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An acute diarrheal disease outbreak in urban setting of Odisha, India

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Abstract

Background Diarrhea, exacerbated by poor hygiene and contaminated water, causes significant child mortality globally. *Vibrio cholerae* O1 is a primary pathogen, with outbreaks linked to specific biotypes and regions like India. This study documents an acute diarrheal disease outbreak in Rourkela (urban setting), Odisha.

Methods A matched case-control study was carried out followed by preliminary investigations. Additionally, laboratory investigations were carried out to confirm the cholera outbreak.

Results The current outbreak reported 1812 Acute Diarrheal Disease (ADD) cases, with a daily incidence rate of 32.7 per one lakh population as of 20th December 2023. Hospitalizations peaked at 58.7%, and six deaths occurred, yielding a case fatality rate of 3.3 per 1000 cases. Sudden rise in cases of ADD was seen in five of the healthcare facilities situated in the urban Rourkela. The mean diarrheal frequency per day among cases was 6.24 ± 2.61 with watery discharge, abdominal pain, and vomiting being reported commonly. And a significant association of cases was found with type of toilet used. Among all the cases; 20.59% were identified as *Vibrio cholerae* 01 and 2.94% as *Shigella flexneri* upon culture serotyping.

Conclusions The emergence of multi-drug resistant strains has a significant impact on outbreak control. Holistic approaches are imperative in combating cholera transmission and minimizing its public health impact in India.

Keywords Outbreak, Investigation, Cholera, Acute diarrheal disease

Introduction

Diarrhea is a major public health problem in low- and middle-income countries. As per WHO report, every year there are around 1.7 billion cases of pediatric diarrheal cases worldwide. Approximately 443,832 children under the age of five and 50,851 children between the ages of five and nine die from diarrhea each year [1]. According to IDSP report in 2020, Acute diarrheal disease accounts for 12 million cases and 1216 deaths annually in India [2].

The major reason for diarrhea outbreak is inadequate hygiene, fecal contamination of food or water and poor sanitation. The majority of diarrheal deaths are caused by

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excessive dehydration and fluid loss. The loss of substantial volumes of fluid and salts can cause severe dehydration and death in a matter of hours if these people are not promptly and appropriately treated [3].

The most common etiological agents of moderate-to-severe diarrhea are the Rota virus, *Vibrio cholerae*, *Escherichia coli*, *Cryptosporidium*, *Salmonella* and *Shigella* [4–7]. *Vibrio cholerae* serotype O1 belonging to the El Tor biotype is the most common in the country, while the frequency of serogroup O139 has declined considerably over the past few years. The large deltaic areas of the Ganges and Brahmaputra rivers are considered to be the homeland of cholera and the adjacent areas are prone to cholera outbreaks [8].

More than 200 serogroups of *Vibrio cholerae* are circulating of which O1 and O139 mainly responsible for epidemic [9]. The O1 serogroup is further divided by serotype (Inaba and Ogawa) and biotype (classical and E1 Tor). In the Haiti epidemic during 2010, the El Tor variant of *V. cholerae* O1 strains was found to spread the cholera epidemic and predominant in South Asia and Bangladesh [10, 11]. This strain was also responsible for cholera outbreak in Nepal in 2012, in Eastern Africa in 2015 and in Yemen during 2016–2017 [12]. The El Tor variant of *V. cholerae* O1 was isolated in the Indian states of Odisha, West Bengal, Punjab Haryana, A&N Islands and Karnataka during 1999, 2006, 2007, 2012, 2015 and 2007 respectively [13–17]. The strain also caused severe cholera outbreaks in the Rajnagar block of Kendrapada district in 2009 [18], in Balasore and Rayagada districts in 2018–2019 [19]. In a recent study, *V. cholerae* O1 Ogawa biotype El Tor was found to be responsible for sequential outbreaks of Cholera in Mayurbhanj, Odisha [20]. In this article, we document an acute gastroenteritis (AGE) outbreak caused by multi-drug resistant *V. cholerae* O1 Ogawa serotype, occurring in Rourkela, a smart city situated in Sundergarh district, Odisha. As per our current understanding and substantiation with the (Integrated Disease Surveillance Programme) IDSP report, this represents the first documented instance of a cholera outbreak in this district.

Census 2011 reported the population of Rourkela Industrial Township as 210,412, Rourkela Township as 309,689 and the urban metropolitan area as 552,970. And current population of Rourkela Township and the urban metropolitan is estimated to be at 385,000 and 782,000 respectively [21, 22]. The area is served by a three tertiary care hospitals, one of which operates under the public sector. Additionally, private hospitals, clinics and nursing homes provide extensive healthcare options. There are several Health and wellness centers (PHC-HWCs) dedicated to meet the primary healthcare needs of the population which is headed by a Community Health Centre (CHC).

