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Tainted Tables in India: Environmental Risks and Challenges of Foodborne Disease Prevalence

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ABSTRACT

Foodborne diseases continue to pose a significant public health challenge in India, affecting diverse regions and populations. This study examines reported foodborne illness outbreaks between January 2023 and March 2025 using secondary data from the Integrated Disease Surveillance Program (IDSP). The analysis is structured around the Epidemiological Triangle framework, encompassing agent, host, and environmental factors. Bacterial pathogens, particularly *Salmonella* and *E. coli*, were identified as the most common causative agents, followed by viral and parasitic infections. Host-related vulnerabilities were prominent among children, elderly individuals, and residents of rural or low-income communities. Environmental contributors, including poor sanitation, unsafe water, improper food handling, and seasonal influences, were found to significantly increase

outbreak risk. The findings underscore key trends and contributing factors that can inform targeted public health interventions and policy decisions aimed at reducing the incidence of foodborne diseases in India.

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Introduction

Foodborne illnesses remain a major public health concern in India, yet they often go unnoticed in national health data. These illnesses can originate from various sources, including street food, home-cooked meals, and products sold by small local vendors. Several factors contribute to the risk, such as unsafe water, poor food storage conditions, and inadequate hygiene during food handling. Despite the large number of people affected each year, many cases are never formally documented due to weak surveillance systems and underreporting (Joshi et al., 2024). The Centers for Disease Control and Prevention (CDC) defines an outbreak as the occurrence of more cases of a disease than expected within a specific population or area over a certain period (CDC, 2023).

This study uses the Epidemiological Triangle as a framework to explore how and why these illnesses continue to spread. The model considers three interconnected elements: the agent (the microorganism that causes disease), the host (the person who becomes ill), and the environment (the conditions that allow transmission). By examining the relationships between these factors, we can begin to understand the complex nature of foodborne disease outbreaks.

The first component of the model, the agent, refers to pathogens such as *Salmonella* and *Staphylococcus aureus*, which are commonly found in raw meat and traditional foods across India. Many of these microorganisms have developed resistance to commonly used antibiotics, making them harder to treat and more dangerous to public health (Das et al., 2024; Zende et al., 2025). It is important to understand how these pathogens enter the food supply and how they are passed from one source to another.

The second element, the host, includes individuals affected by foodborne illnesses. Some people are more vulnerable than others, like older adults, individuals with chronic illnesses such as diabetes or hypertension, and those with limited access to clean and safe food are at higher risk. Personal habits and

socioeconomic factors, including hygiene practices and the ability to afford safer food, also play a role in determining who gets sick.

The final element, the environment, looks at the broader setting where food is produced, sold, and consumed. In many parts of the country, especially in crowded urban or peri-urban areas, food is prepared and sold in informal settings without access to clean water, proper waste management, or refrigeration. These conditions, combined with hot weather, pollution, and inconsistent enforcement of food safety standards, create an environment where harmful bacteria and viruses can thrive (Hossain & Habib, 2023; Shenoy et al., 2025).

This study aims to identify the root causes behind the continued burden of foodborne illness in India by bringing together insights from all three components of the Epidemiological Triangle. The goal is to inform practical, evidence-based strategies to improve food safety, raise public awareness, and guide policies protecting vulnerable communities' health.

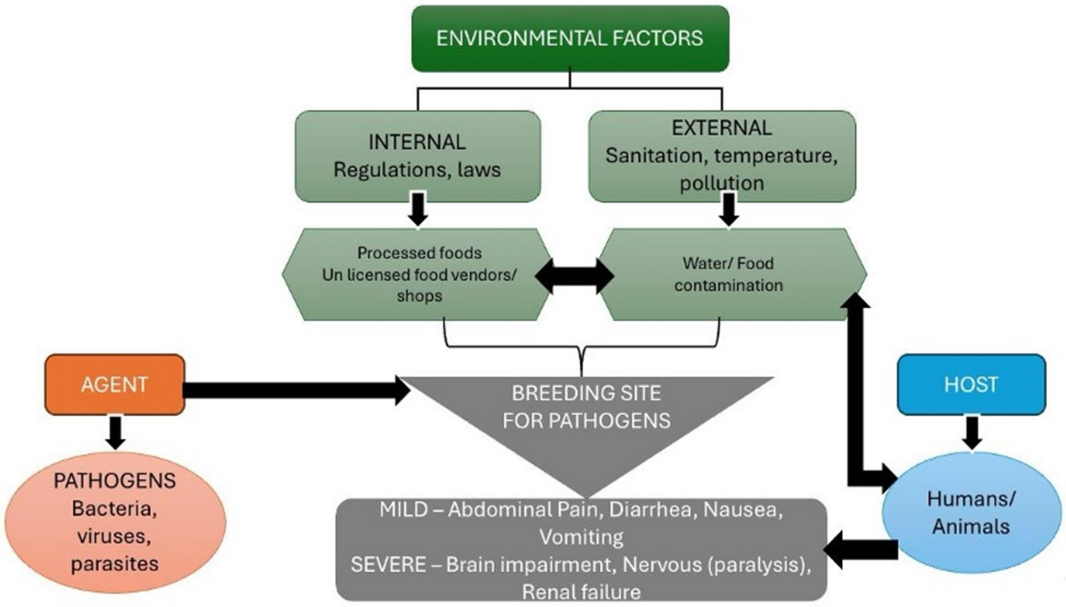
Objective

The primary goal of this epidemiological study is to use the epidemiological triangle model to assess the environmental challenges of foodborne diseases among State populations in India. We aim to describe the interactions between the host, agent, and environment in understanding how foodborne diseases spread and affect Indian populations. This study is crucial because it focuses on gaps in existing research. While some studies have explored foodborne diseases in India, there is limited research on how **s**treet food vendors, local markets, and environmental conditions contribute to the spread of these illnesses. This will help with timely interventions, improve food safety awareness among consumers and food vendors, implement better food safety regulations, and develop effective public health strategies and policy reforms.

Conceptual Framework

The conceptual framework in Figure 1 illustrates how environmental factors contribute to the spread of pathogens and their impact on human and animal health. Environmental factors are divided into two categories- internal and external. Internal factors refer to human-made regulations and policies, such as food safety laws and licensing of food vendors. When these regulations are weak or not enforced, processed foods and unlicensed vendors can contribute to contamination. On the other hand,

external factors include natural and environmental conditions like sanitation, temperature, and pollution. Poor sanitation and high temperatures create ideal conditions for the growth of bacteria, viruses, and parasites. When these factors come together, they create a breeding ground for pathogens. Contaminated food and water become carriers of harmful microorganisms, which can infect humans and animals when consumed. Once these pathogens enter the body, they cause different levels of illness. Mild symptoms include abdominal pain, diarrhea, nausea, and vomiting. However, in severe cases, infections can lead to brain impairment, paralysis, and kidney failure, which can be life-threatening. To prevent the spread of foodborne and waterborne diseases, it is essential to strengthen food safety regulations, improve sanitation, and monitor food vendors to ensure they follow hygiene standards. Educating people about safe food handling and clean water consumption is also crucial. This framework helps us understand how environmental conditions and food safety policies directly impact public health. Addressing these factors can significantly reduce the risk of disease outbreaks and protect humans and animals.



