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Mapping Outbreaks in the Mountains: A Five-Year Epidemiological Surveillance Analysis of Communicable Disease Outbreaks in Himachal Pradesh, India

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Abstract **Background:** Communicable disease outbreaks remain a significant public health concern in hilly regions such as Himachal Pradesh, where environmental and seasonal factors influence transmission. This study aimed to analyse outbreak patterns over a five-year period (2021–2025) to understand their temporal, spatial and disease-specific distribution. **Methods:** A retrospective descriptive study was conducted using secondary data from the Integrated Disease Surveillance Programme (IDSP) for January 2021 to December 2025. Data on district, disease/illness, number of cases, deaths and time of occurrence were analysed. Descriptive epidemiological methods were applied to assess distribution by time, place and disease. Seasonal trends were evaluated by grouping months into four categories. Frequencies, proportions and percentage contributions were calculated. **Results:** A total of 34 outbreaks were reported, comprising 3,937 cases and 2 deaths. The highest number of outbreaks occurred in 2024 (17, 50.0%), accounting for the majority of cases (2,964) and all deaths. Acute diarrheal disease was the most common outbreak (18 outbreaks; 2,796 cases, 71.0%), followed by Hepatitis A (8 outbreaks; 702 cases, 17.8%). Dengue contributed 9.6% of cases, while HFMD and jaundice were minimal. Hamirpur (22.0%), Solan (20.6%) and Mandi (20.4%) together contributed over 60% of total cases. Most outbreaks occurred during monsoon (15 outbreaks; 1,478 cases) and post-monsoon periods (6 outbreaks; 1,208 cases), with peaks in November, October and June. **Conclusion:** Outbreaks were predominantly waterborne with clear seasonal clustering and geographic variation. Strengthening surveillance and targeted preventive measures are essential to reduce outbreak burden.

Key Words Outbreaks, Acute diarrheal disease, Hepatitis A, Dengue, Seasonality, Surveillance, Himachal Pradesh, IDSP, Public health, Epidemiology

INTRODUCTION

Outbreaks of communicable diseases remain a significant public health concern, particularly in geographically diverse and resource-constrained settings [1,2]. In hilly regions such as Himachal Pradesh, environmental factors, seasonal variations and challenges in water supply and sanitation contribute to the recurrent occurrence of infectious disease outbreaks [3,4]. Acute diarrheal diseases, vector-borne infections such as dengue and viral illnesses including Hepatitis A and hand, foot and mouth disease (HFMD) continue to impose a substantial burden on health systems and communities [1,5].

The epidemiology of outbreaks in such regions is often influenced by climatic conditions, especially during monsoon and post-monsoon periods, which facilitate the transmission of waterborne and vector-borne diseases. Despite routine surveillance activities, comprehensive analyses integrating temporal, spatial and disease-specific patterns of outbreaks remain limited. Understanding these patterns is crucial for strengthening early warning systems, optimizing resource allocation and implementing targeted preventive strategies [3,6,7].

Himachal Pradesh, characterized by varied topography and climatic heterogeneity, presents unique challenges in outbreak detection and control. Differences in population distribution, accessibility and infrastructure across districts further influence the magnitude and spread of outbreaks. However, there is a paucity of consolidated evidence examining district-wise, seasonal and disease-specific trends over time.

In this context, the present study aims to analyse reported outbreak events in Himachal Pradesh over a five-year period (2021–2025), focusing on their distribution by time, place and disease. The study seeks to identify patterns in outbreak occurrence, assess the relative burden of different diseases and highlight seasonal and geographical variations to inform evidence-based public health interventions.

METHODS

Study Design and Setting

A retrospective descriptive study was conducted using secondary outbreak surveillance data from Himachal Pradesh, India, for a five-year period (January 2021 to December 2025). The study focused on analysing outbreak events reported across districts of the state.

