of access to safe drinking water affects approximately 663 million people, primarily due to pollution from sewage and animal waste entering water sources.[7] Studies have incriminated contamination of tap water as possible etiological agent for AGE outbreak.[8] History is replete with example of AGE cases being linked to water contamination including handpump at Broadstreet which is a classic example studied by John Snow. In drinking water, where contamination of potable water by microbes can occur due to various factors, including insufficient pressure, inadequate residual chlorine concentrations, and damaged pipes.[9]

This investigation of an outbreak of acute gastrointestinal illnesses in a semi-urban region of Western Maharashtra was undertaken to find out the possible causes of occurrence of such a common illness by performing exhaustive on ground survey of sewage and water system along with filling up of epidemiological case sheets of affected individuals. The study was aimed to implement control strategies to curb further spread in the community and prevent future occurrences of similar outbreaks.

METHODS

Outbreak settings

On 21 May 2024, a sudden sharp rise in acute gastroenteritis (AGE) cases with 26 people presenting with loose stools and vomiting was noted by local healthcare facilities in semi-urban area of Western Maharashtra. The cases continued to increase with 18 fresh cases being reported on 22 May. A team consisting of a resident in community medicine, two health assistants and one laboratory assistant were assembled to investigate the situation. The team's objectives were to describe the characteristics of the outbreak, determine the causative and contributing factors and suggest preventive measures. They examined local monitoring data to verify the outbreak and evaluated the current protocols. Most patients experienced mild symptoms and recuperated within 48 h. To facilitate effective monitoring, precise definitions for cases and controls were established. Ethical clearance of the study was obtained from the Institutional Ethics Committee (IEC) of Armed Forces Medical College

In accordance with CDC guidelines, we characterised an AGE case as a participant who experienced either vomiting episodes (more than one within a 24-hour period) or diarrhoea (exceeding three loose stools in any 24-hour time frame) for descriptive purposes.[10] Individuals with fewer than three loose stools per day and no vomiting were not classified as AGE cases. Those with medical conditions linked to chronic diarrhoea were deemed AGE cases if they reported vomiting; otherwise, they were categorised as non-cases, regardless of diarrhoeal episodes. Controls were defined as individuals residing in the same urban area who did not experience any diarrhoeal or vomiting episodes during the specified period.

Study and sampling

We conducted a matched case-control study using simple random sampling to select controls in a semi-urban area from 20 May to 28 May 2024. All residents were surveyed using a questions based on epidemiological case sheet including 30 identified cases through active case search who were willing to participate. A total of 78 healthy controls were selected, with each control randomly selected from the same building as the cases, ensuring a comprehensive coverage of the area.

Data collection

A house-to-house survey was conducted by our team in our area of responsibility to collect information and to interview the affected individuals. The research team utilised a pre-designed epidemiological case sheet to gather data on various factors, including age, gender, residential location, clinical manifestations, food intake, symptom onset date, and the date of seeking medical attention. This information was obtained from individuals who had fully recovered from their symptoms. In addition, the team extracted data from outpatient department records, inpatient acute gastroenteritis cases, and instances treated outside healthcare facilities or in private settings. The collected data was analysed to illustrate the temporal distribution of cases through an epidemic curve, visualise the geographical spread using a spot map, and examine the age and gender breakdown of affected individuals. This study was conducted as part of an urgent public health initiative.

Laboratory investigation

Most affected individuals present with mild symptoms of the illness. Our team collected stool samples from symptomatic cases to identify and isolate the causative pathogens. In addition, water samples were obtained from various storage tanks for analysis.

The primary Health Centre lacked facilities for stool testing. Upon our team's arrival to investigate, there were only a few individuals exhibiting symptoms. These patients were referred to a tertiary care hospital for stool culture, with some samples yielding positive results for bacterial growth.

Environmental investigation

Our research group collected information on community activities, social gatherings and dietary habits. We inspected water purification plants, neighbourhood bakeries, and the central dining facility, which was identified as the primary source of reported incidents, while interviewing employees and business owners. We examined the rooftop water tanks, collected samples, and

assessed their physical state and chlorine levels. The entire housing complex's water sources and distribution system were analysed. Additionally, we evaluated the general cleanliness, sanitation practices and refuse disposal locations in the vicinity. The water pipeline network was investigated from its origin to the termination points for potential breaches or sewage infiltration. From 22 to 26 May 2024, we procured 08 water specimens from various locations within the water supply network.

RESULTS

Descriptive epidemiology

Overall, out of a population of 1200, 84 infected and symptomatic cases were enrolled as cases and interviewed. A total of 76 cases reported to primary health care facilities and 08 cases were identified by active surveillance (house-to-house survey who did not report to OPD, had only mild symptoms). The AGE cases during the period of investigation were more than average of last 3 years in same duration. A gradual rise in cases was noted from 21 May 2024 onwards, as represented graphically in Figure 1.