Methods

Data Collection

This research uses the epidemiological study design to examine trends and patterns of foodborne disease cases reported in India. From secondary data of IDSP, this research attempts to determine the foodborne disease outbreaks by states and union territories in India. This research deploys an

observational design where accessible data are used to make inferences without manipulating the variables. A foodborne disease outbreak is the occurrence of ≥2 cases of a similar illness resulting from ingesting a common food (Bennett et al., 2018). This report focuses on the foodborne outbreaks in 2023, 2024, and the first six weeks of 2025.

Statistics from the Ministry of Health and Family Welfare's Integrated Disease Surveillance Program (IDSP) department's website were collected. The statistics provide reported cases of foodborne disease over a few years for Indian union territories and states. Data were exported from Microsoft Excel with variables that ranged across years, state/UT, number of outbreaks, and number of people affected, where relevant. IDSP creates grass-roots level real-time surveillance data and thus provides a good platform for making inferences regarding India's foodborne disease-related public health trends (IDSP, 2025).

Classification of the epidemiological triangle

The dataset was systematically analyzed using the Epidemiological Triangle model, which examines the interaction between three core elements: environmental risk factors, host characteristics, and pathogen agents. Environmental risk factors were classified into three major categories: (1) water and food sanitation practices, (2) the presence and enforcement of food safety laws and regulations, and (3) climatic variables such as temperature, humidity, and seasonal changes. Each reported outbreak was reviewed and categorized based on these contributing environmental conditions. The second component of the model, host characteristics, encompasses demographic variables, dietary behaviours, and the presence of pre-existing health conditions that may increase susceptibility to foodborne illnesses. Lastly, the pathogen agent's category included all identified causative organisms, such as bacteria, viruses, and other microbial agents responsible for the reported outbreaks.

Results

Figure 2: Hepatitis A & E cases among the 12 states in 2023.

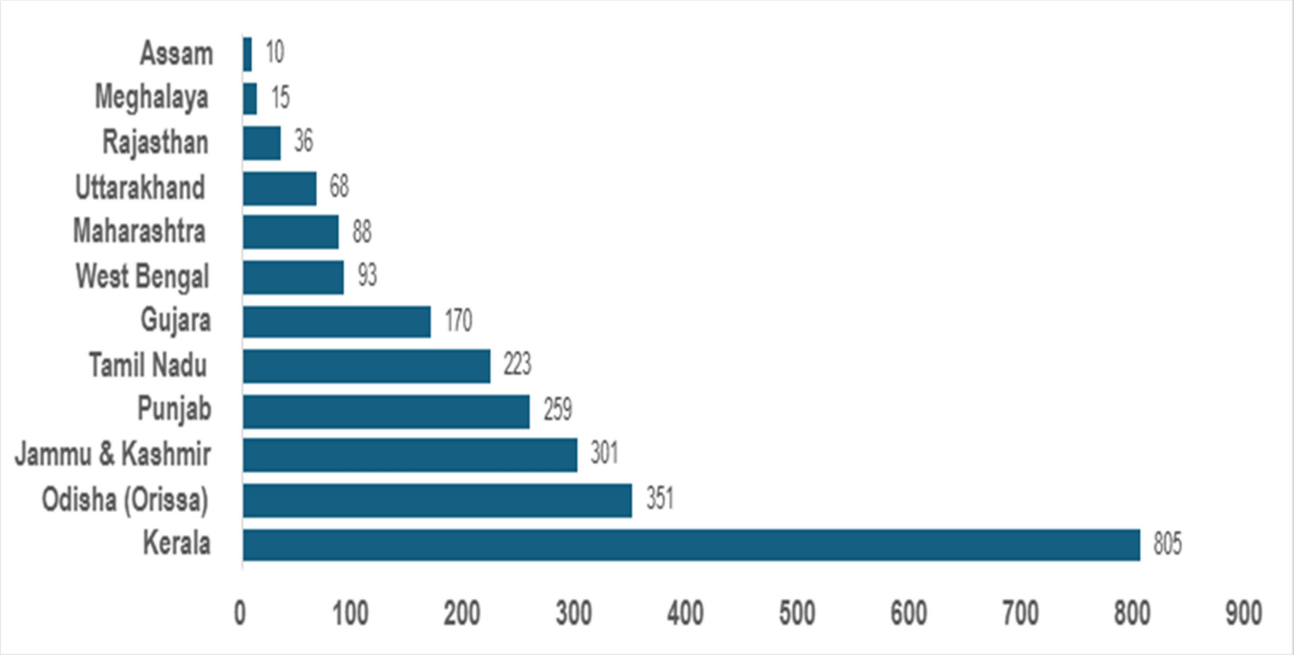


Table 1: Prevalence Rate of Hepatitis A & E in the two states with the highest cases in 2023.

Prevalence Rate	
Kerala	2.25
Odisha	0.73

Figure 2 and Table 1 illustrate that Hepatitis A and E cases are more prominent in Kerala, with 805 cases, with a prevalence rate of 2.25%, 2-3 cases per 100,000 population in 2023. Odisha recorded 351 cases with prevalence rate of 0.73% that is 1 per 100,000 population in the year 2023 due to environmental factors such as inadequate water and food sanitation, poor hygiene practices that is inadequate handwashing and food preparation, demographic factors such as Odisha and Kerala are coastal areas that are susceptible to floods and cyclones leading to contamination.

Figure 3: Illustrates the number of Hepatitis A & E cases among the 16 states in 2024.

