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Original Research Article

Field investigation of viral hepatitis outbreak in a cantonment in northern India: an epidemiological perspective

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ABSTRACT

Background: Viral hepatitis remains a significant public health concern, particularly in closed communities where shared amenities and communal living increase the possibility of outbreaks. A notable increase in viral hepatitis cases was reported in a cantonment in northern India, prompting an urgent epidemiological investigation to comprehend the cause, extent, mode, various contributing environmental and behavioral risk factors.
Methods: An ambispective descriptive epidemiological study was conducted using a line listing of reported hepatitis cases from January to July 2025. An environmental health assessment was carried focussing on the water quality aspects, hygiene, sanitation and public health infrastructure. The structural integrity of the water and sewage pipelines was also inspected to identify any leakages.
Results: Over seven months, a total of 36 viral hepatitis cases were reported in the cantonment, primarily among individuals with a history of travel and those residing in blocks served by old, leaking water pipelines. Water testing showed high coliform counts, with 6-11 pipeline leaks and 1-5 sewage blockages reported monthly. Laboratory confirmation primarily pointed to hepatitis A virus (HAV) and hepatitis E virus (HEV).
Conclusions: The outbreak was attributed to contaminated drinking water, primarily due to water pipeline leakage and sewage intermixing. Recommendations include the urgent replacement of compromised pipelines, enforcement of regular water quality monitoring and public health education on hygiene practices. This investigation highlights the importance of robust environmental surveillance and rapid response mechanisms in high-density residential closed communities.

Keywords: Cantonment, Environmental surveillance, Fecal-oral transmission, Outbreak, Public health response, Viral hepatitis

INTRODUCTION

In developing nations, Viral Hepatitis poses a major public health concern, especially in closed communities with shared amenities and mobile populations, such as those in cantonments.[1] In India, both acute viral hepatitis (AVH) caused by enterically transmitted hepatitis A virus (HAV) and hepatitis E virus (HEV) pose a major health problem.[2,3] India is hyperendemic for both HAV and HEV, with sporadic cases and periodic outbreaks reported regularly, especially during the monsoon and summer seasons.[4-6]

Despite advancements in sanitary conditions, health awareness and socioeconomic conditions, these infections

continue to occur sporadically in different parts of India.[7] Health systems, communities and individuals have all suffered greatly as a result of the viral hepatitis outbreaks.[8] It is responsible for approximately 1.4 million deaths per year from acute infection and hepatitis-related liver cancer and cirrhosis, a toll that is comparable to that of HIV and tuberculosis.[9] Hepatitis epidemics occur frequently in the Indian subcontinent, mostly due to enterically transmitted hepatitis A and E viruses.

HAE and HAV are food- and water-borne infections that can cause acute outbreaks in communities with unsafe water and poor sanitation.[10] They do not result in chronic infection or chronic liver disease and there is no specific treatment available. Prevention can be achieved through improved sanitation, food safety and vaccination. Water or food supplies contaminated by feces have been implicated in major outbreaks reported in all parts of the world with hot climates.[11-16]

In July 2025, a significant increase in the number of cases of acute viral hepatitis was reported among individuals residing in a cantonment. The public health department initiated an epidemiological investigation to assess the magnitude, identify the source and implement control measures to prevent further transmission. An investigation was required in this situation to determine the existence of an epidemic, to find out the time, place and person distribution of cases, sources of infection, to identify and characterize the disease agent and to recommend and adopt control measures.[17]

Objectives

To confirm the occurrence of the outbreak and describe its epidemiological characteristics in terms of person, place and time. To identify the most likely source of infection and route of transmission through field investigation and environmental surveillance. To recommend targeted, evidence-based control and preventive measures to contain the outbreak and avert future outbreaks.

METHODS

Study type

An ambispective descriptive epidemiological study was conducted using line-listed data of reported hepatitis cases from January to July 2025. The investigation was considered ambispective, as it involved both retrospective analysis of initial cases and prospective surveillance of ongoing ones.

Study setting

A cantonment area in Delhi housing with a total population of approximately 17,619 was selected for the study.

Statistical analysis

Statistical analysis was done using Microsoft Excel (Microsoft 365).