Data Source

Data were obtained from the publicly available outbreak reports of the Integrated Disease Surveillance Programme (IDSP), Ministry of Health and Family Welfare, Government of India. The IDSP is a decentralized, nationwide surveillance system that collects data on epidemic-prone diseases to enable early detection and response to outbreaks. Under IDSP, outbreak data are reported weekly by district surveillance units through an online reporting platform and compiled into weekly outbreak reports [8,9].

Data Collection and Variables

All outbreak entries reported from Himachal Pradesh during the study period were extracted from the IDSP portal. Each outbreak record included the following variables:

- District
- Disease/illness
- Number of cases
- Number of deaths
- Year and month of occurrence

Only outbreaks with complete information on the above variables were included in the analysis.

Case Definitions and Outbreak Reporting

Outbreaks were defined and reported as per IDSP guidelines. Surveillance data are routinely collected from health workers, clinicians and laboratories using standard case definitions for epidemic-prone diseases. Any unusual increase in cases or clustering of illness in a defined area is identified as an outbreak and investigated by Rapid Response Teams (RRTs) for confirmation and control measures.

Data Analysis

The data were compiled and analysed using Microsoft Excel. A descriptive epidemiological approach was adopted to examine the distribution of outbreaks in terms of time (year and month), place (district) and person (disease type). Frequencies and proportions were calculated for categorical variables and the total number of cases and deaths were summarized. Detailed analyses were performed to assess disease-wise, district-wise, year-wise and month-wise distributions of outbreaks. Seasonal trends were evaluated by grouping months into four categories: winter (December–February), pre-monsoon (March–May), monsoon (June–September) and post-monsoon (October–November). Additionally, the percentage contribution of individual districts and diseases to the overall case burden was determined. As the study was purely descriptive in nature, no inferential statistical tests were applied.

RESULTS

A total of 34 outbreak events were reported during 2021–2025, accounting for 3,937 cases and 2 deaths. The highest number of outbreaks occurred in 2024 (17), contributing the majority of cases (2,889) and all reported deaths. The number of outbreaks remained relatively stable during 2021–2023 (three outbreaks each year), followed by a marked increase in 2024 (17 outbreaks) and a subsequent decline in 2025 (8 outbreaks) (Figures 1 and 2).

District-wise distribution showed considerable heterogeneity in disease patterns. Acute diarrheal disease was the most widely distributed condition, reported across almost all districts, with the highest burden in Hamirpur (866 cases) and Solan (776 cases). Hepatitis A outbreaks were predominantly concentrated in Mandi (550 cases) and Kangra (84 cases). Dengue outbreaks were limited to a few

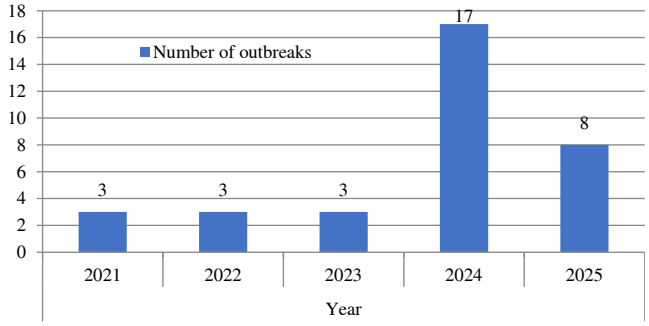

Figure 1: Reported outbreak events in the dataset (2021-2025)

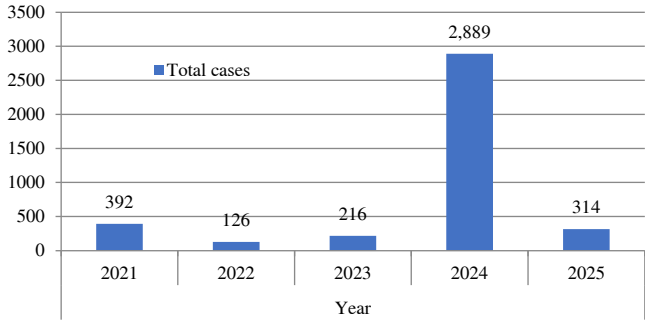

Figure 2: Total cases the reported outbreak events in the dataset (2021–2025)