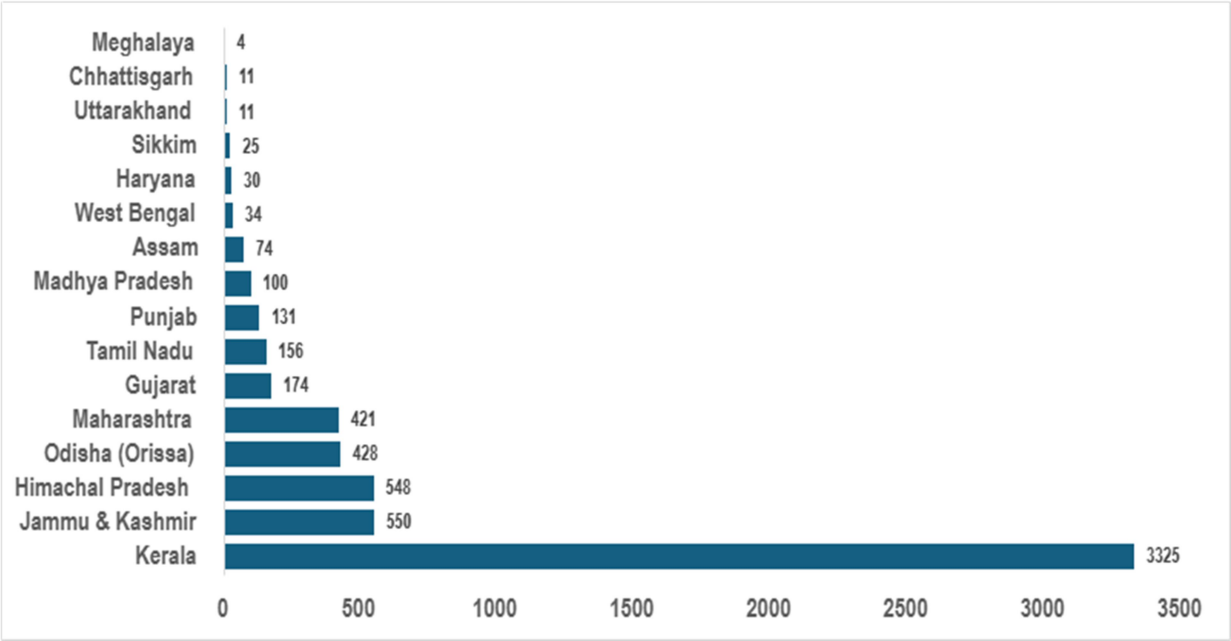
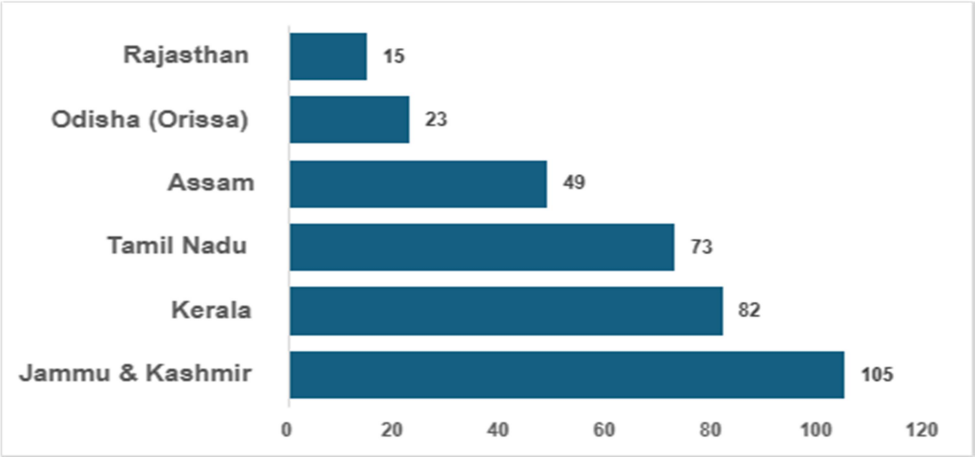


Table 2: Prevalence Rate of Hepatitis A & E in the two states with the highest cases in 2024

Prevalence Rate	
Kerala	9.45
Jammu & Kashmir	3.48

Figure 3 and Table 2 illustrates Hepatitis A and E cases are more prominent in Kerala with 3,325 cases with 9.45% prevalence rate that is 9 cases per 100,000 population in year 2024 with external environmental factors like lack of water and food sanitation and internal environmental factors like lack of food safety laws and regulations for food vendors and host factors such as demographics as Kerala is costal place and dietary habits like undercooked seafood. Jammu and Kashmir reported 550 cases with a prevalence rate of 3.46, 3-4 cases per 100,000 population, with external environmental factors such as the monsoon season, with floods causing the contamination of water and food, and a lack of hygiene practices.

Figure 4: Hepatitis A & E cases among the six states in 2025.



The causal agents for Figures 2, 3, and 4 are the Hepatitis A Virus (HAV) and the Hepatitis E Virus (HEV). HAV is more prominent in children and young adults, and HEV is more prominent in older populations.

Figure 5: Acute Diarrheal Disease among the 29 states in 2023.

