

Seasonal Variation and Climate Influence on the incidence of Typhoid fever: Insights into Risk and Clinical Correlation

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Abstract- *Salmonella entericaserovar typhi* is the cause of typhoid fever that remains one of the primary concerns of public health in most developing regions where the disease is spread by environmental and sanitation problems. The current research paper was conducted with the purpose to assess seasonal fluctuation and climatic factors affecting the occurrence of typhoid fever as well as its risk and clinical association. This is a cross-sectional study carried out in the laboratory during the period between July 2024 and June 2025 and involved 430 cases of clinically suspected typhoid fever. Blood sample was collected in the aseptic condition and subjected to numerous diagnostic tests, such as the Widal test, Typhidot test, Blood culture, and ELISA to enhance the accuracy of diagnosis. The seasonal distribution was determined by pooling cases based on climatic seasons (monsoon, post-monsoon, winter, etc.) to determine the variation in the occurrence of the disease. In 430 samples, 113 cases were found to be positive with *Salmonella typhi*. The analysis of cases were done on monthly basis from July 2024 to June 2025 which shows high occurrence of cases in October 2024 with November 2024 and March 2025. The lowest number of cases were found in July 2024 and January 2025. Seasonal analysis revealed a greater incidence at monsoon, post-monsoon and late winter seasons. The identified seasonal peaks may indicate that climatic factors are closely connected with the transmission processes of the typhoid fever because, at those times, the water and food foundations are likely to be more contaminated. The present research paper has shown a clear seasonality of typhoid fever occurrence and more prevalence throughout the monsoon and post monsoon months.

Key Words: Typhoid fever, *Salmonella enterica* serovar Typhi, Demography, Epidemiology, Seasonal analysis, Clinical association.

I. INTRODUCTION

The typhoid fever is a systemic infection which is caused by *Salmonella entericaserovar typhi*, which is frequently of concern to the whole community especially in the low- and middle-income economies where people are still exposed to poor hygiene, contaminated drinking water, and insufficient sanitation. The disease is still a significant source of morbidity and healthcare burden in endemic areas like South Asia and some parts of Africa despite the progress in diagnostics and the development of vaccination strategies to address the disease. The duration of the typhoid fever is directly associated with socioeconomic determinants as well as climatic and environmental factors which affect the trends of transmission. Over the past few years, there is an increased interest in the contribution of the season and climate change to the epidemiology of infectious diseases, including typhoid fever. Diseases that are sensitive to climate change particularly those caused by contamination of water and food are very sensitive to changes in temperature, rainfall, and humidity. It has been indicated that climatic conditions may have direct impacts on the survival, multiplication, and spread of *Salmonella typhi* in the environment. As an example, temperature changes have been linked to the acceleration of bacteria growth in the polluted food and water sources, thus increasing the chance of

infection (Okoyere et al., 2025). On the same note, changes in the patterns of rain falls, especially in monsoon periods, might cause floods and water pollution and spread of enteric pathogens.

The seasonality of typhoid epidemiology is a well-established phenomenon, but its distribution is different in geographical areas. It has been shown that the prevalence of typhoid is usually the highest at particular periods of the year especially in the warmer and rainy seasons. Environmental drivers have been detected to be rainfall and temperature, and the incidence has been higher in certain areas after heavy precipitation because of the poor sanitation systems and water pollution (Kalule et al., 2025). Moreover, the generalization of climatic data around typhoid shows that the correlation between them is difficult and situation-specific and depends on local infrastructure, population density, and health habits of people (Saad et al., 2018). Climate change also makes this relationship more complicated. The transmission of waterborne diseases is likely to change due to rising global temperatures and the changing patterns of precipitation and the rising occurrence of extreme weather events. Climate change may worsen the already vulnerable situations, by influencing water supply, sanitation facilities, and human conduct. These changes can considerably make the risk of typhoid outbreaks more severe in developing countries where the resources are scarce. According to a recent review, climate change is among the factors that can spur the development and re-development of infectious diseases by providing pathogens with the right environment and causing an ecological imbalance (Agyarko et al., 2025). Moreover, more precipitation and flooding have been associated with the escalated likelihood of transmitting typhoid because of contamination of drinking water resources.

Besides climatic factors, the demographic and behavioral factors are of great importance in determining the susceptibility to typhoid fever. There is a huge impact on distribution of disease among age, gender, socioeconomic status, and hygiene practices. Children and young adults are also more susceptible because of higher exposure to contaminated food and water, whereas other factors, including outside food habits and low personal hygiene were also found to be primary contributors of risks (Hermawan et al., 2026).