Materials and methods

Overview

In December 2023 there was a sudden rise of acute diarrheal disease (ADD) in Rourkela, Odisha. A team from ICMR-Regional Medical Research Centre Bhubaneswar was deputed to carry out the outbreak investigation in collaboration with the local health authorities during 20th to 22nd December 2023. Surveillance data of IDSP centres located in Sundergarh district were accessed and analyzed to identify the affected regions and the time of initiation of the ADD cases. The immediate investigation held by the local emergency response team, stated that the first probable clustering of cases was reported from the Kisan Tola area on 14th December 2023. Prior to it, an unseasonal rainfall was reported between 8th – 10th of December 2023, followed by piped water connections showing turbid and foul smelling ('rotten smell') water supply from 11th – 13th December 2023.

Findings from ADD surveillance data

The graphical distribution of daily reported cases of ADD across various public health facilities within Sundergarh district revealed a significant increase in the number of cases. The daily cases have nearly doubled or more across five facilities of the district. This increase in daily cases suggested a potential outbreak of acute diarrheal diseases across the areas catered by these facilities. Notably, these facilities were located in urban Rourkela. The daily ADD caseloads of the five facilities were compared, indicating a significant increase starting from December 13, 2023. The onset of the ADD outbreak showed rapid progression over a period of five days after December 13, 2023, and then stabilized on December 18th and 19th of the same year. (Supplementary File 1a & 1b) (See Fig. 1).

Case finding and data collection

Case finding

A case definition was derived in terms of time, place, and person based on information retrieved from the prior discussion held and analysis of the ADD surveillance data from IDSP (Integrated Disease Surveillance Programme) keeping in consideration the WHO definition.

Case definition Case was defined as a person presenting with the symptoms of ADD viz., loose motions/watery stool/vomiting of > 3 episodes within the past 24 hours, on or after 13th December 2023 residing in urban Rourkela.

Control definition Control was defined as a healthy person with no symptoms of ADD belonging to urban Rourkela particularly from the areas where cases were identified.