Table 1: District-wise distribution of outbreak entries and total cases by disease (2021–2025)

District	Acute Diarrheal Disease n (cases)	Hepatitis A n (cases)	Dengue n (cases)	Jaundice n (cases)	HFMD n (cases)	Total outbreaks (n)	Total cases
Bilaspur	1 (309)	0 (0)	0 (0)	0 (0)	0 (0)	1	309
Hamirpur	5 (866)	0 (0)	0 (0)	0 (0)	0 (0)	5	866
Kangra	3 (332)	2 (84)	0 (0)	1 (20)	2 (22)	8	458
Kinnaur	1 (186)	0 (0)	0 (0)	1 (18)	0 (0)	2	204
Mandi	6 (254)	5 (550)	0 (0)	0 (0)	0 (0)	11	804
Shimla	0 (0)	1 (68)	1 (149)	0 (0)	0 (0)	2	217
Sirmaur	0 (0)	0 (0)	1 (156)	0 (0)	0 (0)	1	156
Solan	1 (776)	0 (0)	1 (34)	0 (0)	0 (0)	2	810
Una	1 (73)	0 (0)	1 (40)	0 (0)	0 (0)	2	113
Total	18 (2,796)	8 (702)	4 (379)	2 (38)	2 (22)	34	3,937

Table 2: Year-wise distribution of outbreak entries and cases by disease (2021–2025)

Year	Acute Diarrheal Disease n (cases)	Hepatitis A n (cases)	Dengue n (cases)	Jaundice n (cases)	HFMD n (cases)	Total outbreaks (n)	Total cases	Deaths
2021	2 (374)	0 (0)	0 (0)	1 (18)	0 (0)	3	392	0
2022	2 (92)	0 (0)	1 (34)	0 (0)	0 (0)	3	126	0
2023	2 (176)	0 (0)	0 (0)	0 (0)	0 (0)	3	176	0
2024	9 (2,080)	5 (559)	2 (305)	1 (20)	0 (0)	17	2,964	2
2025	3 (109)	2 (75)	1 (40)	0 (0)	2 (22)	8	246	0
Total	18 (2,796)	8 (702)	4 (379)	2 (38)	2 (22)	34	3,937	2

Table 3: Month-wise distribution of outbreak entries and total cases (2021–2025)

Month	Total outbreaks (n)	ADD n (cases)	Hepatitis A n (cases)	Dengue n (cases)	Jaundice n (cases)	HFMD n (cases)	Total cases
January	1	1 (112)	0 (0)	0 (0)	0 (0)	0 (0)	112
February	2	1 (26)	1 (68)	0 (0)	0 (0)	0 (0)	94
March	4	2 (395)	1 (88)	0 (0)	1 (18)	0 (0)	501
May	2	1 (73)	1 (59)	0 (0)	0 (0)	0 (0)	132
June	5	5 (784)	0 (0)	0 (0)	0 (0)	0 (0)	784
July	3	3 (164)	0 (0)	0 (0)	0 (0)	0 (0)	164
August	4	1 (45)	0 (0)	2 (305)	0 (0)	1 (4)	354
September	3	1 (47)	1 (25)	0 (0)	0 (0)	1 (18)	90
October	5	1 (40)	2 (410)	2 (74)	0 (0)	0 (0)	524
November	2	1 (776)	0 (0)	0 (0)	1 (20)	0 (0)	796
December	2	1 (415)	1 (41)	0 (0)	0 (0)	0 (0)	456
Total	34	18 (2,796)	8 (702)	4 (379)	2 (38)	2 (22)	3,937

districts, with Sirmaur reporting the highest number of cases (156). Kangra was the only district reporting HFMD outbreaks, while jaundice outbreaks were confined to Kangra and Kinnaur (Table 1).