These factors tend to interact with the environmental conditions increasing the risk of being infected. Another aspect that is significant in knowing the burden of typhoid fever is clinical correlation. Not only do seasonal peaks affect the incidence rates, but they also can also impact the severity of the disease, the use of health care, and the patterns of diagnosis. High-transmission seasons can also pose a challenge to the healthcare system in terms of patient overload, and this may affect prompt diagnosis and treatment. Besides, the clinical presentation can also differ because of the differences in bacterial load, host immunity, and exposure to the environment.

Since the interdependence of climatic variables, demographic determinants, and clinical outcomes exist, a holistic approach to the study of the typhoid fever is necessary. Knowledge of seasonal patterns and climate changes can assist in forecasting outbreaks, resource distribution and taking specific preventive measures. This information is especially important in endemic countries where appropriate interventions can greatly decrease the burden of disease. Thus, the current research aims to examine the seasonal change and climatic impact on the prevalence of typhoid fever along with the investigation of related demographic trends and clinical associations. With the help of incorporating environmental, epidemiological and clinical views, the study is expected to develop a more comprehensive view of the dynamics of typhoid and help create effective strategies of preventing and controlling the epidemic as a public health concern (Stanaway et al., 2019).

II. MATERIALS AND METHODS

Study Design and Setting

This paper was an observational study, which was laboratory-based and needed to be conducted over a one-year period, between July 2024 and June 2025. The experiment was conducted in the Department of Microbiology. The aim was to determine the seasonal change and climatic impact on typhoid fever incidence as well as estimate the risk factors and clinical correlation of the disease.

Sample size and Population of study.

The patients that were included in the study comprised of 430 clinically suspected patients of typhoid fever. The patients who came to the clinic with a history of

long-lasting fever (2 weeks), headache, abdominal pains, diarrhea or constipation, and other indicative clinical manifestations were taken into consideration.

Inclusion Criteria

- All-age and sex of patients.
- Typhoid fever- Clinically suspected cases.
- Informed consent was obtained by patients.

Exclusion Criteria

- Patients who have a history of long term antibiotic therapy.
- Patients whose alternative diagnoses have been confirmed.
- Poor or erythrocytes hemolytic blood samples.

Ethical Considerations

The Institutional Ethics Committee reviewed and accepted the study protocol. All the participants or their guardians gave informed consent in writing, in case of minors. Patient information during the study was classified and kept confidential as per the ethical standards (World Medical Association, 2013).

Sample Collection

Five to ten ml of blood was taken aseptically in adult patients and 2-5 ml in pediatric patients with sterile disposable syringes with the usual aseptic precaution. To reduce the chances of contamination, the venipuncture spot was wiped with 70% isopropyl alcohol and then covered with povidone-iodine. The blood obtained was separated into two parts, one of which was used as a blood culture and the other as serological analysis (Cheesbrough et al., 2020).

Sample Distribution

The blood sample collected was separated in the following way:

- Blood culture: 2-5 mL of blood transferred into culture bottles immediately.
- Serological tests (Widal, Typhidot, ELISA): The rest of the blood was transferred into plain vacutainers to separate serum.

Sample processing

Serum Separation

A plain vacutainer was used in the collection of blood samples and permitted to clot at room temperature of 20-30 minutes and centrifuged at 3000 rpm 10 minutes to extract the serum. Clear serum was then transferred into sterile microcentrifuge tubes with the help of

micropipettes and placed at 2-8degree Celcius until the next analysis to ensure that the antibodies remained intact (Collee et al., 2014).

III.LABORATORY DIAGNOSTIC METHODS

Blood Culture

The bottles with the culture were incubated at 35-37 degree Celcius within the instrument and constantly followed up to 5-7 days. The system automatically gave positive samples an audible and visual warning. A sample was taken when a bottle tested positive in the aseptic test and Gram staining was done to determine the morphology and Gram stain of the organism. Subcultures were prepared on the suitable solid medium like Blood agar and MacConkey agar. *Salmonella typhi* has been identified using the colony morphology, Gram staining patterns, and biochemical tests including triple sugar iron (TSI) agar, indole test, citrate utilization and urease test (Forbes et al., 2017).

Widal Test

Widal test was conducted by the slide agglutination procedure in order to identify O and H antibodies against *Salmonella typhi*. A drop of patient serum was put on clean glass slide and combined with a drop of Widal antigen (TO, TH, AH, BH). The mixture was rotated gently approximately 1 minute and agglutination noted. A positive reaction was represented by visible clumping which implied the presence of antibodies towards Salmonella antigens and negative was represented by the absence of agglutination (Olopoenia et al., 2000). Agglutination method of antibody titration was further used to confirm the positive samples in a tube.