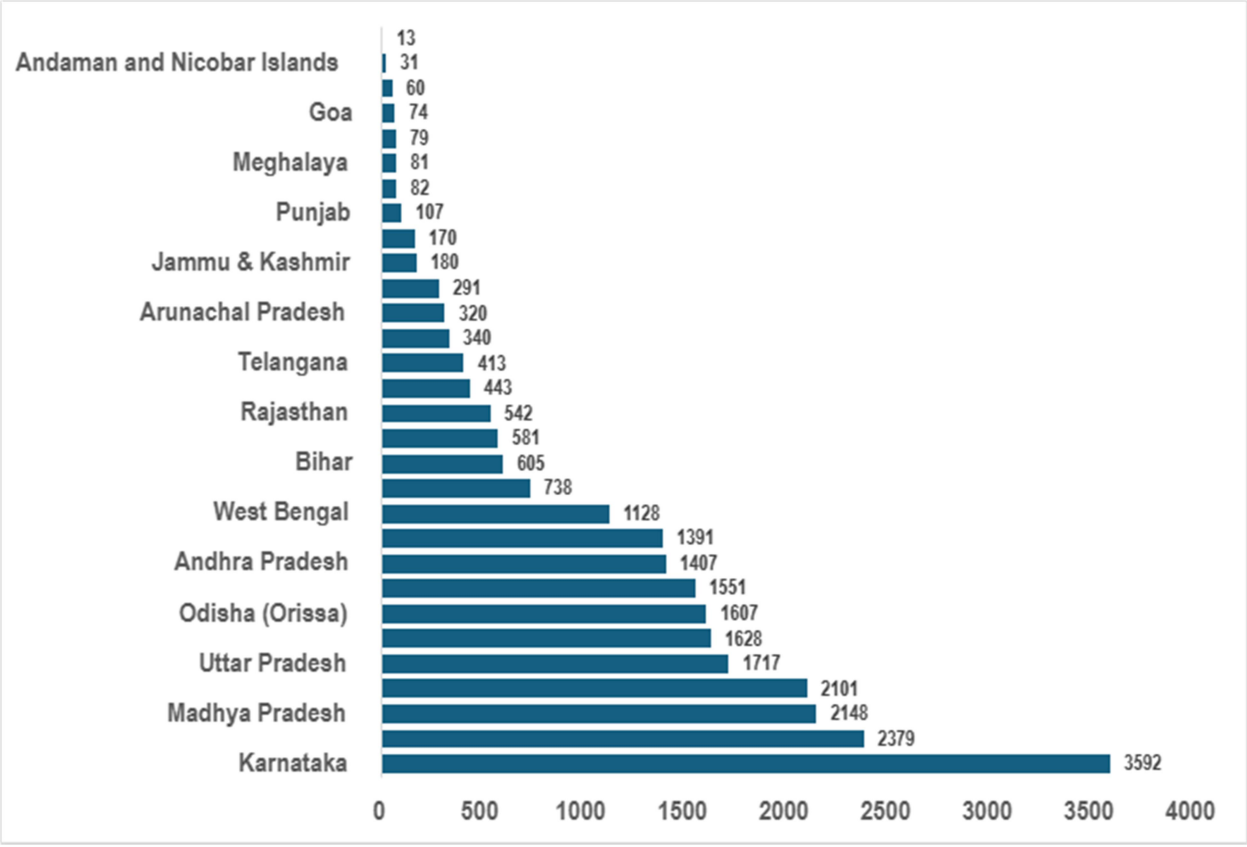


Table 3: Prevalence Rate of Acute Diarrheal Diseases in the two states with the highest cases in 2023

Prevalence Rate	
Karnataka	5.31
Chhattisgarh	7.92

Figure 5 and Table 3 illustrate that Karnataka has reported 3592 cases with a prevalence rate of 5.31%, equating to 5-6 cases per 100,000 population in the year 2023. Contributing environmental factors include inadequate hygiene practices, contaminated food and water due to a lack of proper sanitation, and seasonal changes such as rising temperatures. The causative agents are Vibrio cholerae, rotavirus, and Cryptosporidium. Chhattisgarh has 2,379 cases with a prevalence rate of 7.92%, corresponding to 7-8 cases per 100,000 population. Environmental factors include inadequate sanitation and hygiene practices, like handwashing, leading to the contamination of food and water, along with seasonal variations such as a warmer climate, which is more prone to bacterial contamination, and a cooler climate, which favors viral contamination. Host factors, including underlying conditions such as malnutrition, make patients more susceptible to ADD. The causative agents are E. coli, salmonella, and rotavirus.

Figure 6: Acute Diarrheal Disease cases among the 24 states in 2024

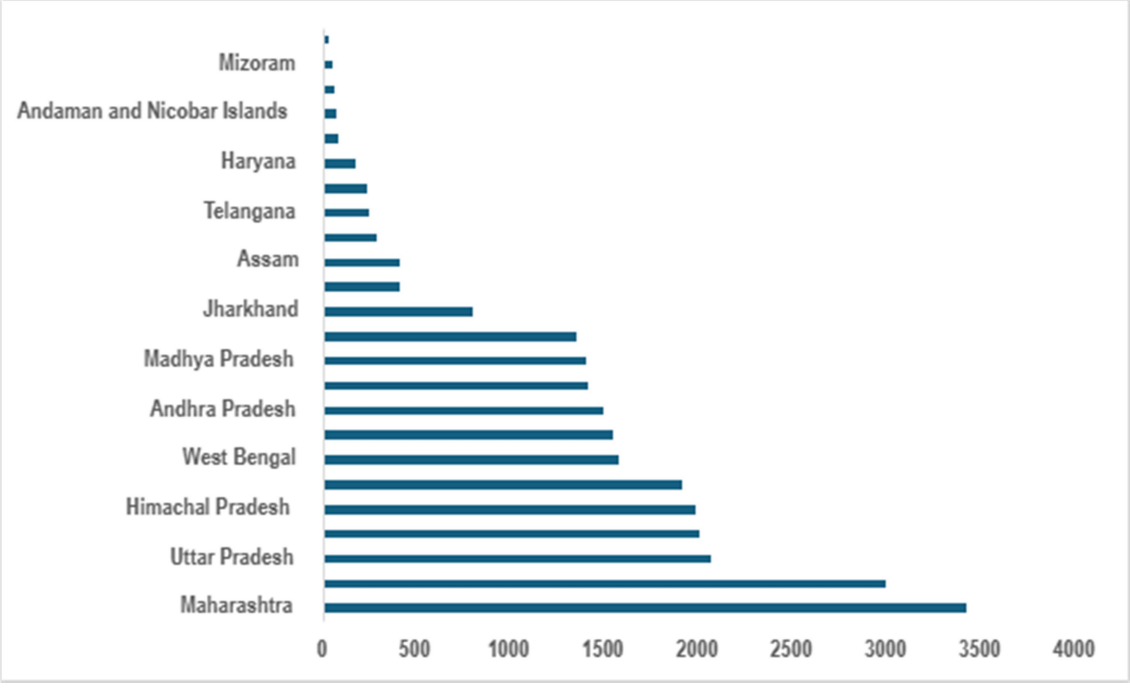


Table 4: Prevalence Rate of Acute Diarrheal Diseases in the two states with the highest cases in 2024.

prevalence Rate	
Maharashtra	2.57
Gujarat	4.06

Figure 6 and Table 4 illustrate that Maharashtra reported 3413 cases with a prevalence rate of 2.57%, equating to 2-3 cases per 100,000 population. Contributing environmental factors include seasonal changes, heavy rainfall, flooding, and large gatherings with poor hygiene and inadequate sanitation, all of which lead to contamination and breeding sites for organisms. Moreover, Gujarat reported 2986 cases with a prevalence rate of 4.06%, or 4 cases per 100,000, influenced by poor sanitation, lack of surveillance, and insufficient food safety awareness, and seasonal changes such as floods and droughts, which also contribute to an increase in diarrheal diseases. The main causative agents are Shigella and Vibrio cholerae.

Figure 7: Illustrates the number of cases of Acute Diarrheal Disease among the 13 states in 2025.

