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RESEARCH ARTICLE

Association of climate variability with hepatitis A and E infections in Dhaka (2016–2023)

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Abstract

Background: Acute viral hepatitis, predominantly caused by hepatitis A virus (HAV) and hepatitis E virus (HEV), remains a major global public health issue, especially in low- and middle-income countries. This study was conducted to determine the prevalence of acute hepatitis A and E infections in Dhaka city and to examine the influence of weather conditions on their transmission.

Methods: This retrospective study, based on laboratory data, was conducted at the Department of Virology, Bangladesh Medical University from 2016 to 2023. It analysed the test results for anti-HAV-IgM and anti-HEV-IgM antibodies from blood specimens of suspected acute hepatitis cases. The patients' details and laboratory results were retrieved using the Laboratory Information System, and climatic variables (temperature, humidity, and rainfall) were obtained from the Bangladesh Meteorological Department.

Results: In this study, test reports from 19,542 individuals for HAV and 23,249 individuals for HEV were analysed. HAV was detected in 29.5% of the population, and HEV was found in 20.6%. Males were predominantly seropositive for both HAV (65.1%) and HEV (76%). HAV was most common in those aged ≤10 and 11–20 years (37.9%), whereas HEV was most common in the 21–30 years group (40.6%). Higher HAV transmission was observed during autumn and late autumn, while HEV was more prevalent in summer and the rainy season.

Conclusion: Acute HAV and HEV infections are common in Dhaka city, and climatic factors affect their spread. Understanding these patterns can improve public health readiness and raise awareness of social health hygiene.

Key messages

Acute viral hepatitis caused by hepatitis A and E viruses is heavily influenced by demographic factors. Age and gender play a crucial role in susceptibility to these infections. Climatic factors, including temperature, humidity, and rainfall, also affect disease transmission. Recognising these factors can support targeted public health measures.

Introduction

Acute viral hepatitis (AVH) is a pressing global public health issue due to its significant contribution to morbidity and mortality worldwide [1]. This is more apparent in low- and middle-income countries where the availability of proper sanitation infrastructure, access to clean water and safe hygiene practices are lacking [2]. Several hepatotropic viruses—including hepatitis A, B, C, D, and E—can cause acute viral hepatitis (AVH), but hepatitis A virus (HAV) and hepatitis E virus (HEV) are the most common enterically transmitted types. Both are primarily spread via the faecal-oral route, typically through contaminated food or water. Clinical symptoms include fever, nausea, vomiting, loss of appetite, abdominal pain, and jaundice, with severity ranging from asymptomatic to fulminant hepatic failure. An estimated 1.4 million new cases of HAV and approximately 20 million new cases of HEV are reported globally each year [3]. Addressing this morbidity and mortality burden remains a major public health challenge, especially in resource-constrained endemic settings.

Bangladesh, endemic for viral hepatitis and the transmission of HAV and HEV is influenced by socio-demographic and environmental conditions [4, 5]. The environment supports the persistence and transmission of enteric viruses due to poor sanitation, limited access to clean water, unhygienic practices, and widespread consumption of unsafe street food [6]. Moreover, distinct climatic variability due to the nature of Bangladesh's tropical climate–characterised by high humidity, heavy precipitation and temperature variation – is linked to changes in transmission dynamics [7, 8, 9]. Unplanned urbanisation, overcrowding further contribute to the sustained transmission of HAV and HEV [10].

A nationwide surveillance reporting hepatitis A in approximately 19% of cases and hepatitis E in about 10% [11] and several existing research on acute HAV and HEV-related viral hepatitis from the country has primarily focused on clinical and demographic risk factors, often overlooking the precise influence that meteorological variables, particularly within the local context [12]. This knowledge gap is especially critical given Bangladesh's climate vulnerability from the effects of climate change in the coming years [13]. Despite the established endemicity of HAV and HEV, there remains a gap in understanding how their prevalence correlates with demographic and climatic variability in Dhaka city. The city's dense population and rapid urbanisation have created major public health challenges, including poor sanitation, unsafe street food practices, inadequate drainage, and air pollution—conditions that facilitate frequent disease outbreaks [10]. Addressing such issues are paramount for developing effective disease forecasting, outbreak preparedness and evidence-based public health interventions within the epidemiological landscape of the city. Therefore, this study aimed to explore the seroprevalence of acute HAV and HEV infections in Dhaka city, with the intention of gaining a better understanding of how weather conditions influence the transmission of hepatitis A and E in a crowded city with numerous health risks.

Methods

Study design and place

This was a laboratory-based retrospective observational study carried out at the Department of Virology, Bangladesh Medical University, Dhaka, using data from 2016 to 2023.