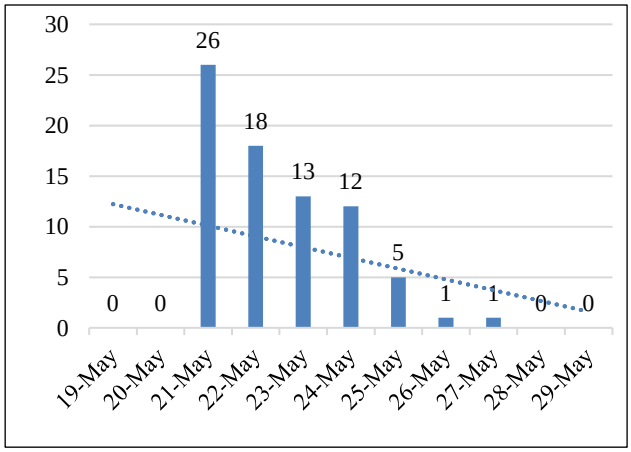

Figure 1: Distribution of all age cases by date of reporting to primary health care facilities.

This pattern suggests a point-source outbreak. The age range of effected individuals spanned from 1-40 yrs, with 1-10 years bracket being most effected. Approximately half of the cases were females and results are presented in the Table 1. A spot map of the area was created, marking the residences of the affected residents. A concertration

of cases was noted in phase 2 pump house water supply area complex, as illustrated in spot map in Figure 2. All patients (100%) experienced diarrhoea, 97% had vomiting, 89% had abdominal pain and 75% developed fever. Table 2 displays the characteristics of cases and controls based on their food and water consumption, along with the sources over previous week.

Table 1: Age and sex distribution of the cases with age.

Age group (in yrs)	Female (n1)	Male (n2)	Total (n)	Attack rate % (total population = 1200)
1-10	22	08	30	2.5
11-20	09	10	19	1.5
21-30	07	11	18	1.5
31-40	06	11	17	1.4
Total	44	40	84	7

Figure 2: Spot map of residential complex in semi urban area (houses with cases are marked with red arrow.

Table 2: Characteristics of cases and controls based on their consumption of food/water in last 7 days before starting the symptoms.

Variables		Cases	Controls	Odds ratio with 95% CI	P value
Gender	Female	12	32	0.95 (0.41-2.56)	0.92
	Male	18	46		
	Total	30	78		
Details of consumption of food and water					
Water source					
Common water source at residential complex	Yes	24	22	10.18 (3.66-28.27)	0.0001
	No	6	56		
Food items from shopping complex/ outside					
Dal	Yes	20	52	1.00	1.00
	No	10	26		

Variables		Cases	Controls	Odds ratio with 95% CI	P value
Rice	Yes	16	43	0.93 (0.39-2.17)	1.6
	No	14	35		
Paneer sabzi	Yes	9	22	1.14 (0.45-2.89)	0.77
	No	21	56		
Meat/ meat products	Yes	11	22	1.54 (0.63-3.78)	0.34
	No	19	56		
Roti	Yes	21	55	0.97 (0.38- 2.44)	0.95
	No	9	23		

Laboratory results

From these cases, we obtained 15 rectal swabs and 15 stool samples. Additionally, we gathered eight water samples in sterile containers for microbiological testing. These included one sample from the main pump house, two from the shared reverse osmosis (RO) system in the complex where all cases were identified, three from the piped water supply, and two from overhead tanks. All samples were collected for analysis.

Multiplex PCR for rectal swabs and stool samples

Multiple organisms were detected in five stool samples and four rectal samples. Diarrheagenic *E. coli* strains were identified in four stool and four rectal samples, whilst the remaining samples tested negative for these strains. In one stool sample, *Shigella* isolates were serologically confirmed using a slide agglutination test with antisera as given in Table 3.

Table 3: Organisms found from collected stool samples (15) and rectal samples (15).

Organism found in stool samples and rectal swabs	Total stool samples positive	Total rectal swabs positive
E. coli	04	04
Shigella	01	Nil

Water samples

Of the eight water samples obtained, conventional culture and biochemical analysis revealed that four were positive for *E. coli*. Additionally, one water sample tested positive for *Pseudomonas*. Table 4 presents a summary of the data, including the sample collection dates, sources, and test results.

Table 4: Bacteriological analysis of collected water samples (08).

Date of water sample collection	Location (sample)	Chlorine results	Bacteriological results
23 May 2024	Main pump house (01)	0.4 ppm	Satisfactory
23 May 2024	RO complex (02)	Nil	Unsatisfactory (*E. coli* growth)
23 May 2024	Building P-24, H no – 5	Nil	Unsatisfactory (*Pseudomonas* growth)
23 May 2024	Building 316/06	Nil	Unsatisfactory (*E. coli* growth)
23 May 2024	Piped water supply in complex (03)	Nil	Unsatisfactory (*E. coli* growth)

Through active environmental surveillance, we were able to pinpoint the contaminated water source in the semi-urban region, as depicted in Figure 3.