Year-wise analysis (Table 2) revealed that 2024 had the highest number of outbreaks (17) and cases (2,964), including the only reported deaths (n=2). Acute diarrheal disease remained the predominant outbreak across all years, particularly contributing to the surge observed in 2024. Hepatitis A outbreaks were also notably higher in 2024, while dengue outbreaks were sporadic and limited to specific years. HFMD outbreaks were observed only in 2025, indicating a recent emergence in the dataset.

Month-wise distribution (Table 3) demonstrated a clear seasonal pattern of outbreaks. Acute diarrheal disease outbreaks were predominant during June and July, while Hepatitis A cases peaked during October and December. Dengue outbreaks were restricted to monsoon and post-monsoon months, particularly August and October. The highest case burdens were observed in November (796 cases), October (524 cases) and June, indicating clustering of outbreaks during monsoon and post-monsoon periods.

Seasonal grouping of outbreaks further highlighted the influence of climatic factors. The majority of outbreaks occurred during the monsoon season (15 outbreaks, 1,478 cases), followed by the post-monsoon period (6 outbreaks, 1,208 cases). Pre-monsoon and winter seasons contributed comparatively fewer outbreaks and cases. This distribution suggests a strong seasonal association of outbreaks, particularly with monsoon-related environmental conditions (Table 4).

Disease-wise analysis as Table 5 showed that acute diarrheal disease accounted for the majority of outbreaks (18, 52.9%) and cases (2,796, 71.0%). Hepatitis A contributed 17.8% of total cases and was the only disease associated with mortality (2 deaths). Dengue accounted for 9.6% of cases, while jaundice and HFMD contributed minimally to the overall burden. These findings indicate that water- and sanitation-related diseases were the predominant contributors to outbreak morbidity.

District-wise contribution to case burden (Table 6) revealed that Hamirpur (22.0%), Solan (20.6%) and Mandi (20.4%) together accounted for more than 60% of total cases. Mandi reported the highest number of outbreaks (n=11), whereas Solan, despite having only two outbreaks, contributed substantially to the total case burden, indicating larger outbreak sizes. This variation suggests differences in outbreak frequency and magnitude across districts.

Table 4: Seasonal grouping of outbreaks

Season	Months included	Number of outbreaks	Total cases
Winter	Dec–Feb	5	662
Pre-monsoon	Mar–May	8	589
Monsoon	Jun–Sep	15	1,478
Post-monsoon	Oct–Nov	6	1,208
Total	—	34	3,937

Table 5: Disease-wise burden and proportion of total cases (2021–2025)

Disease/Illness	Number of outbreaks	Total cases	Percentage of total cases	Deaths
Acute Diarrheal Disease	18	2,796	71.0	0
Hepatitis A	8	702	17.8	2
Dengue	4	379	9.6	0
Jaundice	2	38	1.0	0
HFMD	2	22	0.6	0
Total	34	3,937	100	2

Table 6: District-wise contribution to total case burden and outbreak frequency (2021–2025)

District	Number of outbreaks	Total cases	Contribution %
Hamirpur	5	866	22.0
Solan	2	810	20.6
Mandi	11	804	20.4
Kangra	8	458	11.6
Bilaspur	1	309	7.8
Shimla	2	217	5.5
Kinnaur	2	204	5.2
Sirmaur	1	156	4.0
Una	2	113	2.9
Total	34	3,937	100

DISCUSSION

The present study provides a comprehensive assessment of outbreak patterns in Himachal Pradesh over a five-year period (2021–2025), revealing important insights into the temporal, spatial and etiological dynamics of communicable disease outbreaks in a geographically diverse, hilly setting. One of the most notable findings is the substantial surge in outbreaks during 2024, which alone accounted for 50% of all reported events and a disproportionately high share of the total case burden. This sharp increase may reflect a combination of factors, including heightened surveillance sensitivity under the Integrated Disease Surveillance Programme (IDSP), environmental and climatic variations and the occurrence of large, clustered outbreaks—particularly of acute diarrheal disease and Hepatitis A. The fact that all reported deaths occurred during this year further emphasizes the public health significance of outbreaks in this period and highlights the need for strengthened outbreak preparedness and response mechanisms.