Climatic conditions

The winter period in the area starts from October and continues till the end of February. The temperature ranges from 4 degrees Celsius in winter to 46 degrees Celsius in summer. Relative humidity on an average is between 70% to 90%. Average rainfall is 0.98 mm.

Surveillance system and early warning system in the cantonment

The public health system in a cantonment maintains a robust surveillance mechanism that includes: I) daily hospital admissions of communicable diseases; II) laboratory surveillance of the patients being tested for various communicable diseases; III) water quality monitoring (free chlorine and bacteriology)- daily free chlorine checks, weekly water bacteriology, fortnightly visit to water supply point; IV) regular inspection of the water distribution system; V) regular sanitary inspections of the area of responsibility; VI) health intelligence.

Outbreak investigation

Case identification

Clinical profile of cases: Patients reported with yellow discoloration of urine, nausea, vomiting and loss of appetite. Most patients had a history of fever that followed an uneventful recovery path. The majority of cases had a history of travelling outside the cantonment.

Case definitions: as per the WHO criterion

Suspect: Any individual residing in the cantonment area who developed an acute onset of jaundice, nausea/vomiting, abdominal discomfort, fatigue, or dark-colored urine.

Clinical criteria: Any individual residing in the cantonment area who developed a discrete onset of an acute illness with signs/symptoms of acute viral illness (e.g. fever, malaise, fatigue) and liver damage, which can be clinical (e.g. anorexia, nausea, jaundice, dark urine, right upper quadrant tenderness), and/or biochemical [alanine aminotransferase (ALT) levels] more than 10 times the upper limit of normal.[18]

Biomarker criterion: Positive for IgM anti-HAV or IgM anti-HEV.

Epidemiological criterion: Epidemiological link to a case confirmed with biomarker (i.e. contact with a person with hepatitis A confirmed with biomarker testing 2-6 weeks

before onset, or occurrence in the context of an outbreak confirmed by biomarker testing).

Confirmed case

A case of acute hepatitis that tests positive for the biomarker criterion Hepatitis A (HAV IgM) or Hepatitis E (HEV IgM) positivity via ELISA or a case of acute hepatitis with an epidemiological link to a confirmed case.

Case classification

Fresh local case: A confirmed case occurring within the closed community with no recent travel history or external exposure, indicating local transmission.

Imported case: A confirmed case introduced from outside, such as an individual who recently moved to the cantonment or returned from leave, with symptom onset within 2-6 weeks of arrival and no exposure to the local outbreak source.

Formulation of health teams

An ambispective epidemiological field investigation was undertaken to assess the rise in cases of viral hepatitis reported within the cantonment. Two specialized health teams were formulated to conduct the investigation.

The investigation team was formed that composed of: head, public health department; two residents, department of community medicine; health inspector; health assistants; laboratory technician.

The investigation was conducted between 04 July and 31 July 2025.

Team 1

The first team, led by the officer in charge of the public health department of the cantonment, was overall in charge of the field investigation. Residents from the department of community medicine were responsible for case verification, data collection and clinical epidemiological mapping. Review of medical records at the hospital and the Medical inspection room (MIR). A line listing of all the patients was done and epidemiological case sheets were filled for all the cases covering symptoms, onset, water and food history, hygiene, history of travel and exposure risks.

Team 2

The second team, comprising Health assistants (HAs) and Health inspectors (HI's), focused on environmental surveillance, particularly of the water supply, sanitation infrastructure and food-handling practices. This team conducted spot inspections of residential areas, food joints, water tanks, overhead reservoirs and sewage pipelines.

Environmental survey

A designated health inspection team carried out the environmental surveillance of the cantonment area to identify the potential environmental contributors to the outbreak of viral hepatitis. The survey focused on evaluating the integrity and safety of the water supply system, sewage infrastructure and hygiene and sanitation standards within the cantonment area.

Water supply surveillance

Source evaluation

The water sources in the cantonment were located and mapped, including the overhead tanks, bore wells and piped municipal supply lines. The areas which reported any cluster were taken into consideration for any breaches in the water supply system.

Sampling and testing

Water samples were collected from source points (pumphouses, water sumps), mid-distribution points (water distribution system) and consumer end points (household taps). A total of 1524 samples were collected over six months and tested for: residual chlorine levels (using orthotolidine test kits); microbiological contamination, specifically for coliform organisms and *E. coli*, was tested at the laboratories of the dependent hospital (Table 1).