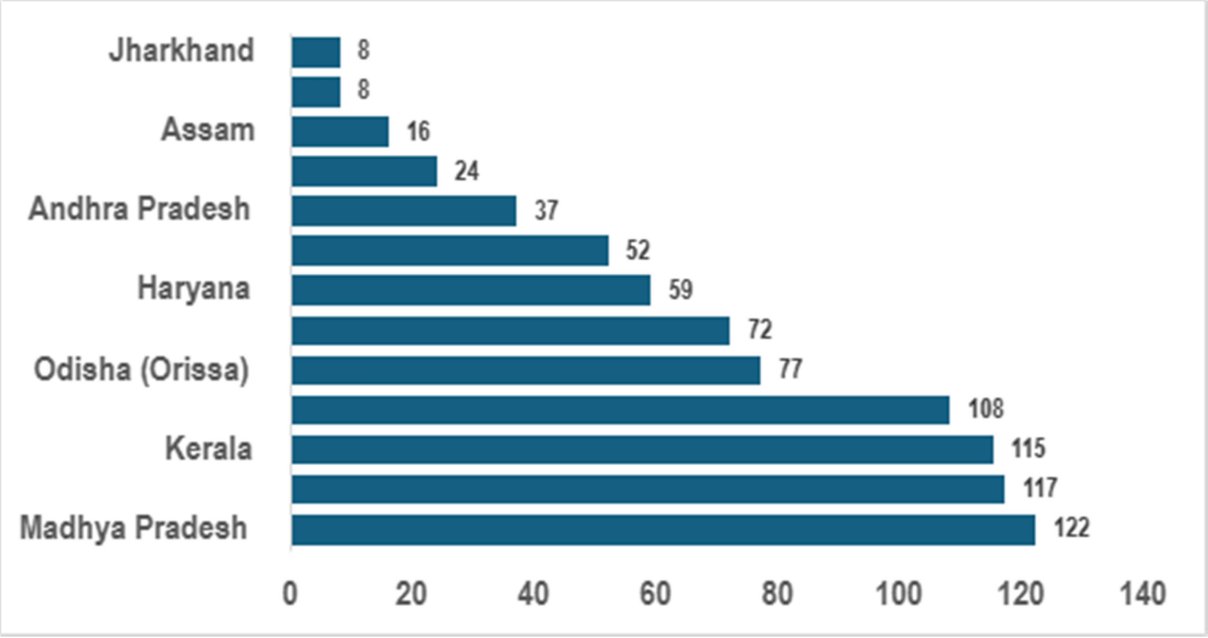


Figure 8: Number of cases of Cholera among the 15 states in 2023.

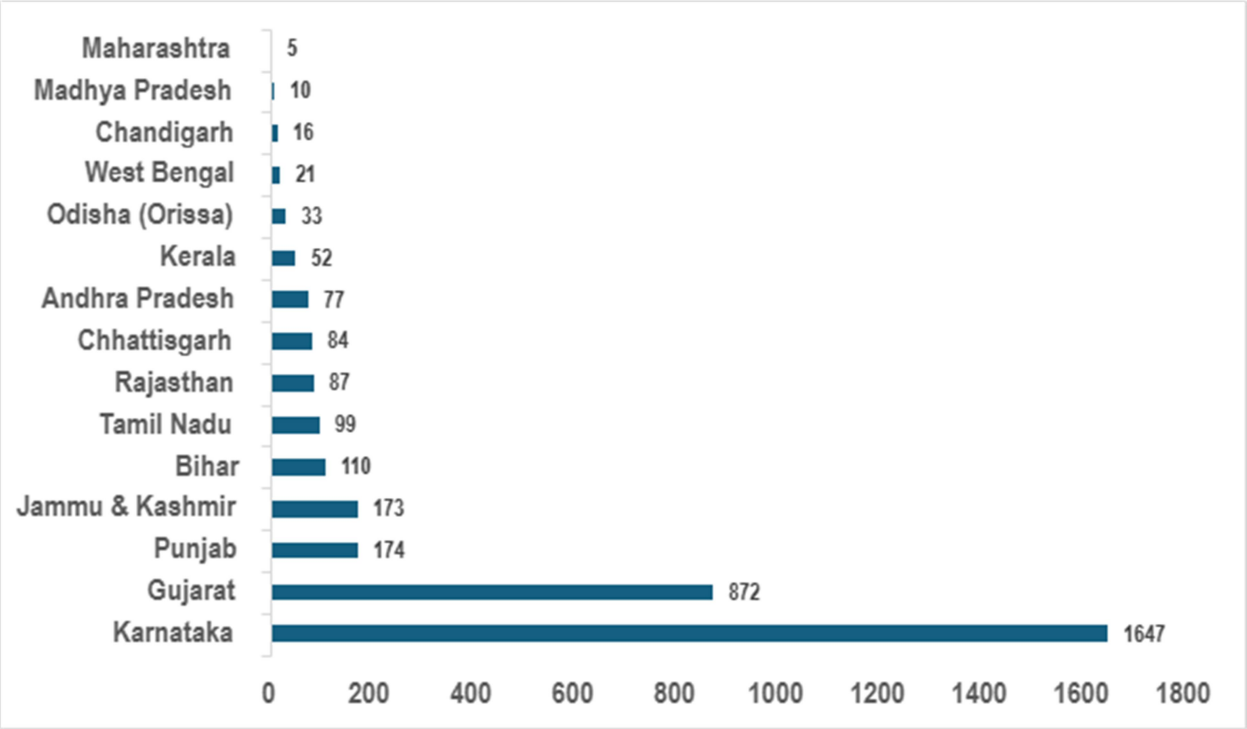


Table 5: Prevalence Rate of Cholera in two states with highest cases in 2023.

Prevalence Rate	
Karnataka	2.43
Gujarat	1.23

Figure 9: Illustrates the number of cases of Cholera among the 17 states in 2024.