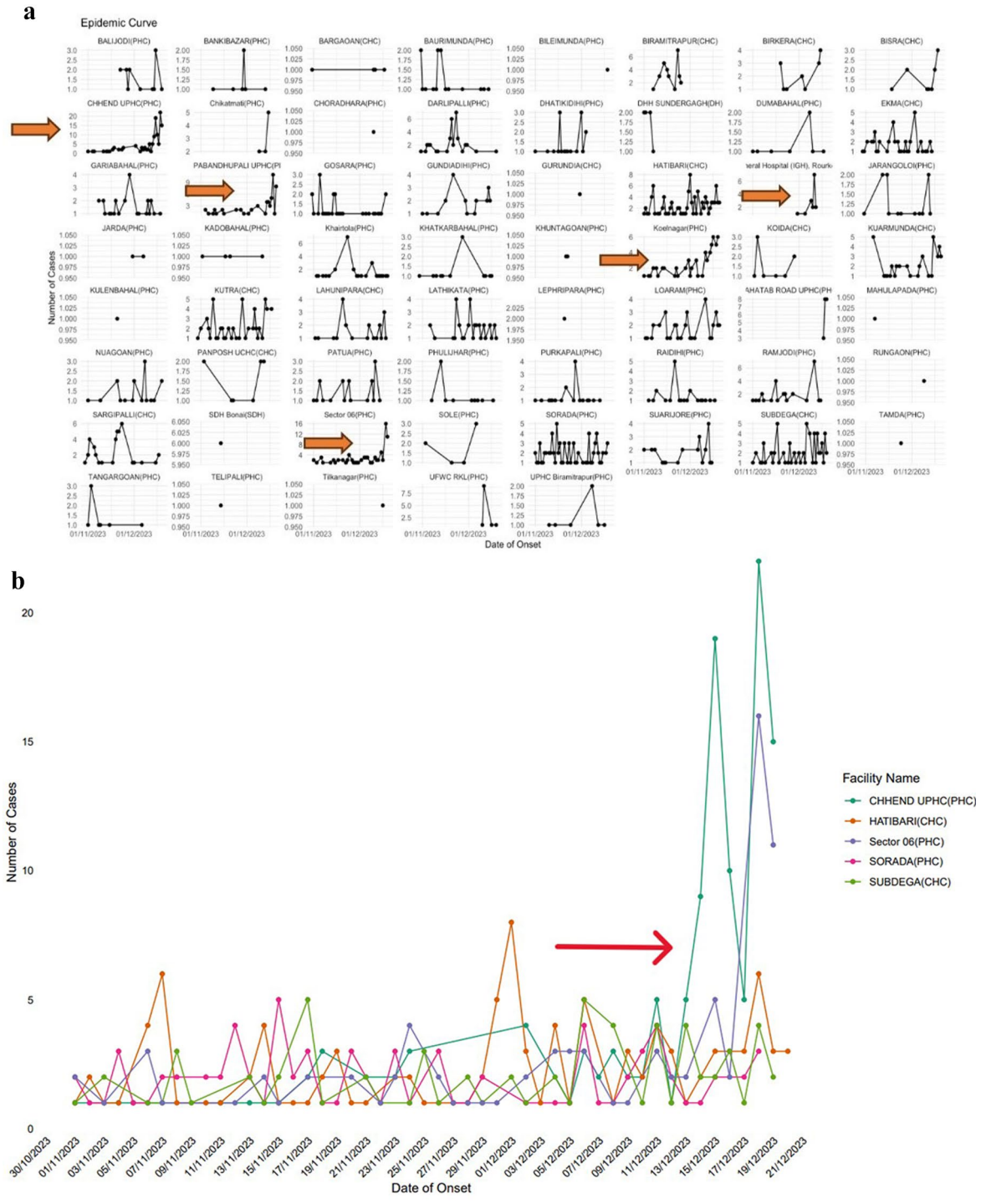


Fig. 1 (**a**) Daily facility wise reported cases of acute diarrhea across the district. (**b**) Daily caseloads and dates for identifying a cut off of date

Data collection

A standard questionnaire for epidemiological investigation of diarrheal disease by WHO (i.e., Acute Diarrheal Syndrome case investigation form [23]) was used to collate information from the participants on general demographics, exposure to possible known sources and potential risk factors. A face-to-face interview was done with both controls and cases by trained investigators.

Sample collection and transport

Whole stool and rectal swab samples were collected from both the cases and controls in Cary Blair Transport Media and transported to the Laboratory at

ICMR-Regional Medical Research Centre. The samples were collected before the administration of any antibiotic therapy. Additionally, water samples were collected from the participants' households in sterile container following the standard procedure.

Investigations

Laboratory investigations

Microbiological examination The clinical samples were cultured using standard procedures for isolation of various causative bacterial pathogens as previously defined by WHO-CDC and other published protocols. The pathogens were identified biochemically by standard methods.

Biochemical & serological identification Suspected colonies obtained on the above media were subjected to biochemical & serological identification using commercially available antisera (Mast Group Ltd., UK) as previously described (ICMR, 2019) [24, 25].

Antibiotic sensitivity testing Antimicrobial susceptibility tests of the isolates were performed in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines [26] by the disc diffusion method [27] using commercially available discs (Hi-Media, India) (Bhattacharya et al., 2015). AST results were classified as susceptible (S), intermediate (I) and resistant (R) according to the guidelines of the CLSI [26].

Epidemiologic and statistical analyses

Case control study

A hospital cum community based matched case control study was carried out and a total of 39 cases were enrolled from both hospital as well as community setting. Controls were selected from the same locality to identify the etiological agent for the outbreak.

Statistical analysis

Descriptive statistics (viz., frequency & percentage) were used to present the sociodemographic characteristics, and prevalent symptoms among cases. Association with the possible risk factors were measured in terms of chi square or fishers exact test based on the criteria. The analysis was carried out using STATA statistical software version 17.0 for Windows (Stata Corp, College Station, TX, US) and R version 4.3.3.

Results

Descriptive epidemiology

As of 20th December 2023, a total of 1812 cases were identified in Rourkela, Odisha with an approximate incidence rate of 32.7 new cases per day per 1 lakh population. Cases were ascertained via both passive means, wherein individuals self-reported to healthcare facilities, and active surveillance conducted by the health system through door-to-door visits facilitated by Accredited Social Health Activist (AHSA) workers. The investigation of the first few cases to delineate the temporal sequence of events leading up to outbreak, indicated towards the possible contamination of water. There was unseasonal rainfall between 8th – 10th of December 2023, which coincided with the reports of turbid and foul-smelling water from piped connections between 11th and 13th of December 2023. Following which there was a noticeable rise in cases viz., reporting of 14 cases in a single day. This was strongly suggestive of the plausible association between contamination of water source and the outbreak. But the testing of water for chlorination using Orthotolidine (OT) test kit later during the investigation (i.e., after 20th December 2023) suggested presence of adequate chlorine concentration. This may be due to the preventive measures adopted in response to the outbreak. A geographical heat map was constructed in conjunction with the state health and water resources department that shows the possible linkages with the city's piped water supply (Fig. 2).

Complications

Hospitalization rates were initially high. The peak hospitalization rate was 58.7% out of 252. A total of 6 deaths were reported with a case fatality rate of 3.3 per 1000 cases.