Chlorination practices

Water quality monitoring for free chlorine and bacteriology was done. Free chlorine was checked twice daily from various locations; bacteriological examination of the water was done weekly and a visit to the water supply point was carried out fortnightly. From January 2025 to July 2025, 1524 water samples were collected and tested in three laboratories as highlighted in Table 2.

Table 1: Summary of bacteriological samples (water).

	Total samples	Satisfactory	Unsatisfactory	Remarks
Lab 1	45	39	06	Necessary remedial measures taken
Lab 2	13	13	-	
Lab 3	14	08	06	
Total	72	60	12	

Table 2: Summary of water samples.

	Samples tested	Free chlorine found	Not found	Remarks
Lab 1	791	764	27	Necessary remedial measures taken
Lab 2	323	313	10	
Lab 3	410	404	06	
Total	1524	1481	43	

Table 3: Summary of leaking/blocked pipelines.

Month	Leaking water pipelines	Leaking/blocked sewage pipelines
Jan 2025	06	05
February 2025	11	02
March 2025	08	01
May 2025	04	05
June 2025	07	03
July 2025	06	03

Pipeline integrity and public health engineering

Several field reports from January 2025 to July 2025, had depicted recurrent leakages in the water supply system and sewage pipelines in the cantonment across multiple sites. A total of 42 water pipeline leakages and 19 sewage line blockages or leakages were documented over six months (Table 3). Especially, in the old quarters and low-lying areas, the field inspections revealed multiple points where the potable water pipelines and sewage lines were collocated, raising suspicion of potential cross-contamination.

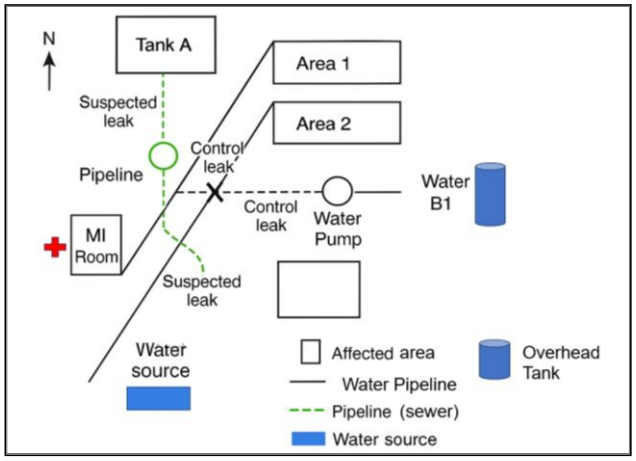

Figure 1: Spot map showing the distribution of water supply and sewage pipeline (possible leak).

Sanitation and wastewater management

During the public health engineering survey by the field team, an assessment of latrine sanitation and greywater drainage systems was also conducted. Overflowing soak pits, open manholes, broken joints and stagnant wastewater pools were observed in some domestic clusters, especially near cookhouses and bathing areas. Uncovered drains and poorly maintained sewage disposal systems were flagged as potential risk factors for fecal-oral transmission of hepatitis viruses (Figure 1).

Community hygiene practices

Informal interviews and observation checklists were used to assess water storage practices, personal hygiene (handwashing) and food hygiene. Water storage practices and hand hygiene among food handlers in the eateries, restaurants, community kitchens and sweet shops were assessed during the environmental survey and were found to be satisfactory. Monthly medical examinations of cooks and food handlers were reviewed and found to be diligently conducted. Additionally, the vaccination status of all food handlers was also verified and found to be up to date.

Risk mapping

Using findings from the environmental survey and line-listing of cases, a risk map of the cantonment was developed. Clustering of cases was observed in areas with frequent pipeline issues and poor sanitation, supporting an environmental mode of transmission.

Laboratory analysis

28 blood samples tested for hepatitis A and hepatitis E IgM using ELISA. Stool samples and water samples were tested for fecal coliforms and total coliforms.

RESULTS

Case load

Between January and July 2025, a total of 36 cases of viral hepatitis were reported and admitted, compared to 28 cases in the corresponding period in 2024. The highest

number of cases was recorded in May 2025, with a peak of 11 cases.