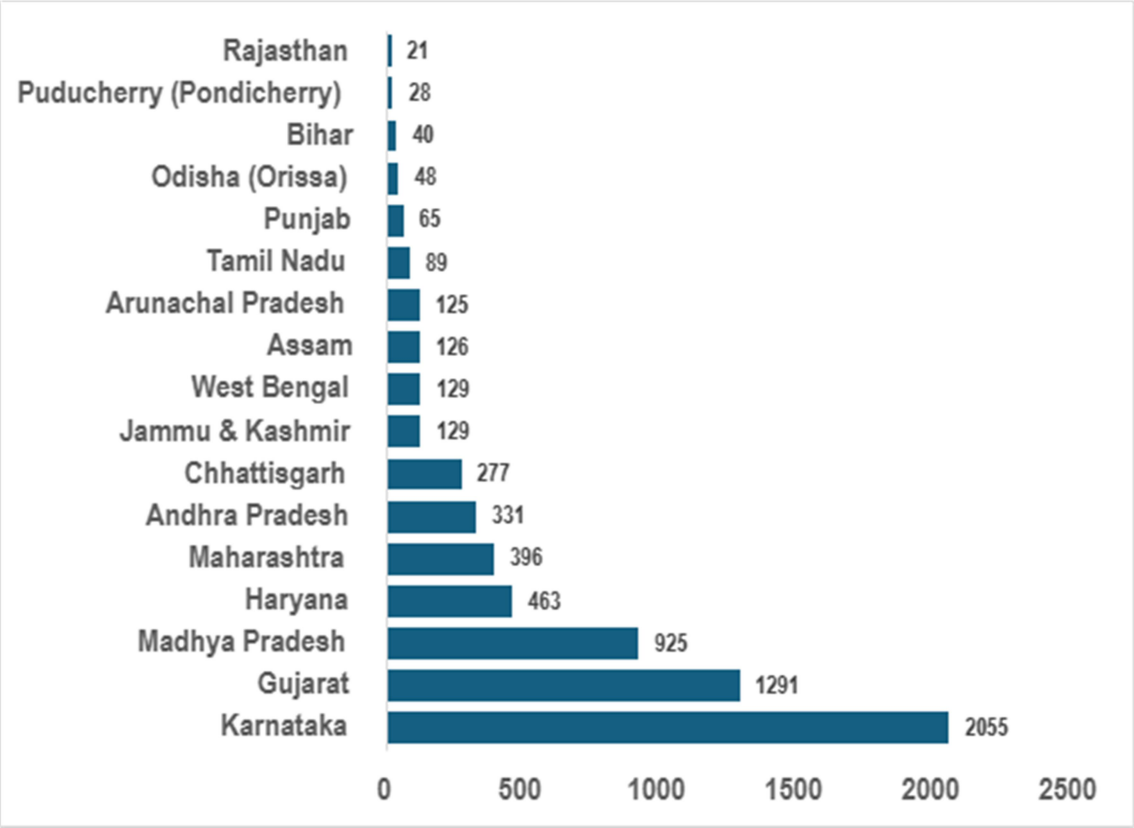


Table 6: Prevalence Rate of Cholera in two states with highest cases in 2024.

Prevalence Rate	
Karnataka	2.84
Gujarat	1.81

Figure 8, 9 and Table 5, 6 illustrates Karnataka has reported 1647 cases with prevalence rate of 2.43% that is 2-3 cases per 100,000 population in 2023 and 2055 cases in 2024 with prevalence rate of 2.84% in 2024, showing Karnataka being in top place in reporting cholera compared to other states followed by Gujarat with 872 cases with prevalence rate of 1.23% that is 1-2 cases per 100,000 population in year 2023 and 1291 cases with prevalence rate of 1.81% that is 2 cases per 100,000 population in year 2024. Environmental Factors that are affecting this outbreak are poor sanitation, inadequate hygiene and seasonal changes like monsoon and floods lead to contaminated food and water.

Poor surveillance and infrastructure and lack of proper food safety laws and regulation contributed the spread of cholera.

Figure 10: Illustrates the number of cases of Food Poisoning among the 20 states in 2023.

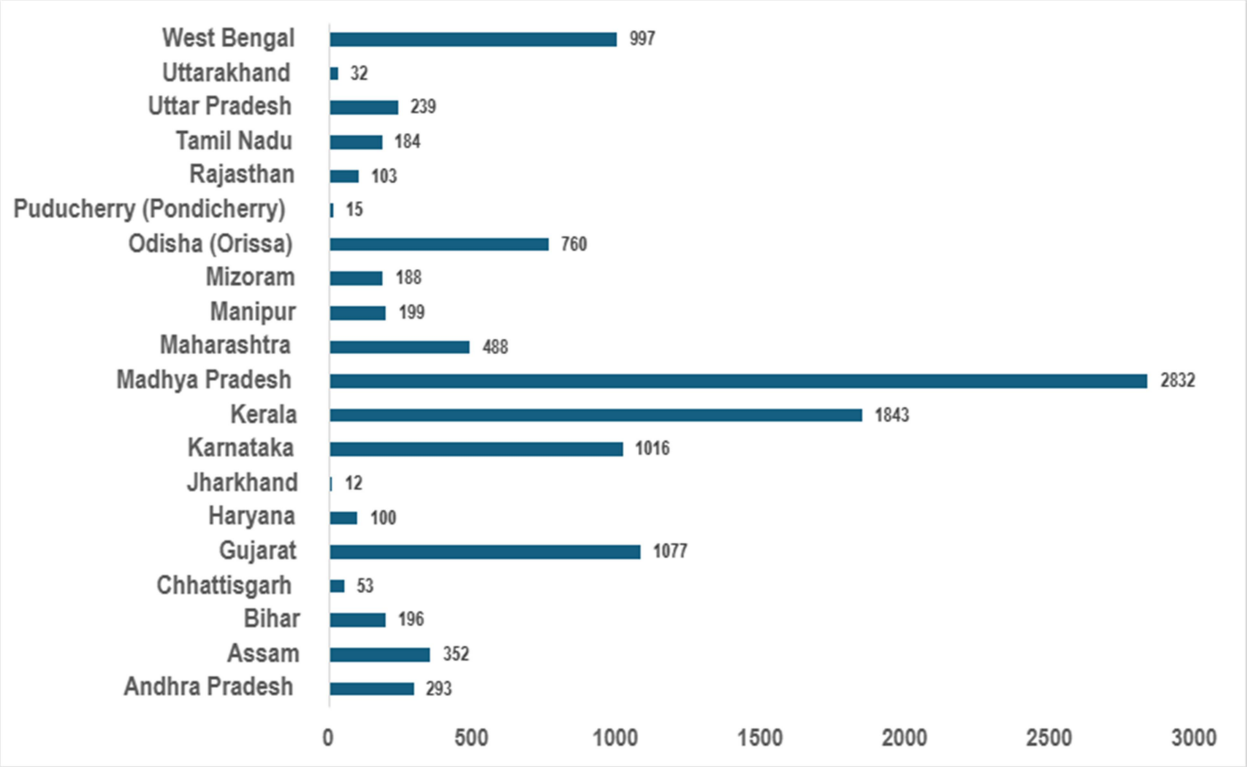


Table 7: Prevalence Rate of Food Poisoning in two states with highest cases in 2023.

Prevalence Rate	
Madhya Pradesh	3.26
Kerala	5.25

Figure 11: Number of cases of Food Poisoning among the 25 states in 2024.