Epidemic curve

An epidemic curve using the data on new cases identified via passive surveillance (in Out Patient Department), active surveillance (in community-based health camps), hospitalizations, discharges and deaths shows a rapid progression in the first five days since 13th December 2023 followed by stabilization during 18th to 19th December 2023 and finally a downward trajectory depicting a declining trend in incidence of ADD. The forecasting model shows that outbreak had attained its peak and would touch baseline by 24th December 2023 (Fig. 3).

Findings from case control study

The mean age of all the participants was found to be 29.98 years ± 15.58. It was higher among cases (39 years ± 17.35) compared to the controls (21 years ± 11.31). Among both the cases (66.67%) and control (80.95%) a higher proportion of the participants fell in the age group of 19–59 years. Females were a slightly higher in numbers than male among among both cases (53.85%) and controls (57.14%). Both the cases and controls exhibited a comparable distribution in terms of working status. None of the demographic factors listed showed a significant association with ADD. Both cases and controls

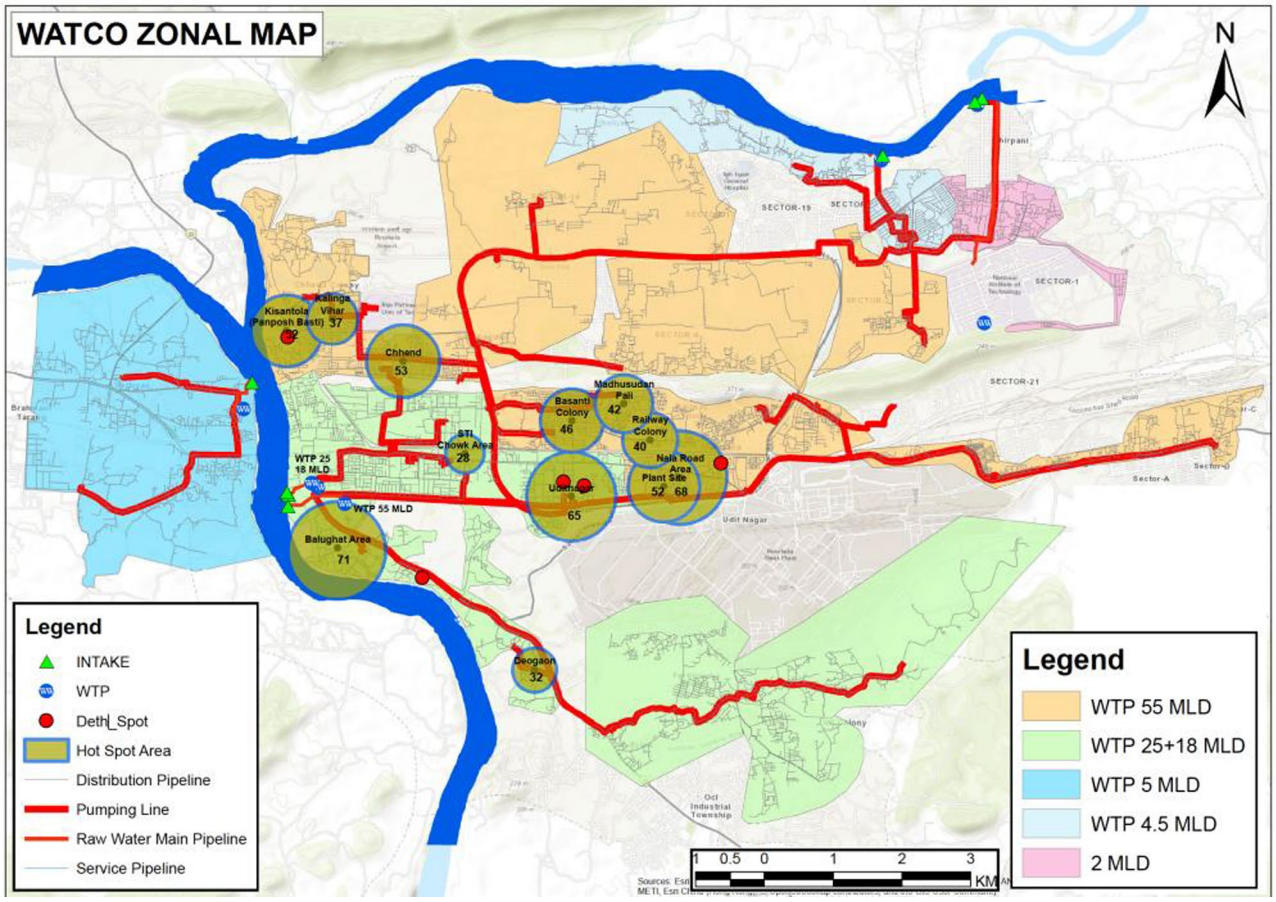


Fig. 2 Heat map overlay with water supply

exhibited a comparable distribution regarding their source or drinking water. A significantly larger proportion of the cases used traditional toilets, whereas the controls went outdoor for toileting. Culture serotyping of the cases detected 17.95% with *V. Cholerae* and 2.56% with *S. flexneri* whereas no such organisms were detected among controls. Among all of the listed factors; type of toilet used showed a significant association with the occurrence of ADD (Table 1).