Historical outbreak

A notable outbreak occurred in February-March 2025 in one area of the cantonment, where 12 cases were reported. The outbreak was epidemiologically linked to sewage contamination of a water source, indicating a likely common-source exposure.

Distribution patterns

Type

Out of the 36 cases, 6 were identified as fresh (local) cases, while 30 were categorized as imported, having had probable exposure outside the cantonment (Figure 2).

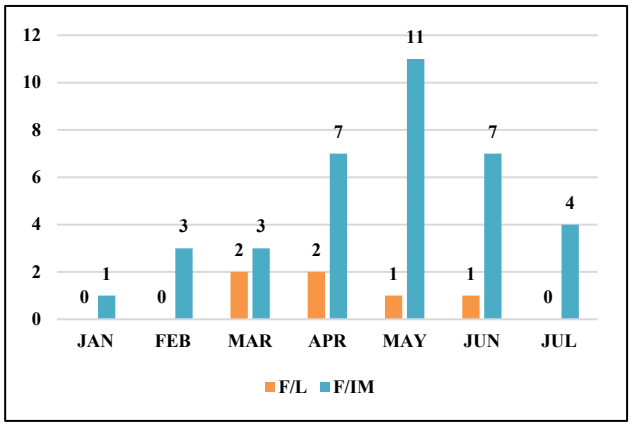

Figure 2: Distribution by type of case. Maximum cases were imported.

Trends over the last two years

An analysis of the monthly distribution of hepatitis cases over the past two years revealed two distinct epidemiological patterns. In 2023, the outbreak was predominantly local in origin, with a marked spike in March 2023, accounting for 18 cases, of which 12 were fresh local cases. February 2023 also recorded a modest number of local cases (n=4). Conversely, in 2024, the pattern shifted, with the majority of cases being imported, particularly during the summer months. May 2024 recorded the highest number of imported cases (n=10), followed by June (n=6) and July (n=4). Local transmission remained limited in 2024, with at most two fresh local cases per month (Figure 3).

The peak months were March (2023) and May (2024), corresponding to periods of increased travel activity, particularly temporary duty and leave, indicating a likely link between travel-related exposure and case importation. This is further supported by the relatively low number of local cases during the same period. The trend also highlights the seasonal vulnerability during spring and summer, when increased temperatures may raise the demand for hydration, often leading to consumption of unsafe food and water en route. This reinforces the need for pre-travel advisories and preventive health briefings for individuals proceeding on leave or movement orders.

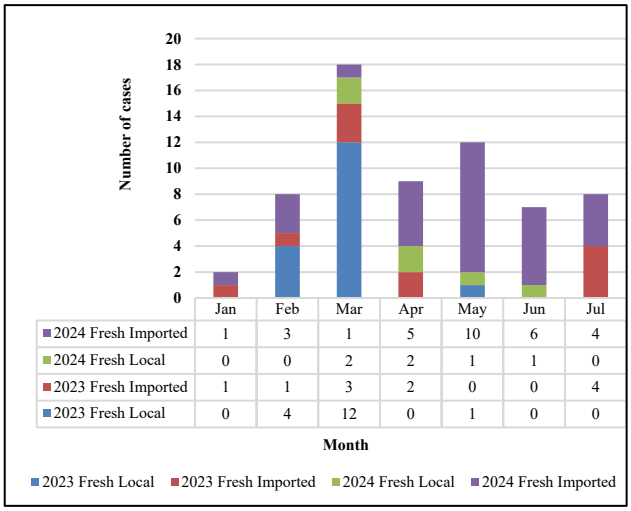

Figure 3: Distribution by type of case in the last 2 years (2023-2024).

Travel status

Most of the imported cases had a recent history of travel, either on leave or some outstation duty. Notably, several had undertaken long-distance rail journeys before the onset of symptoms, suggesting a travel-related exposure risk (Figure 4).