Acute diarrheal disease emerged as the dominant contributor to both outbreak frequency and case burden, accounting for over 70% of total cases and being reported across nearly all districts. This widespread distribution underscores the persistent vulnerability of the region to waterborne diseases, likely driven by challenges in ensuring safe drinking water, sanitation and hygiene, especially in rural and hard-to-reach areas. The hilly terrain of Himachal Pradesh, combined with seasonal disruptions such as heavy rainfall, can compromise water supply systems and facilitate contamination, thereby increasing the risk of diarrheal outbreaks. The consistently high burden across multiple districts suggests that these are not isolated events but rather indicative of systemic environmental and infrastructural determinants.

Hepatitis A was identified as the second most significant contributor to outbreak burden and the only disease associated with mortality in the dataset. The concentration of Hepatitis A outbreaks, particularly in Mandi and Kangra districts and their clustering during specific months point toward localized transmission dynamics, potentially linked to contaminated water sources and inadequate sanitation practices. The occurrence of large outbreaks, including one with substantial case numbers and associated deaths, highlights the potential severity of Hepatitis A in susceptible populations and underscores the importance of preventive measures such as ensuring water safety, improving hygiene and considering vaccination strategies in high-risk areas.

Dengue outbreaks, although fewer in number, demonstrated a clear seasonal and geographic pattern. These outbreaks were confined to specific districts and predominantly occurred during the monsoon and post-monsoon periods, which are conducive to vector breeding. This observation aligns with established epidemiological patterns of dengue transmission, where increased rainfall and humidity create favourable conditions for Aedes mosquito proliferation. The relatively limited geographic spread of dengue in this study may reflect ecological constraints, variations in vector density or differences in urbanization and population movement across districts.

The temporal analysis revealed a pronounced seasonal trend, with a higher concentration of outbreaks during the monsoon (June–September) and post-monsoon (October–November) periods. Together, these seasons accounted for the majority of outbreaks and cases, highlighting the strong influence of climatic factors on disease transmission. Monsoon-related flooding and water stagnation can lead to contamination of drinking water sources, thereby increasing the incidence of waterborne diseases such as acute diarrheal disease and Hepatitis A. In the post-monsoon period, residual environmental conditions may sustain transmission, while vector populations remain elevated, contributing to continued risk of both waterborne and vector-borne diseases. The observed peaks in case burden during October and November further reinforce the extended impact of these seasonal dynamics.

Spatial heterogeneity in outbreak distribution was another important finding of this study. Mandi district reported the highest number of outbreaks, indicating a higher frequency of outbreak events, whereas Hamirpur and Solan contributed disproportionately to the total case burden. Notably, Solan, despite reporting only two outbreaks, accounted for a substantial proportion of cases, suggesting the occurrence of large-scale outbreaks. This disparity between outbreak frequency and magnitude highlights the need to consider both indicators when assessing disease burden. The observed geographic variation may be influenced by differences in population density, environmental conditions, healthcare infrastructure, surveillance efficiency and community practices across districts [8].

The detection of HFMD exclusively in Kangra and only during the later years of the study period suggests either an emerging epidemiological trend or improved case detection and reporting. Although HFMD contributed minimally to the overall burden, its presence indicates the evolving nature of disease patterns and the importance of maintaining robust surveillance systems capable of identifying emerging infections.

Overall, the findings of this study underscore the predominance of waterborne diseases, the critical role of seasonal and environmental factors and the uneven geographic distribution of outbreaks in Himachal Pradesh. These observations highlight the need for a multifaceted public health approach that includes strengthening water, sanitation and hygiene (WASH) interventions, enhancing vector control measures and improving surveillance and rapid response systems. Targeted, district-specific strategies, particularly during high-risk seasons, may be essential for mitigating the impact of outbreaks and reducing the overall disease burden in the region [9].