The cases presented with an average diarrhoea frequency of 6.24 ± 2.61. Overall, majority of participants exhibited symptoms such as acute watery discharge (39, 100%), abdominal pain (25, 64.71%), and vomiting (25, 64.71%). A smaller proportion experienced nausea (16, 38.24%) and acute mucosal diarrhoea (12, 35.29%). Other symptoms were reported less frequently. The highest reported symptoms among all the age groups in both male and females was acute watery diarrhea. Abdominal pain was the second most commonly reported symptom among females aged 19 to 59 years, whereas vomiting among males in the same age bracket. A detailed picture of distribution of symptoms across the sex and age group is depicted in the table (Fig. 4).

Laboratory findings

A total 54 samples were collected from the participants, of which 10 whole stool samples and 24 rectal swabs collected were from 34 cases; whereas 16 whole stool samples and 4 rectal swabs were from 20 controls. Among 34 cases of acute diarrheal disease, seven samples produced typical colony of *V. cholerae* and one sample exhibited typical colony like *Shigella* genus. Further upon serotyping, *Vibrio cholerae* O1 Ogawa serotype was confirmed and one *Shigella* genus was confirmed as *Shigella flexneri 2a*. Overall, 20.6% of the cases tested positive for *Vibrio cholerae*, implicating it in the current outbreak. All the *V. cholerae* O1 strains were found to harbour *ctxA* and B, *tcpA (El Tor)*, *toxR*, *toxS*, *toxRS*, *toxT*, *ace*, *zot*, *ompU and tcpP*.

The antibiotic susceptibility profile of the eight-participants tested positive with either *V. Cholerae* or *S. flexneri* suggested an evidently higher proportion of resistance to ceftazidime (100%) and Imipenem (100%) followed by Nitrofurantoin (87.5%) and Ciprofloxacin (75%). Among all the antibiotics Gentamicin was seen to be the most suceptible (87.5%) (Fig. 5).