Study population

The study population comprised individuals with clinical suspicion of acute hepatitis from both outpatient and inpatient departments of the university hospital, whose blood samples were submitted for laboratory testing. The analysis was conducted using test results obtained from these blood specimens. A total of 19,542 and 23,249 specimens were tested for anti-HAV-IgM and anti-HEV -IgM, respectively, during the study period and the resulting serological data were utilised. The demographic profiles (age and gender) of the study populations were retrieved from the Laboratory Information System (LIS), and other details were kept anonymised to ensure patients' confidentiality.

Climatic data collection

The climate data of Dhaka city from January 2016 to December 2023 (average monthly temperature in °C, average monthly humidity %, and total monthly rainfall in mm) were collected from the climate and weather data portal of Bangladesh Meteorological Department (BMD), Agargaon, Dhaka 1207, Bangladesh and matched temporally to the laboratory testing results. For the seasonal analysis, they were classified into the following periods: Spring runs from mid-February to mid-April, summer from mid-April to mid-June, the rainy season from mid-June to mid-August, autumn from mid-August to mid-October, late autumn from mid-October to mid-December, and winter from mid-December to mid-February [14].

Statistical analysis

The collected data were rechecked, coded, and analysed using SPSS (version 21). Descriptive statistics were used to summarise demographic data, and age groups were categorised into ≤10 years, 11–20 years, 21–30 years, 31–40 years, 41–50 years and >50 years. A multivariable logistic regression model was constructed to identify predictors of HAV and HEV infections. The model included: demographic variables (age, gender), environmental variables (temperature, humidity, rainfall), and temporal variables (month and season). Significance was set at $P<0.05$. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated to estimate each variable's effect on the odds of infection.

Ethical considerations

All patient data were anonymised before analysis, and no personal identifiers were used during the interpretation of results.

Results

Between 2016 and 2023, a total of 19,542 and 23,249 suspected AVH patients were tested for anti-HAV-IgM and anti-HEV-IgM, respectively. Among these, 5,767

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Table 1 Patients' demographics and hepatitis A and E virus infection

Characteristics	Total samples (n)	Negative n (%)[a]	HAV infection n (%)[b]	HEV infection n (%)[b]	HAV and HEV infection n (%)[b]
	42791	32244 (75.3)	5767 (29.6)	4780 (20.5)	85 (0.6)
Gender[c]					
Male	29756	22369 (69.4)	3755 (65.1)	3632 (76.0)	62 (72.9)
Female	13035	9875 (30.6)	2012 (34.9)	1148 (24.0)	23 (27.1)
Age group in years[c]					
≤10	7198	4675 (14.5)	2183 (37.9)	340 (7.1)	10 (11.8)
11–20	10477	7046 (21.9)	2186 (37.9)	1245 (26.0)	41 (48.2)
21–30	10828	7990 (24.8)	898 (15.6)	1940 (40.6)	27 (31.8)
31–40	5539	4596 (14.3)	230 (4.0)	713 (14.9)	5 (5.9)
41–50	3786	3368 (10.4)	115 (2.0)	303 (6.3)	2 (2.4)
>50	4963	4569 (14.2)	155 (2.7)	239 (5.0)	0 (0)

[a]n= number of participants, % in bracket; [b]Total samples tested for HAV infection=19452, HEV infection=23249 and both HAV and HEV infection = 13997; [c]Percentages for the HAV, HEV and both (HAV and HEV) infection were calculated from the total tested samples, respectively. The percentages within the group in the gender and age categories were calculated.

(29.6%) tested positive for anti-HAV-IgM, and 4,780 (20.5%) for anti-HEV-IgM. A breakdown by gender showed that males accounted for the majority of positive cases in both infections. The prevalence of dual HAV and HEV infection was 85 (0.6%), with a male predominance of 72.9%. Age categorisation by each decade of life showed that anti-HAV-IgM was most frequently detected among younger individuals. In contrast, anti-HEV-IgM was predominantly observed among young adults, with the highest proportion (40.6%) occurring in the 21–30 age group. For dual infections, those aged 11 to 30 years were the most affected group (Table 1).