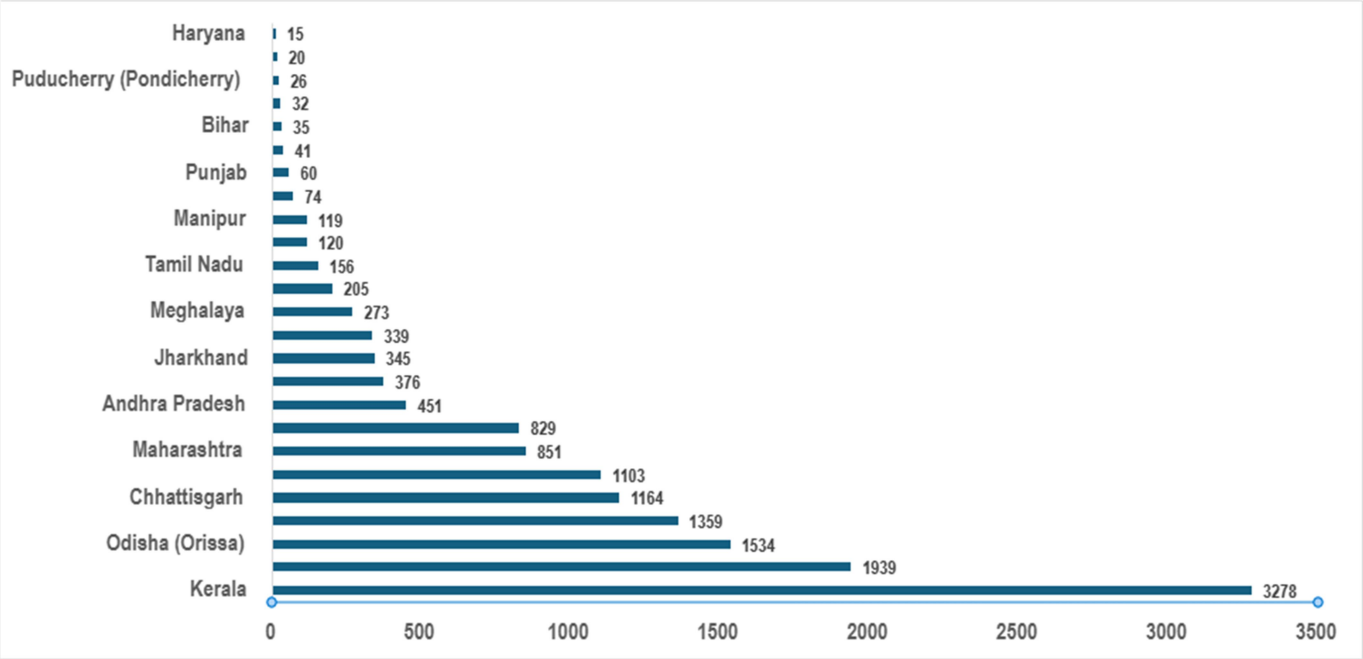
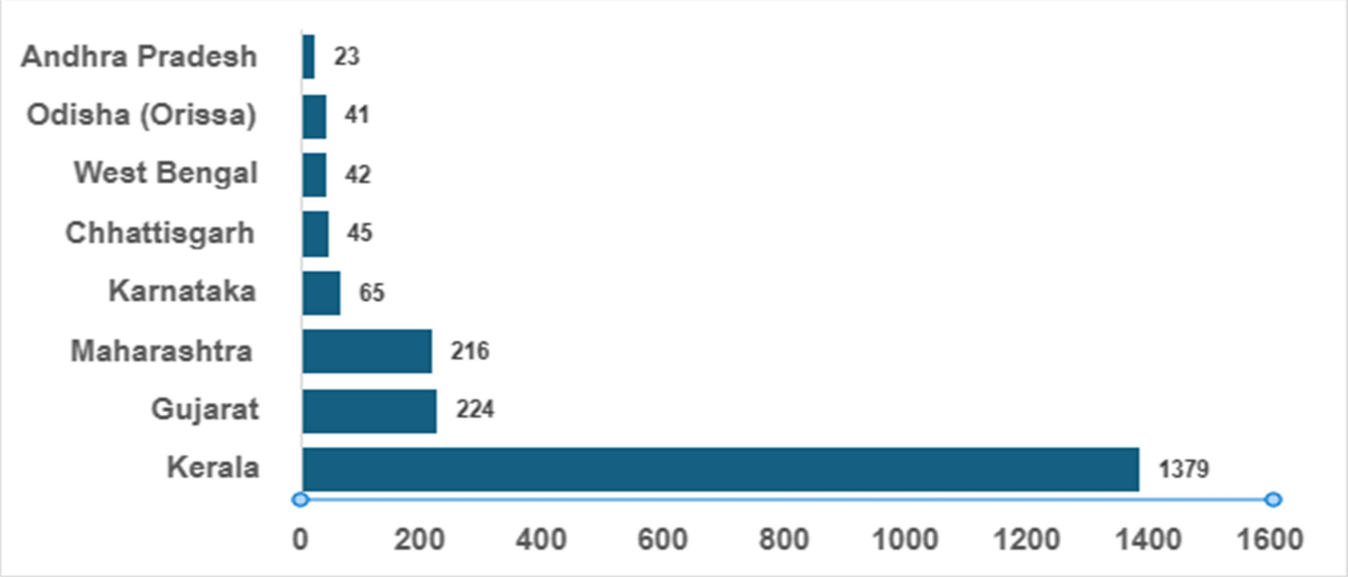


Table 8: Prevalence Rate of Food Poisoning in two states with highest cases in 2024.

Prevalence Rate	
Kerala	9.11
Karnataka	2.82

Figure 12: Illustrates the number of cases of Food Poisoning among the 8 states in 2025.



Figures 10, 11, 12 and Tables 7, 8 illustrate that Kerala reported 1843 cases with a prevalence rate of 5.25% in 2023 and 3278 cases with a prevalence rate of 9.11% in 2024. Madhya Pradesh recorded 2832 cases with a prevalence rate of 3.26% in 2023, while Karnataka had a prevalence rate of 2.82%. Contributing factors include poor hygiene and sanitation among food handlers, a lack of laws and regulations that lead to informal markets, insufficient practice of proper handwashing, improper cleaning and sanitation of utensils, inadequate food storage methods, and ultra-processed food that is not stored properly. Additionally, climate changes contribute to the spread of bacteria and viruses. Agents such as Salmonella and E. coli are particularly prominent in causing food poisoning.