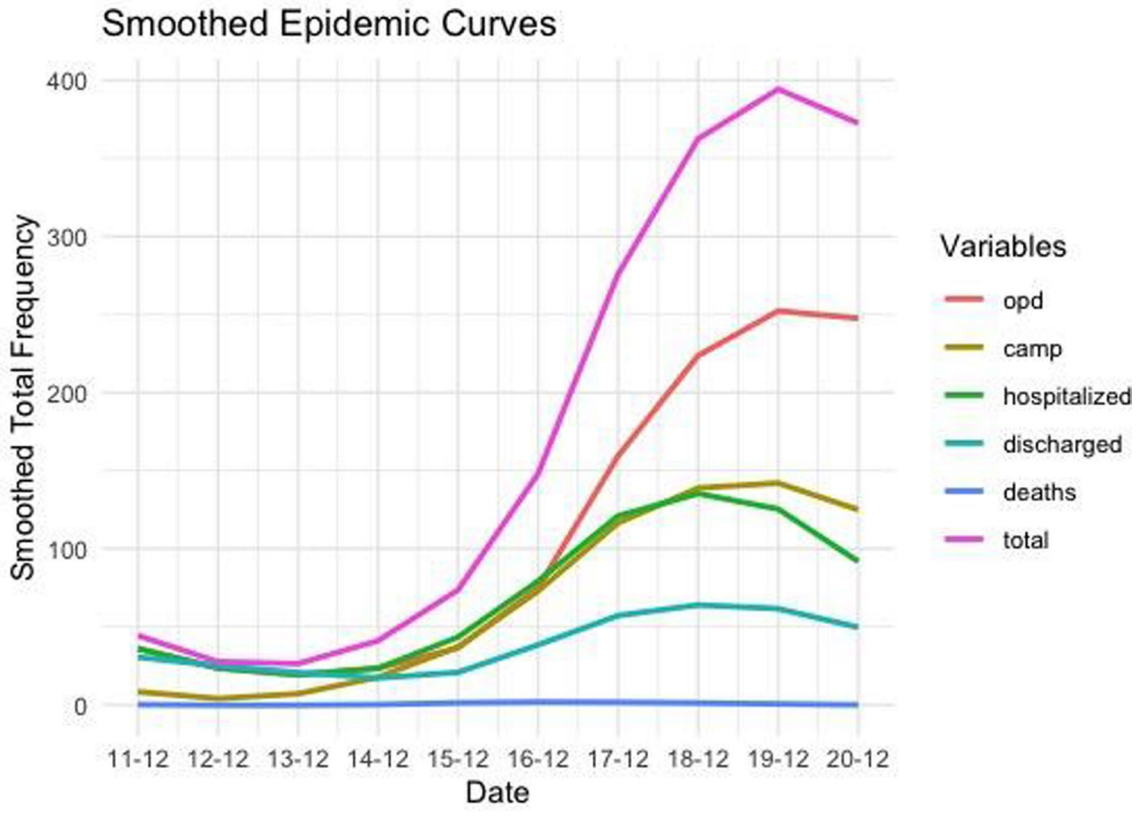


Fig. 3 Epidemic curves for ADD outbreak in Rourkela

Discussion

Cholera outbreaks are of major concerns in the developing countries and is spreading among the growing population. It still remains underreported in major parts of India [28]. The current outbreak reported 1812 ADD cases, with a daily incidence rate of 32.7 per one lakh population as of 20th December 2023. Hospitalizations peaked at 58.7%, and six deaths occurred, yielding a case fatality rate of 3.3 per 1000 cases. Sudden rise in cases of ADD was seen in five of the healthcare facilities situated in the urban Rourkela. The mean diarrheal frequency per day among cases was 6.24 ± 2.61 with; watery discharge, abdominal pain, and vomiting being reported commonly. And a significant association of cases was found with type of toilet used. Among all the cases; 20.59% were identified as *Vibrio cholerae* 01 and 2.94% was *Shigella flexneri* upon culture serotyping.

The current investigation estimated a daily incidence rate of 32.7 per one lakh population. Former study estimates suggested Odisha to be among the states contributing to 91% of all cholera outbreak-related cases [29]. A recent review examining cholera outbreaks in India found Odisha contributing a moderate number of occurrences (19 outbreaks), accounting for 3% of the overall total [30]. There has been a considerable decrease in the occurrences of cholera outbreaks in recent years but as seen the increasing urbanization clubbed with inadequate clean water and sanitation, and climate change can increase the risk of such outbreaks.

The confirmed Cholera cases in this outbreak reported an average diarrheal frequency of 6.24 ± 2.61. Majority of them presented with symptoms like acute watery diarrhea, abdominal pain and vomiting. WHO states most of the cases remain asymptomatic. Among those who develop symptoms, a very few develop acute watery diarrhea with severe dehydration [31].

The present investigation showed a significant (p value < 0.01) association between cases and type of toilet used. In many developing and middle- and low-income countries, the key reason for cholerae outbreak is due to inadequate sanitation and contaminated water source. The World Health Organization (WHO) estimates that upon adequate sanitation and clean water source can decrease diarrhea cases by up to 35% [20].

The suspected causative agent for the diarrheal outbreak was *V. cholerae*. Earlier studies on outbreaks in Odisha confirmed the isolation of the Haitian variant of *Vibrio cholerae* in Kendrapada, Rayagada, Baragarh and Mayurbhanj [18, 19, 32]. This is the first-time reported isolation of *V. Cholerae* O1 type in Rourkela, Sundergarh, Odisha.

Table 1 Distribution of socio – demographic characteristics and associated factors associated with acute diarrheal disease across cases and controls

Attributes		Cases	Controls	*p* value*
		n (%)	*n* (%)	
Mean age (completed years) ± SD		39 ± 17.35	21 ± 11.31	
Age Groups (*n* = 60)	Under 18 years	9 (23.08)	4 (19.05)	0.37
	19–59 years	26 (66.67)	17 (80.95)	
	Above 60 years	4 (10.26)	0	
Sex (*n* = 60)	Female	21 (53.85)	12 (57.14)	0.81
	Male	18 (46.15)	9 (42.86)	
Caste (*n* = 60)	Scheduled Tribe	13 (33.33)	12 (48.00)	0.41
	Scheduled Caste	9 (23.08)	3 (14.29)	
	Other Backward Class	7 (17.95)	3 (14.29)	
	Others	10 (25.64)	3 (14.29)	
Working Status (*n* = 60)	Working	33 (84.62)	15 (71.43)	0.22
	Not working	6 (15.38)	6 (28.57)	
Source of drinking water (*n* = 60)	Drilled water	13 (33.33)	7 (33.33)	0.99
	Pipe water	22 (56.41)	12 (57.14)	
	Well	4 (10.26)	2 (9.52)	
Type of toilet (*n* = 58)	Water sealed toilet	7 (18.92)	7 (33.33)	< 0.01
	Traditional toilet	26 (70.27)	5 (23.81)	
	Public toilet	1 (2.70)	0	
	Outside	3 (8.11)	9 (42.86)	
Culture Serotyping (*n* = 54)	Non-pathogenic *Escherichia coli (E. coli)*	26 (76.67)	20 (100)	0.05
	V. cholerae	7 (20.59)	0	
	S. flexneri	1 (02.94)	0	