This study investigates the month-wise (Figure 1) and season-wise (Figure 2) infection patterns of HAV and HEV in relation to meteorological variables—temperature (°C), humidity (%), and rainfall (mm). Monthly analysis reveals that fluctuations in humidity coincide with both HAV and HEV (Supplementary Figure 1) cases, with HEV showing a stronger association. Both infections exhibit a proportional rise and fall throughout the year, with rainfall emerging as a key environmental driver. In July, the peak month, HAV and HEV cases reached 10% and 11%, respectively, alongside a rainfall level of 345 mm. HAV transmission was most prominent during the warmer months with moderate rainfall, particularly from July

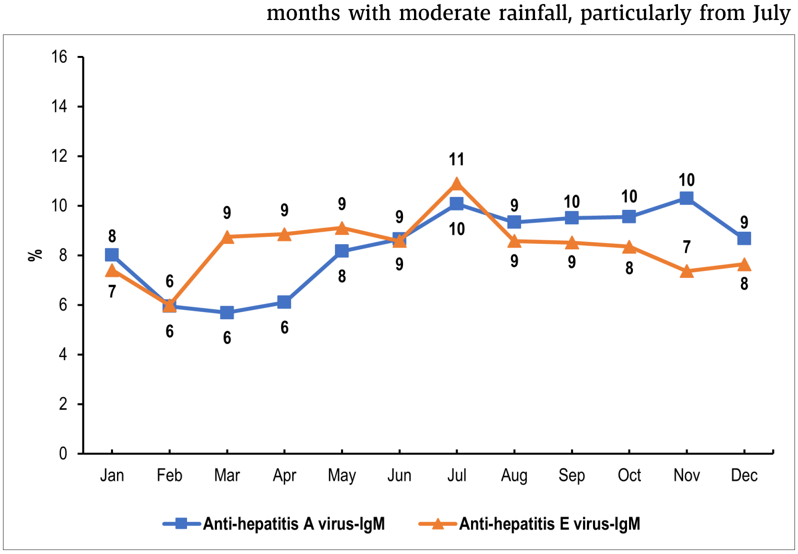

Figure 1 Monthly distribution of anti-hepatitis A virus-IgM and anti-hepatitis E virus-IgM positive among all the tested samples

to November, while HEV transmission peaked during months characterised by high humidity and precipitation, spanning March through September. Seasonal climatic analysis further affirmed these trends (Supplementary Figure 2). HAV infections were most prevalent in autumn (19%) and late autumn (20%), despite declining temperature (27.8°C), humidity (69.8%), and rainfall (62.3 mm). In contrast, HEV infections peaked during the summer (18%) and rainy season (19%), aligning with elevated humidity levels (75.6–78.7%) and high rainfall (287–289 mm).

A multivariable logistic regression model using continuous predictors identified several significant associations (Table 2). Demographic and temporal factors were identified as significant predictors of infection. Compared to males, females had slightly higher odds of HAV infection (OR 1.1; 95% CI 1.1–1.2) but were significantly less likely to test positive for HEV (OR 0.8; 95% CI 0.8–0.9). When age groups were compared against the reference category of ≤10 years, the odds of HAV infection declined with increasing age. However, HEV showed the opposite trend, with the 21–30 age group demonstrating the highest risk (OR 2.5; 95% CI 2.0–3.1). Temporal trends were also evident. Compared to January, the odds of HEV infection increased sharply between April and September, with the highest risks recorded in June (OR 15.5; 95% CI 11.6–20.7). HAV did not exhibit such pronounced monthly fluctuations, although the odds were lowest from February to May (P<0.05) compared to other months. In terms of seasons, late autumn was associated with significantly lower odds of HEV infection (OR 0.8; 95% CI 0.7–0.9), while no seasonal variation reached statistical significance for HAV.

Discussion

AVH, especially those caused by HAV and HEV represent a substantial global public health concern that disproportionately impacts low- and middle-income countries. In Bangladesh, the persistence of these viral infections is exacerbated by poor sanitation, unsafe water and unhygienic food practices, particularly due to the presence of unregulated street vendors and emerging climate variability. Bangladesh is one of the countries that will be most severely impacted by climate change. It is believed that climate factors may influence disease transmission dynamics– an area we aimed to investigate in this study for HAV and HEV. This study is the first of this kind from Bangladesh in observing the integration of laboratory-confirmed sero-prevalence data with temporal meteorological parameters like temperature, humidity and rainfall on an extensive dataset aimed to illuminate the interplay between environmental conditions and disease dynamics in an endemic setting from a dense population residing in a city.