Typhidot Test

The qualitative detection of IgM and IgG antibodies against *Salmonella typhi* was performed by performing a rapid immunochromatographic test called Typhidot test. The samples of serum were placed on the test device and then the assay buffer was added and the results were interpreted after 15-20 minutes depending on the development of colored bands of positive or negative reactions (Fadeel et al., 2011).

IV.ELISA

The detection of specific antibodies against *Salmonella typhi* was done by enzyme-linked immunosorbent assay (ELISA). Microtiter plates

coated with antigens were utilized and patient serum samples were placed and incubated. Substrate solution was then added after washing to give enzyme-conjugated antibodies to produce a color reaction. The ELISA reader was used to measure the optical density and its results were interpreted based on the instructions of the manufacturer (Engvall et al., 1971).

Seasonal and Climatic Classification

The timeframe of the study was separated into seasons according to the types of the climate in the region:

- Monsoon (July-September)
- Post-monsoon (October-November)
- Winter (December-February)
- Summer/Pre-monsoon (March-June)

Seasonal analysis was done through case distribution on a monthly basis. Certain climatic variables like temperature and rainfall were taken into consideration when it comes to correlation to disease occurrence (Okyere et al., 2025).

Quality Control

The laboratory procedures were done according to the standard operating procedures in order to achieve accuracy and reliability. Each batch of tests contained positive and negative controls and all reagents checked prior to use in relation to quality and expiry. The

laboratory equipment was calibrated on a regular basis to ensure consistency of the result (Forbes et al., 2017).

V.RESULT

Four hundred and thirty-five clinically suspected cases of typhoid fever were assessed within twelve months (July 2024- June 2025). Among them, 113 cases were test positive of *Salmonella typhi* leading to a total positivity rate of 26.3%.

The cases were analyzed on a monthly basis and it was evident that the incidence of typhoid fever has varied during the period of study. The first months showed comparatively fewer cases 4 cases in July and 9 cases in August with 9 cases in September. It was noted that the positivity rate was significantly high after October, 2024 where 17 cases were recorded in October and 15 cases were recorded in November with a tendency to increase towards positivity during the post-monsoon season. There were also moderate cases of December 2024 (11 positives) shown in table 1.

Its cases were observed to be on the decline during the winter months where 5 cases were reported in January 2025. Nevertheless, there was again a slight increase in February 2021 (11 cases) and March 2025 (14 cases), which indicates a second rise. This was followed by a reduction in the number of cases, 7 cases in April, 5 cases in May and 6 cases in June 2025 shown in figure 1.

Month	Total Cases	Positive Cases	Positivity (%)
July-24	20	4	20.00%
August-24	24	9	37.50%
September-24	42	9	21.40%
October-24	64	17	26.60%
November-24	55	15	27.30%
December-24	40	11	27.50%
January-25	25	5	20.00%
February-25	64	11	17.20%
March-25	36	14	38.90%
April-25	22	7	31.80%
May-25	17	5	29.40%
June-25	21	6	28.60%

Table1 : Distribution of Typhoid Cases on a monthly basis.

The period with the most number of confirmed cases was in October 2024 with November 2024 and March 2025 coming in second and third position respectively. On the contrary, the fewest incidence was recorded in July 2024 and January 2025. In general, the figures show a clear seasonal pattern, where the incidence seems to be higher during the monsoon and post-monsoon months and lower during winter and early summer seasons. These results indicate that seasonal changes and climatic conditions have a very strong effect on the dynamics of typhoid fever transmission.