Notes: * Chi square test

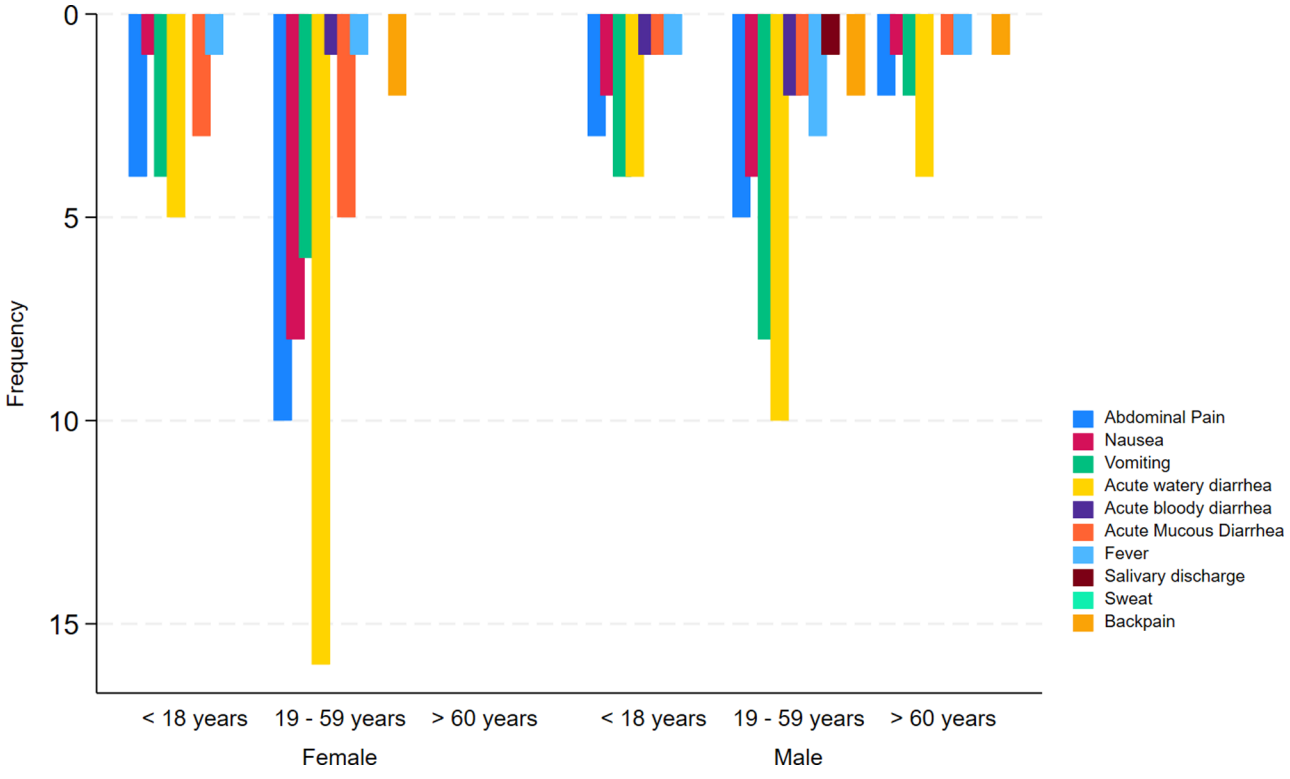
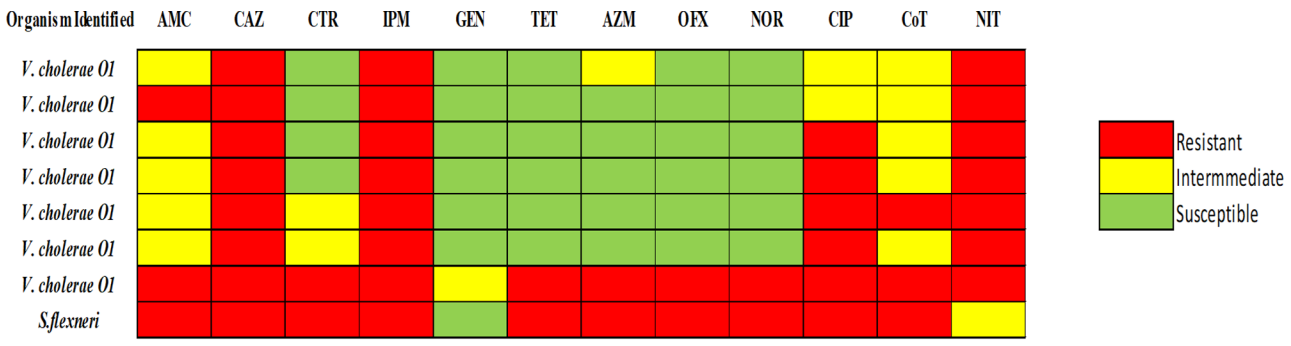