Our findings regarding age and gender patterns in AVH cases align with previous reports. Consistent with earlier studies, we observed that HAV infections predominantly affected children and adolescents, whereas HEV infections were more common among young adults [2, 11]. A male predominance was noted for both viruses, although it was more pronounced for HEV. Previous studies have reported that males

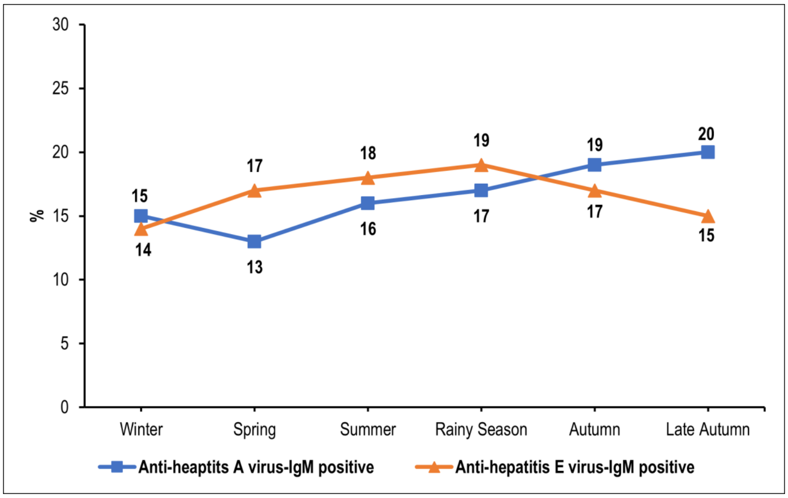

Figure 2 Seasonal distribution of anti-hepatitis A virus-IgM and anti-hepatitis E virus-IgM positive among all the tested samples

comprise approximately >60% of HAV cases and >70% of HEV cases [15, 16], findings that closely parallel our results. Additionally, prominent age- and gender-specific susceptibilities were observed, children and adolescents (≤20 years) were predominantly affected by HAV, while HEV was more common in young adults (21–30 years). Notably, males contributed to the majority of the positive cases for both viruses, possibly reflecting gender-based differences in exposure risks, such as outdoor occupations or dietary practices, due to their engagement in job-related activities [17]. Similar gender-age patterns were also observed in dually infected cases. Still, earlier studies have mentioned that it may have an impact on the prognosis of fulminant failure in some cases [18].

This study also demonstrates that climatic factors play a significant role in the transmission patterns of HAV and HEV. HAV infections peaked during the late autumn months, coinciding with moderate temperatures and humidity, while HEV incidence was highest during the rainy season characterised by peak precipitation and high moisture. Comparison with previous literature corroborates our findings. Earlier studies have shown a significant association between temperature and HAV infections. A positive association was observed, particularly in China [8, 19]. Sun *et al.* identified both positive and negative associations within different regions of China, emphasising the regional variation within the same country [20].

The complex interplay between temperature, human behaviour, sanitation systems and other environmental factors likely contributes to these variations in disease patterns across different geographical contexts. Previous studies have indicated that moderate humidity is conducive to HAV transmission, a finding that reflects our study [21, 22]. However, it might vary with different humidity [19, 20, 23]. Hepatitis A demonstrates notable seasonal variation across different geographical regions. Some observed spring and summer peaks [24], while others observed peaks during the rainy season [5, 8, 25]. Our study did not find any consistent seasonal association with HAV despite absolute cases peaking during late autumn.

Heavy rainfall and delayed wastewater clearance were significant factors for predicting the HEV incidence during the rainy season in our study. Similar observations were also made by many in different regions [24, 26, 27]. In China, HEV exhibits a high-incidence season in spring [28], while other studies report increased incidence during rainy seasons [29]. Recent research from the Democratic Republic of Congo found a strong association between HEV cases and the dry season, with significantly higher seropositivity [30]. These complex seasonal patterns underscore that effective HEV prevention requires consideration of the combined effects of multiple environmental factors rather than focusing on single variables.

As mentioned earlier, both HAV and HEV infections are transmitted through the faecal-oral route, exposing individuals of all ages to the same risk. Often, these infections spread from individuals who are asymptomatic or immune. In addition to transmission through contaminated food or water sources, other methods have been documented. HAV transmission was thought to occur from person to person, involving high-risk behaviours, such as sharing needles; this was not observed for HEV transmission. HEV is associated with transfusion-related transmission and can also infect the fetus when transmitted from the mother [31]. Due to the complex interplay of age, gender, climate, sanitation, hygiene practices, and viral genetic factors, predicting the transmission route and timing remains a challenging task.