CONCLUSIONS

In conclusion, this study highlights the substantial burden and distinct epidemiological patterns of communicable disease outbreaks in Himachal Pradesh over a five-year period. Acute diarrheal disease emerged as the predominant outbreak, while Hepatitis A contributed significantly to morbidity and was associated with mortality. A marked increase in outbreaks was observed in 2024, along with a clear seasonal clustering during monsoon and post-monsoon periods. Spatial heterogeneity was evident, with certain districts contributing disproportionately to outbreak frequency and case burden. These findings underscore the interplay of environmental, seasonal and infrastructural factors in shaping outbreak dynamics in hilly regions. Strengthening surveillance systems, improving water and sanitation conditions and implementing targeted, season-specific interventions are essential to reduce the burden of outbreaks and enhance public health preparedness.

Recommendations

Based on the findings, several key recommendations can be proposed. Strengthening the Integrated Disease Surveillance Programme at the district level, particularly in high-burden areas, is essential to ensure timely detection and response to outbreaks. Focused efforts should be directed toward improving water quality, sanitation infrastructure and hygiene practices, especially before and during the monsoon season. Regular monitoring and maintenance of water supply systems, along with community-based interventions such as health education and behaviour change communication, should be prioritized. Vector control measures need to be intensified in districts prone to dengue outbreaks, particularly during and after the monsoon period. Capacity building of healthcare workers, strengthening laboratory diagnostic facilities and ensuring rapid deployment of response teams will enhance outbreak management. Additionally, consideration may be given to preventive strategies such as targeted vaccination for Hepatitis A in high-risk populations. Finally, integrating environmental and climatic surveillance with disease surveillance could improve early warning systems and facilitate proactive public health action.

Limitations

The present study has certain limitations that should be considered while interpreting the findings. Firstly, the analysis was based on secondary data obtained from the IDSP portal, which is dependent on the accuracy, completeness and timeliness of reporting by district surveillance units. Underreporting or delayed reporting of outbreaks, particularly from remote and hard-to-reach areas, cannot be ruled out. Secondly, the study relied on aggregated outbreak-level data, which limited the ability to perform detailed individual-level analyses, including demographic characteristics, risk factors and clinical outcomes. Thirdly, laboratory confirmation details and classification of cases (suspected, probable, confirmed) were not uniformly available, which may affect the precision of disease categorization. Additionally, the absence of denominator population data precluded the calculation of incidence rates and risk comparisons across districts. Finally, as a descriptive study, causal inferences could not be established and potential confounding factors such as environmental conditions, socio-economic determinants and health system variations were not directly assessed.

Clinical and Public Health Implications

The findings of this study have important clinical and public health implications. The predominance of acute diarrheal disease and Hepatitis A highlights the critical need for strengthening water quality monitoring, sanitation infrastructure and hygiene practices, particularly in vulnerable and high-burden districts. Clinicians should maintain a high index of suspicion for waterborne diseases during monsoon and post-monsoon periods, facilitating early diagnosis and timely management to prevent complications and mortality. The observed seasonal clustering of outbreaks underscores the importance of pre-emptive preparedness, including stockpiling essential supplies, strengthening laboratory capacity and enhancing Rapid Response Team (RRT) readiness during high-risk periods. Furthermore, the identification of districts with high outbreak frequency or large outbreak size provides an opportunity for targeted interventions, focused surveillance and resource prioritization. Strengthening community awareness, early reporting mechanisms and intersectoral coordination will be essential to mitigate the impact of future outbreaks.

Acknowledgement

The authors acknowledge the Integrated Disease Surveillance Programme (IDSP), Ministry of Health and Family Welfare, Government of India, for providing publicly accessible outbreak data.

Ethical Statement

The study utilized secondary data available in the public domain without any personal identifiers; therefore, ethical approval was not required.

The data used in this study are publicly available from the Integrated Disease Surveillance Programme (IDSP) portal and can be accessed through the official website of the Ministry of Health and Family Welfare, Government of India. "https://idsp.mohfw.gov.in/index4.php?lang=1&level=0&linkid=406&lid=3689".

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