Fig. 4 Prevalence of acute diarrheal symptoms among the cases across sex and age group (*n* = 39)



Notes: AMC - Amoxicillin And Clavulanic acid, AZM – Azithromycin, CAZ – Ceftazidime, OFX – Ofloxacin, CTR – Ceftriaxone, NOR – Norfloxacin, IPM – Imipenem, CIP – Ciprofloxacin, GEN – Gentamicin, CoT – Cotrimoxazole, TET – Tetracycline, NIT - Nitrofurantoin

Fig. 5 Antibiotic sensitivity profile of seven cases positive with V. Cholerae and one case with S. Flexneri

The antibiotic susceptibility profile in the present investigation revealed a multi drug resistant (MDR) showing resistance to at least three drugs and larger proportion of the confirmed *V. Cholerae* 01 type cases were resistant to ceftazidime (100%) and Imipenem (100%) followed by Nitrofurantoin (87.5%) and Ciprofloxacin (75%) and so on. Since 1996, the prevalence of multidrug resistant (MDR) *V. cholerae* O1 strains has steadily increased in Odisha and other regions of the nation [20]. A similar analysis of antibiogram profile in another study affirmed resistances to different drugs viz., streptomycin, nalidixic acid, ampicillin, co-trimoxazole, and furazolidone [33]. The circulation of these strain within community and any contamination with human food or water source can lead to such outbreak which could be difficult to control.

The cholera outbreak in Rourkela, Odisha, accentuates the persistent threat posed by *V. cholerae* O1, especially in the light of increasing antimicrobial resistance. Effective management of severe diarrhea plays a crucial role in combating cholera. However, the rising resistance of *V. cholerae* to commonly used antimicrobial agents is alarming, especially given the organism's potential to cause epidemics. Monitoring *V. cholerae* resistance is imperative in the wake of extensive and inappropriate use of antimicrobials, which results in selective pressure on microbes, leading to potential development of resistance mechanisms. The identification of *V. cholerae* O1 in Rourkela for the first time indicates geographical expansion of cholera strains, necessitating broader public health responses. Moreover, the emergence of multi-drug resistant strains exacerbates the challenge of managing and controlling outbreaks effectively. Comprehensive strategies addressing sanitation, water quality, antibiotic stewardship, and surveillance are imperative to curb the spread of cholera and mitigate its impact on public health in India. Additionally, continued research into the epidemiology and antimicrobial resistance patterns of *V. cholerae* O1 strains is crucial for guiding effective control measures and minimizing the risk of future outbreaks.

Strengths and limitations

The study was carried out by a multidisciplinary team specializing in outbreak investigation. Their collective expertise enables thorough examination of risk factors and exposure sources contributing to outbreaks. Additionally, access to advanced laboratory facilities ensured accurate diagnosis and analysis, validating the epidemiological findings. Collaboration with the health system supported data collection and facilitated timely implementation of control measures. A significant challenge in this study was the inability to conduct follow-up with participants. It additionally has the risk of recall bias as it is a case control study.

Counter measures

Few of the counter measures initiated by the authorities included Information Education Communication (IEC) activities promoting safe drinking water practices and hand washing, and active case finding and management with Oral Rehydration Therapy (ORT). In addition to it the team suggested the following immediate public health interventions:

- Continue active case finding and add surveillance of water quality at scale, for at least 2–3 weeks.
- Collect data in structured case report forms (format by IDSP) from all presumptive cases; compile and analyze daily till outbreak subsides.
- Intensive IEC campaign for at least 2–3 weeks.
- Standardize protocols for case definitions, screening, management, testing and discharges.

Conclusions

Such outbreaks, emphasizes the critical importance of improved sanitation and antibiotic management. The emergence of multi-drug resistant strains has a significant impact on outbreak control. Holistic approaches are imperative in combating cholera transmission and minimizing its public health impact in India.

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Author contributions
Conceptualization: JSK & DB; Methodology: JSK, DB, UKR & SK; Investigation: JSK, ASK, DB, UKR, SK, AD, RP, AP, AKB, SPS, &TP; Resources: SP & DB; Data curation: JSK, ASK & AKP; Writing original draft preparation: SK & UKR; Writing-review and editing: all authors; Supervision: SP; Project administration: JSK, DB & ASK. All authors have read and agreed to the published version of the manuscript.

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Data availability
The datasets used and/or analyzed during this study are available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
The informed consent was obtained from each participant prior to the collection of samples. Ethical clearance was waived off by IHEC, ICMR - RMRC Bhubaneswar; as the investigation was a pivotal component of the public health response to an outbreak. It was undertaken to swiftly identify the outbreak's source for immediate control, and prioritizing the community's welfare.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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