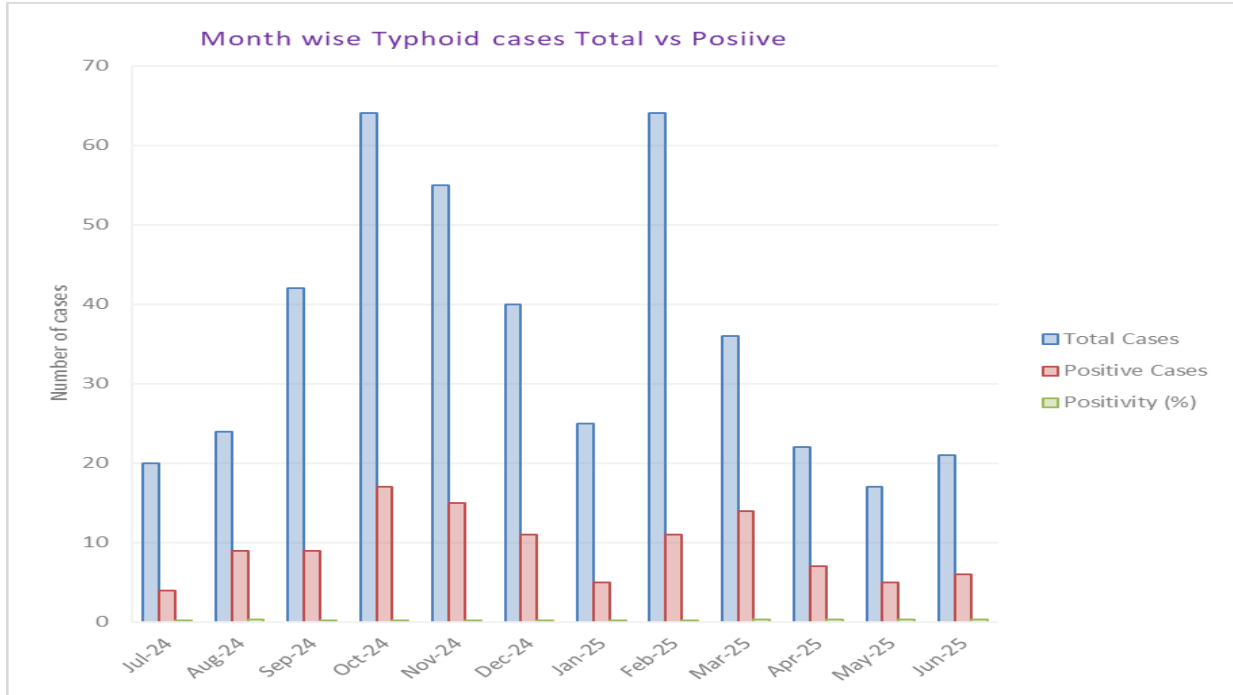


Figure 1: Showing Total and Positive number of Typhoid cases

VI.DISCUSSION

The current investigation shows that there is a distinct seasonal difference in the occurrence of typhoid fever whereby most of the cases are experienced during the monsoon and post-monsoon months. This observation indicates that climatic conditions, including rainfall, temperature, and humidity, have a high influence in the spread of *Salmonella typhi* which is mainly by contamination of food and water supply.

The same has been found in recent reports that have indicated that a significant correlation of seasonal patterns with the occurrence of typhoid has been found. As an example, the findings of the present study were supported by the findings of another study conducted by (Mujiyanto et al. 2025) who found that there was a significant clustering of typhoid cases during times of high rainfall. The maximum incidence experienced in this study in months of October and November coincides with the post-monsoon trends in endemic areas.

Moreover, massive epidemiological studies have brought into the limelight that typhoid fever has persistently exhibited temporal fluctuation that is dependent on the environmental and infrastructural circumstances. (Murthy et al., 2025) pointed out that incidence of typhoid infections are still high in areas

with poor sanitation and lack of access to clean water that could be further aggravated by the change of seasons.

There have also been mathematical modeling studies which have helped to support the significance of seasons of transmission. In a recent study (Koh et al., 2025) established that the trends in typhoid outbreaks have time-dependent variations, which are frequently attributed to climatic variability. These results are accredited to the increase in the cases during monsoon and post monsoon seasons in the current study.

In addition, research studies on the dynamics of infectious diseases have revealed that seasonal drivers play a great role in enteric infections. According to the reports of different authors (Ahmed et al., 2024) the transmission rates are likely to rise when the environment is favorable, which coincides with the second increase in the cases that may be observed in February-March in this study.

In general, the current research reveals that the seasonal and climatic parameters are important in influencing the epidemiology of typhoid fever. Primarily, it is necessary to enhance the measures of public health, especially in risky situations, to mitigate disease burden and preclude outbreaks.

VII.CONCLUSION

The current research paper has shown a clear seasonality of typhoid fever occurrence with more prevalence throughout the monsoon and post monsoon months. The results have shown that climatic circumstances that have a considerable effect on the transmission dynamics of *Salmonella typhi* include rainfalls, temperatures, and environmental circumstances. These changes in the distribution of the cases over the year indicate the importance of infected water sources and ineffective sanitation in the spread of the diseases and more so during the seasons of high risk.

The article highlights that there is a need to subject the population to specific public health interventions, such as having better water quality, sanitation and hygiene practices particularly during peak transmission seasons. The reinforcement of early diagnosing efforts and effectiveness of surveillance mechanisms can also contribute to the timely identification and treatment of the cases. In general, seasonal trends can be studied to implement more effective prevention measures and contribute to lessening the burden of typhoid fever in endemic areas.

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