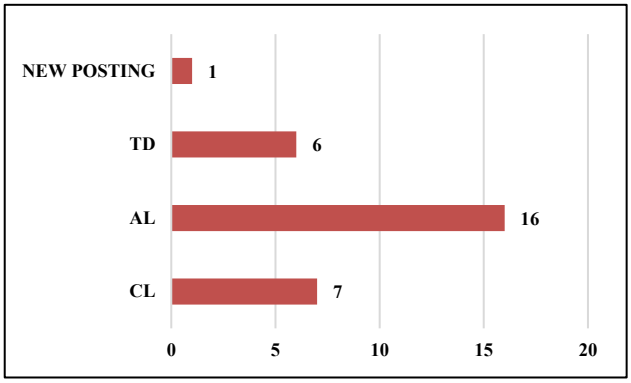

Figure 4: Distribution time of occurrence among imported cases. Maximum cases have occurred while on annual leave.

Time

A single peak in case numbers was observed in May 2025, suggesting a possible point-source exposure or seasonal trend. The onset of the first case was on 12th January 2025 and the last case was reported on 28th July 2025 (Figure 5).

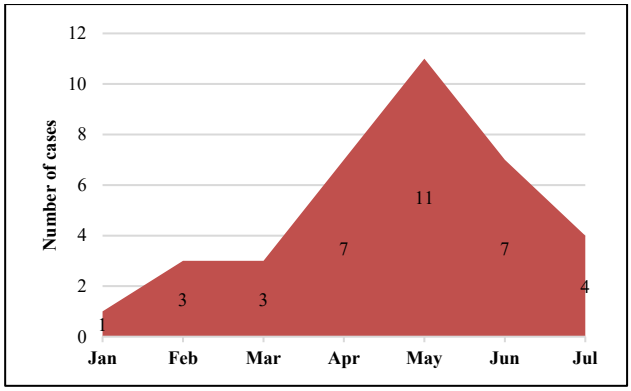

Figure 5: Time trend of hepatitis cases.

Person

A total of 36 hepatitis cases were reported, all of whom were males. The mean age of affected individuals was 37.3 years, with a standard deviation of 9.9 years (Figure 6), indicating that the cases were primarily among middle-aged adults. The overall attack rate in the cantonment was 0.20%, with 36 cases reported among a total population of 17,619. However, among the approximately 800 individuals in the most affected unit, the attack rate was 1.5%, with 12 confirmed cases reported during the localized outbreak in February-March 2025.

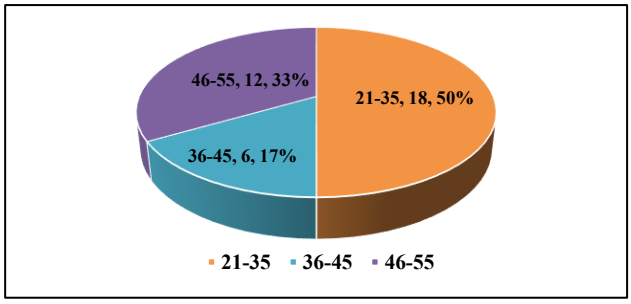

Figure 6: Distribution of cases as per age group.

Place

The spatial distribution of cases indicates clustering among residents from specific states, particularly Punjab, followed by Kerala and Odisha. These trends may reflect varying levels of immunity or prior exposure in individuals from different regions. The fact that imported cases formed the majority underscores the need for stricter sanitation practices post-travel and active surveillance for individuals returning from outstation.

Water testing results

Bacteriological examination

Out of 72 water samples tested, 12 (16.6%) were found to be unsatisfactory, indicating fecal contamination (Table 4).

Free chlorine levels

Out of 1,524 samples tested for residual chlorine, 42 samples (2.75%) showed inadequate chlorination levels, falling below the recommended threshold (Table 3).

Table 4: Summary of laboratory tests (blood/stool/water).

Sample type	Test	Positivity rate
Blood (n=28)	HAV IgM	22 (78.5%)
Blood (n=28)	HEV IgM	3 (10.7%)
Stool	Fecal coliforms	Detected in 5/6 samples
Water	Fecal coliforms	Positive in 4/8 samples
Water	Residual chlorine	0 ppm in 3/8 samples

Laboratory results

Out of 1524 water samples tested routinely between January and July 2025, 43 (2.8%) showed inadequate residual chlorine levels, indicating lapses in disinfection. Additionally, 8 targeted water samples were collected during the outbreak for detailed microbiological testing. Of these, 4 tested positive for fecal coliforms and 3 had 0 ppm residual chlorine which support the evidence of water contamination.