Table 2 Odds ratios of factors linked to hepatitis A virus and hepatitis E virus infection in relation to patients' demographics, month and seasonal weather data (n=42791)

Characteristics	Odds ratio (95% confidence interval)	
	HAV infection[a]	HEV infection[a]
Gender		
Male	1	1
Female	1.1 (1.1–1.2)[a]	0.8 (0.8–1.0)[a]
Age group in years		
≤10	1	1
10–20	1.0 (0.9–1.1)	2.0 (1.8–2.4)[a]
21–30	0.5 (0.4–0.6)[a]	2.5 (2.0–3.1)[a]
31–40	0.4 (0.3–0.5)[a]	1.6 (1.2–2.1)[a]
41–50	0.4 (0.2–0.6)[a]	0.8 (0.6–1.3)
>50	0.7 (0.4–1.7)	0.4 (0.3–0.8)[a]
Month		
January	1	1
February	0.6 (0.5–0.7)[a]	2.8 (2.2–3.5)[a]
March	0.4 (0.3–0.5)[a]	8.3 (6.4–10.8)[a]
April	0.6 (0.5–0.8[a]	13.1 (10.1 –17.0)[a]
May	0.8 (0.6–1.0)[a]	13.7 (10.4–18.0)[a]
June	1.0 (0.8–1.3)	15.5 (11.6–20.7)[a]
July	1.0 (0.8–1.3)	14.5 (10.6–19.8)[a]
August	1.0 (0.8–1.3)	14.1 (10.5–18.9)[a]
September	0.9 (0.7–1.7)	13.1 (9.7–17.7)[a]
October	0.8 (0.7–1.0)	9.8 (7.6–12.8)[a]
November	0.9 (0.7–1.1)	4.4 (3.4–5.5)[a]
December	0.9 (0.8–1.1)	1.6 (1.4–2.0)[a]
Season[b]		
Winter (mid–December to mid–February)	1	1
Spring (mid–February to mid–April)	1.1 (1.0–1.3)	1.0 (0.9–1.2)
Summer (mid–April to mid–June)	1.1 (1.0–1.3)	1.0 (0.8–1.2)
Rainy Season (mid–June to mid–August)	1.0 (0.8–1.1)	1.1 (0.9–1.3)
Autumn (mid–August to mid–October)	1.1 (1.0–1.3)	0.9 (0.8–1.1)
Late Autumn (mid–October to mid–December)	1.1 (1.0–1.3)	0.8 (0.7–0.9)[a]

[a]$P<0.05$; [b]As per Bangla calendar (Winter: *Poush–Magh*; Spring: *Falgun–Chaitra*; Summer: *Boishakh–Joishtho*; Rainy Season: *Aashar–Shrabon*; Autumn: *Bhadro–Ashwin*; Late Autumn: *Kartik–Ograhayon*)

The strength of the study was its examination of a large number of individuals from Dhaka city, with data reported to a single tertiary care centre and analysed in relation to the local climate. However, this study had several limitations. First, the laboratory-based, hospital-centric, retrospective design of data collection from a single tertiary care hospital in Dhaka introduces selection bias, potentially omitting asymptomatic or mild cases that did not seek medical attention. Consequently, the data may not represent the general population and the findings might not be generalisable to the entire country. Second, the meteorological data collected on a city level may mask localised patterns of short-term, extreme weather events and hinder understanding of hyper-localised disease-climate interactions. Third, the study lacked data on potential confounders such as socioeconomic status, access to healthcare, sanitation practices, water source quality, HAV vaccination history, and environmental exposures like proximity to contaminated water bodies or flooding events. Lastly, we did not have access to viral genotype data which is a crucial factor in transmission dynamics, particularly for HEV.

Future research should focus on multicenter, community-based prospective studies with a representative cohort, the integration of high-resolution, localised meteorological data, a systematic assessment of key confounders, and the incorporation of viral genotyping to more accurately elucidate transmission dynamics.

Conclusion

This study confirms the high burden and endemic nature of both acute HAV and HEV infections throughout the year. More importantly, it provides strong evidence that climatic variability significantly impacts the occurrence of these infections. These findings highlight the vital need to incorporate climate data and demographic information into public health strategies seasonally, such as targeted awareness campaigns to promote hygienic practices or vaccinations for high-risk groups. Improving water safety and sanitation infrastructure, along with implementing climate-aware solutions, will be essential to reducing the burden of enteric hepatitis in Bangladesh.

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Author contributions

Conception or design of the work; or the acquisition, analysis, or interpretation of data for the work: SMRUI, AAM, AAMi, RA, MAB, SUM, AN. *Drafting the work or reviewing it critically for important intellectual content:* SMRUI, MAB, AN. *Final approval of the version to be published:* SMRUI, AAM, AAMi, RA, MAB, SUM, AN. *Accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved:* SMRUI, AAM, AAMi, MAB, AN.

Conflict of interest

We do not have any conflict of interest.

Data availability statement

We confirm that the data supporting the findings of the study will be shared upon reasonable request.

Supplementary file

Supplementary file 1: Hepatitis A and E infection based on temperature, humidity, and rainfall according to months and seasons

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