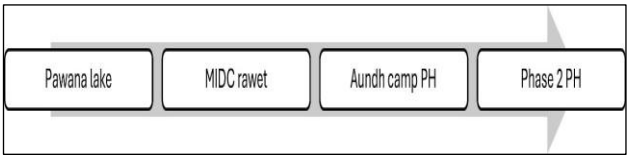

Figure 3: Main source of water supply in semi urban area of western Maharashtra.

The water supply for the RO units in a residential complex originates from the Phase 2 pump house, but there is a lack of regular water quality monitoring and chlorine content is non-existent. Examinations uncovered uncleaned overhead tanks without proper coverings, while discussions with residents suggested that aging pipelines are susceptible to fractures and seepage. The previous year's typhoid outbreak within the same complex is a cause for alarm. The conduits for drinking water appeared corroded and unclean, with noticeable leaks between the pump house and RO units. Furthermore, wastewater pipes situated near the ROs exhibited indications of contamination compounded by unpleasant smells in regions linked to the filtered water distribution system.

DISCUSSION

Acute gastroenteritis is a widespread infectious condition characterized by a combination of symptoms, including nausea, vomiting, diarrhoea, and abdominal discomfort.[3] Diarrhoea is indicative of infections caused by various bacterial, viral, and parasitic organisms, typically spread through water contaminated with faeces.[11] Previous instances of such diarrhoeal disease outbreaks have been documented in India across diverse settings.[12-15] Our research delineated the particulars of an acute gastroenteritis outbreak by drawing on medical indicators, epidemiological features, and laboratory results.[16] The outbreak persisted for approximately one week, with most cases occurring between 21-28 May 2024. The findings of the investigation suggest that the outbreak stemmed from faecal contamination of water supplied through defective sewage pipelines, which provided an environment for these pathogens to flourish collectively as described in many other studies too, leading to the transmission of waterborne outbreaks in most instances.[8,17,16,18] In a study by Gautam et one or two pathogens were incriminated as the source.[19] Similarly in this investigation, the laboratory findings revealed multiple pathogens, including Shigella spp., *E coli*, and *Pseudomonas*, which were implicated in the outbreak and isolated from patients, water sources, and the surrounding environment.

In this study, 24 out of 30 investigated cases utilized water from the RO treatment facility for both drinking and food preparation. Water chlorination is typically employed as a preventive measure against diarrheal diseases, however record of regular chlorination being carried out at pump houses could not be found. Furthermore, studies have brought out that chlorination at a single point may not sufficiently maintain the required chlorine levels throughout the entire water distribution network.[20,21] To mitigate risks during outbreaks, periodic chlorination at all sumps and storage facilities and regular checks at consumer end need to be ensured.[22]

During our investigation, we found that the water supply and sewage conduits were deteriorated and had leaks in certain sections. Moreover, the wastewater pipelines were located close to the sump area, which functioned as the primary source of potable water for the community. This study underscores the necessity for regular water supply quality checks and appropriate chlorination procedures. Moreover, as per WHO guidelines, a systematic water quality monitoring programme can detect contamination and act as an early alert mechanism.[23]

Laboratory findings prompted local authorities to implement urgent public health measures without delay. Consequently, the entire campus water system underwent immediate chlorination and the pipelines of the affected area were replaced. Ongoing pipeline monitoring and swift repairs were instituted. These decisive actions by the authorities effectively curbed the spread of the outbreak.

This study has few limitations. Period of outbreak coincided with summer vacations of schools of that area due to that a lot of individuals were travelling and could not be traced. This suggests that the actual number of cases may be significantly higher than previously reported.

CONCLUSION

This study validated that leaking sewage pipes and inadequate chlorination of potable water led to a polymicrobial gastroenteritis outbreak in a peri-urban region, manifesting as AGE. To reduce such incidents, it is crucial to conduct daily chlorine level checks and carry out regular bacterial monitoring. advocated enhanced on ground water surveillance with repeated checks on quality of water pipelines, regular chlorination and distribution of mass treatment resources, including oral rehydration solutions, zinc supplements, and antimicrobial drugs, to the affected communities. Furthermore, water tanks containing reverse osmosis-filtered and chlorinated water should undergo routine cleaning and replacement. Establishing a proactive surveillance system with epidemiological and laboratory support will aid in preventing future outbreaks.

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Ethical approval: The study was approved by the Institutional Ethics Committee of Armed Forces Medical College, Pune, Maharashtra

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