Mode of transmission

Feco oral transmission was suspected.

Source of infection

The probable source of infection was drinking water or contaminated food consumed by the troops while on leave or during travel. The following factors seem to have influenced the transmission of hepatitis: a) poor water discipline, b) lack of availability of adequate drinking water en route, c) consumption of water from unauthorized sources, d) easy availability of eatables and water from civil shops/railway stations

Interpretation

From the line listing of cases, it was seen that the majority of cases were imported. It was also evident that troops travelling have manifested with hepatitis.

Hypothesis as to the cause

Individuals travelling out of the cantonment while on leave or travel acquire infection due to poor water discipline and lack of safe drinking water while travelling. Due to the long incubation period of the disease, they manifest the disease when they report to the unit. The rest of the cases were from cross-contamination

of the water supply and sewage, indicating a point source outbreak within a confined area.

Epidemiological interpretation

The outbreak was most likely caused by the consumption of contaminated drinking water, facilitated by damaged infrastructure and inadequate chlorination. The temporal clustering, peak and clinical presentation were consistent with hepatitis A virus transmission via the fecal-oral route. The mixed HAV and HEV findings suggest secondary contamination or exposure to common risk factors, such as shared water or food sources.

Control measures implemented

In response to the outbreak, a series of control measures were systematically implemented. Health advisories and health bulletins were disseminated to units from March to July 2025, aimed at increasing awareness and reinforcing hygiene practices. Sanitary surveys played a pivotal role in identifying infrastructural vulnerabilities. Multiple leakages in water and sewage lines were detected and corrective actions were taken promptly. As part of the health education initiative, six targeted lectures on hepatitis prevention were conducted for individuals. These sessions helped clarify routes of transmission and reinforced the importance of preventive practices.

Public health interventions undertaken

Immediate measures

To curtail the outbreak and prevent further spread, several immediate interventions were deployed. All overhead tanks and pipeline systems underwent chlorination. Safe drinking water was ensured through distribution in sealed cans and by advising individuals and households to boil drinking water before use. Infected individuals were isolated to prevent secondary transmission and IEC campaigns involving posters and public announcements were rapidly launched.

Corrective actions

Longer-term corrective actions were initiated concurrently. Emergency repair and sealing of all identified leakages were undertaken. Bleaching powder was used to disinfect sewage overflow areas. Food handlers and mess workers underwent screening for potential carrier status.

DISCUSSION

This investigation of the increased incidence of viral hepatitis in a cantonment in northern India reveals the significance of integrating the epidemiological data with environmental surveillance. Strong suspicions about feco-oral transmission were raised by the pattern of cases, especially the clustering around specific locations with shared water sources and compromised infrastructure. Our findings are in line with the hepatitis E outbreak reported in Hyderabad (2006), where water pipelines passing through open sewage drains contributed to the outbreak, pointing towards possible fecal contamination of the drinking water supply due to leaking pipelines lying near the sewage systems.

As per the WHO Guidelines for Drinking-water Quality, the most reliable indicator of recent fecal contamination is *Escherichia coli* (*E. coli*). Its presence in any 100 ml sample of drinking water indicates a breach in water safety and potential exposure to harmful pathogens. Even a single colony-forming unit (CFU) renders the supply unfit for consumption and calls for prompt public health action. Remediation techniques include source identification, corrective measures like chlorination and close follow-up monitoring.[19]

Importantly, this investigation not only highlighted immediate corrective actions, such as improving water safety and initiating targeted health education but also emphasized the need for long-term public health preparedness. Inter-sectoral coordination, regular surveillance and infrastructure audits must all be integrated for timely detection of audit. As seen in previous urban outbreaks, the proactive identification of environmental vulnerabilities can significantly reduce disease transmission and build a resilient health system.