Discussion

This study examined the environmental risk factors contributing to the spread of foodborne diseases in India, particularly through the lens of the Epidemiological Triangle model. By focusing on the dynamic interplay between agents, hosts, and environmental conditions, the research aims to bridge the existing knowledge gap regarding how informal food systems, such as street vendors, local markets, and public event catering, intersect with sanitation issues and regulatory shortcomings to influence disease patterns. Drawing upon outbreak data reported through the Integrated Disease Surveillance Program (IDSP) from 2023 to early 2025, the study provides evidence-based insights into the spatial, temporal, and demographic characteristics of five major foodborne diseases: Hepatitis A and E, Acute Diarrheal Disease (ADD), Cholera, and Food Poisoning across multiple Indian states. The findings

reinforce the pivotal role of natural and systemic environmental determinants in shaping disease prevalence. States like Kerala, where population density intersects with coastal geography and underdeveloped sanitation infrastructure, showed a marked increase in Hepatitis A and E, rising from 805 cases in 2023 to 3,325 in 2024. In 2025, 82 cases had been reported as of this study's data cut-off, with final numbers still pending. These increases align with recurring monsoonal flooding, poor waste disposal, and the absence of effective food safety regulation conditions that support pathogen survival and transmission. Similarly, Odisha reported 351 cases in 2023, largely due to waterborne exposure following floods and insufficient water treatment systems. Jammu and Kashmir, traditionally underrepresented in national data, reported 550 hepatitis cases in 2024 primarily post-monsoon highlighting how seasonal and regional environmental stressors can trigger new disease clusters.

At the same time, host characteristics played a defining role in the burden and distribution of disease. Communities with high levels of poverty, poor nutrition, or underlying health conditions such as diabetes, hypertension, and hyperlipidemia faced increased susceptibility. In Chhattisgarh, ADD reached 2,379 cases in 2023, reflecting the vulnerability of malnourished populations living in areas with limited access to clean water and health education. Karnataka, with 3,592 ADD cases in the same year, exemplified how unplanned urban growth, dense populations, and high seasonal temperatures facilitated pathogen growth and transmission. In 2024, Maharashtra and Gujarat followed similar trajectories, reporting 3,413 and 2,986 cases respectively largely due to compromised hygiene practices in informal food economies and climatic conditions conducive to disease proliferation.

Infectious agents, including E. coli, Vibrio cholerae, Salmonella, and Hepatitis viruses, demonstrated high adaptability to these conditions. Cholera outbreaks were especially prominent in Karnataka, increasing from 1,647 in 2023 to 2,055 in 2024, while Gujarat recorded 872 cases in 2023 and 1,291 in 2024. These organisms thrive in environments where water contamination, poor drainage, and food handling without temperature regulation are common. Food poisoning, linked primarily to Salmonella and E. coli, requires particular attention. Kerala recorded 1,843 cases in 2023 and 3,278 in 2024, driven by mishandling of processed food and widespread gaps in cold-chain systems. In 2023, Madhya Pradesh reported 2,832 cases. By 2025, Karnataka had also reported food poisoning outbreaks, with a prevalence rate of 2.82%. These patterns point to insufficient regulatory oversight in informal food markets, lack of food safety training, poor personal hygiene among vendors, and seasonal influences such as heatwaves or monsoon humidity that accelerate bacterial growth.

These findings highlight that outbreaks are not just the result of a single failing, but a multifactorial interaction. Poor internal controls such as the lack of mandatory food handler training and

weak implementation of food licensing combine with external pressures like monsoon flooding, fluctuating temperatures, and inadequate infrastructure. When these vulnerabilities are layered upon already at-risk populations with limited access to safe food and healthcare, the result is an amplified disease burden, especially in under-resourced areas.

An additional challenge noted in this study is the unequal distribution of disease reporting and surveillance effectiveness across Indian states. While Kerala, Karnataka, and Maharashtra consistently document outbreaks, likely due to more robust health reporting systems, other states with similar risk profiles, such as Bihar or Jharkhand, remain underreported. This variation likely reflects disparities in diagnostic capacity and public health outreach rather than actual disease absence.

Seasonal patterns were also evident. Bacterial diseases such as ADD and Cholera peaked during hot, rainy months when water sources were most vulnerable to contamination. Hepatitis outbreaks, particularly A and E, aligned more with post-flood and post-monsoon conditions where viral pathogens are more likely to spread via compromised water sources. These trends are in line with global findings, where warm, humid climates significantly increase the risk of foodborne and waterborne disease transmission.

Overall, this study demonstrates that the persistence and recurrence of foodborne illnesses in India are deeply embedded in a nexus of environmental vulnerabilities, host factors, and high-risk microbial agents. These findings stress the importance of adopting a multidimensional strategy that incorporates surveillance enhancements, public health education, infrastructure improvements, and regulatory reform. Investing in laboratory systems, mandating food safety training for vendors, and engaging communities in food hygiene practices are key to shifting from reactive crisis management to proactive prevention. In doing so, India can take significant steps toward reducing the burden of foodborne diseases and building a more resilient and equitable public health system.

Conclusion

The analysis of foodborne disease outbreaks reported through the IDSP from 2023 to early 2025 highlights the continued burden of these illnesses on public health in India. Bacterial contamination, particularly through unsafe food and water sources, remains the leading cause of outbreaks. Host susceptibility is notably higher among vulnerable groups such as children, the elderly, and individuals residing in areas with limited access to healthcare and sanitation. Environmental conditions including inadequate waste disposal, lack of clean water, substandard food storage, and climatic factors play a substantial role in the spread of infections. These findings emphasize the need for improved food safety

practices, enhanced community awareness, investment in sanitation infrastructure, and stronger regulatory enforcement. Strengthening surveillance systems and integrating preventive strategies across public health and policy platforms will be critical for minimizing future outbreaks and safeguarding population health.

A recurring limitation of the IDSP data was the lack of specific laboratory confirmation linking outbreaks to distinct pathogens or contaminated food sources. The inability to trace the food supply chain or identify exact microbial strains limits the accuracy of modeling disease trends and impedes targeted intervention. Even high-quality surveillance can struggle to inform precise, localized responses without such data. In many cases, foodborne illnesses share overlapping symptoms with other conditions, which can further obscure case definitions and reduce reporting accuracy.

Nevertheless, this study underscores the urgent need for a multifaceted approach to preventing and managing foodborne diseases. Policy interventions should prioritize strengthening state-level disease surveillance and lab infrastructure, enforcing mandatory hygiene training for food handlers, increasing public education around food and water safety, and mandating traceback protocols for large-scale outbreaks.

Community-based participatory monitoring models can also empower local stakeholders to report suspected outbreaks and ensure rapid containment, especially in peri-urban and rural communities. The increase in cases such as Hepatitis A in Kerala and Cholera in Karnataka demonstrates the need for state-specific risk assessment frameworks that can be integrated into national food safety programs.

While foodborne diseases in India are largely preventable, the current trend of rising cases across multiple states, seasonal surges, and infrastructural gaps paints a concerning picture. A proactive, well-resourced, and evidence-based public health strategy, one that bridges data gaps and addresses both environmental and behavioral drivers, is vital to curbing the ongoing threat of foodborne illnesses and safeguarding public health in India.

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