The pattern of the outbreak points to a travel-associated, sporadic importation of the disease rather than a single point source with fecal-oral route was the likely mode of transmission. The consumption of unhygienic food/water from civil shops or railway stations, Inadequate water intake, poor water discipline, lack of awareness during travel are the major contributing factors. High temperature and humidity increase the demand for fluids during travel. While local sporadic cases were also detected, these were quickly resolved with public health surveillance and localized sanitary corrections. Super chlorination has been used as a measure to control the waterborne outbreaks in institutional settings where an outbreak was reported due to nil residual chlorine and sewage spillage, among other causes.[20]

There are some limitations. The study may have underestimated the actual disease burden, as the mild or asymptomatic cases that did not manifest at the medical facility might have been missed, thereby underestimating the true burden.

Confirmatory virological tests (such as PCR for viral RNA) in stool and water samples were not carried out, despite the administration of IgM ELISA testing for HAV and HEV due to resource constraints.

Environmental samples might no longer accurately reflect the circumstances during peak transmission because of

the hepatitis virus's long incubation period and the interval between exposure and research.

A comparison group should have been taken and the odds ratio or relative risk for the exposed and nonexposed group should have been calculated. As the cases had already occurred at the time of investigation, a comparison group could not be taken and we had used descriptive methodology for the investigation.

CONCLUSION

The hepatitis outbreak in the cantonment was contained through timely investigation, environmental control and health education. A total of 36 cases of viral hepatitis were admitted to the hospital from January to July 2025, with a notable spike in May when 11 cases were reported. An outbreak was observed in one residential area of the cantonment during February and March 2025. The source of the outbreak was traced to sewage contamination of water lines near the individual bathroom area. These cases were primarily local.

However, the majority of cases overall were found to be imported. Several individuals developed symptoms after returning from leave or temporary duty (TD), likely due to the prolonged incubation period of hepatitis viruses. Cases were also reported among troops who had travelled by both rail and road, particularly long-distance train journeys involving multiple transit points. These extended trips increased the likelihood of exposure to contaminated food and water at railway stations and adjoining civil markets. The risk was further aggravated by the seasonal demand for hydration during peak summer months.

Six local, sporadic cases were detected within the cantonment and were thoroughly investigated, with appropriate remedial actions undertaken. Importantly, to mitigate future risks, troops travelling out of units must be consistently educated about hepatitis prevention strategies. These health advisories should be formally incorporated into movement orders.

These observations underscore the importance of preventive health education, environmental vigilance and strong inter-sectoral coordination in mitigating hepatitis transmission. Implementation of the above recommendations can greatly strengthen the cantonment's public health preparedness and resilience against future outbreaks. The existing surveillance system successfully captured the cases early. Continued health education, stricter water quality monitoring and endorsement of preventive instructions on movement orders are vital to preventing recurrence.

The outbreak investigation highlights how even small breaches in water safety can cause significant morbidity in congregate living settings. Timely public health response and multi-sectoral coordination helped contain the outbreak and reinforced the need for sustainable water and sanitation safety measures.

Recommendations

A series of thorough, multifaceted recommendations is put forth to improve outbreak preparedness in the cantonment and prevent recurrence in light of the epidemiological investigation's findings. It is crucial to make sure that regular water safety monitoring is carried out, which includes daily testing for residual chlorine and monthly bacteriological evaluations to detect fecal contamination early. To remove physical sources of contamination, it is essential to address infrastructural flaws such as leaking pipelines and improper sewage-water line segregation. It is essential to strengthen the public health infrastructure and the public health engineering aspects.

To develop community-level immunity, hepatitis A vaccination should be prioritized for high-risk groups like food handlers, healthcare workers, children and the immunocompromised. Targeted behaviour change communication (BCC) strategies that encourage promoting boiling of drinking water, hand hygiene and safe food practices. Visual aids and printed IEC materials can be distributed widely across the affected areas. Particularly for jaundice and other symptoms resembling hepatitis, a robust surveillance system with timely case reporting needs to be established. It is necessary to develop and test preparedness such as alert thresholds and response frameworks. At the policy level, integrating hygiene advisories into movement and leave instructions can play a preventive and promotive role. It is necessary to maintain increased testing frequency and intensified chlorination efforts during the summer, when viral hepatitis cases are likely to increase. Lastly, individuals should be educated about the use of ORS, boiled water and the avoidance of street food while in transit. Wen taken as whole, these recommendations, when implemented proactively, can significantly strengthen public health protections and build resilience against future outbreaks in the cantonment.

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