RESEARCH PAPER

Etiology, Risk Factors and Demographic Determinants of Typhoid Fever: An Epidemiological Analysis

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ABSTRACT

Salmonella enterica serovar typhi, which causes typhoid fever, is a disease that is endemic in few low and middle-income countries, most probably due to absence of hygienic sanitary structures and due to insecurity of drinking water. The aim of the current work was to evaluate etiological profile, demographic and significant risk factors of typhoid fever in Bhiwani and Rohtak districts, Haryana, India. The study was conducted through a cross-sectional study between July 2024 and June 2025, 430 cases of typhoid fever with clinical suspicion were used. Laboratory confirmation of the blood samples was done in Typhidot, Widal test, blood culture and ELISA. Demographic and epidemiological fragments of information were collected with the help of structured questionnaire. A total of 430 suspected cases were obtained with 113 (26.3%) being positive to Salmonella typhi. The small margin better exhibited more prevalence of male (53.1%) than female (46.9%). Most of the cases were recorded in people who were aged 15 to 40 years (56.6%). The vast majority of the patients who were affected were in the middle socioeconomic group (43.4%). The most significant risk factors were found to be poor food hygiene (76.9%), poor sanitation (63.7%), and drinking of contaminated drinking water (38%). Typhoid fever remains an important issue in the study area in terms of public health. The environmental and hygienic associated factors are more important in regard to the disease transmission. To manage typhoid fever, one should be in control of water safety, sanitation systems and hygienic methods of preventing typhoid fever.

Keywords: Typhoid fever, Salmonella Typhi, Demography, Etiology, risk factors, hygiene, waterborne infection

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Introduction

Salmonella enterica serovar typhi a human specific pathogen, causes typhoid fever or Salmonellosis; it is an acute systemic infection. Despite the intense improvement in the healthcare and the overall health intervention activities, the typhoid fever has continued to be a leading health problem in the majority of the low- and middle-income countries and particularly in South Asia. India is a significant contributor to the global burden of the disease, which is mainly attributed to the persistence of such challenges as lack of proper sanitation, lack of access to safe drinking water, and congestion. Most of it is transmitted by consumption of food or water contaminated with fecal content of infected cases or asymptomatic carriers, and hence the strong connection between typhoid fever and environmental hygiene (Crump et al., 2004).

Typhoid fever causes high morbidity and mortality throughout the world. The recent statistics provided by the World Health Organization (WHO, 2023) reveal that every year, about 1120 million cases of typhoid fever are reported, which causes about 128000 - 161000 cases of death projected to be 128,000 - 161,000 globally. The greatest burden of disease is in South Asia and sub-Saharan Africa. In India, uncontrolled urbanization, ineffective waste disposal mechanisms, overpopulation, and unequal availability of clean water have been some of the factors that have led to the continuous spread of *Salmonella typhi*. Moreover, as new and resistant microbes have emerged and propagated, treatment and control have become even more challenging (Parry et al., 2011).

Typhoid fever pathogenesis is complicated with the interaction of the system of immune structures with the

pathogen. After oral intake, *Salmonella typhi* invades intestinal epithelium and lives in the macrophages, which facilitates its spread by blood. This causes systemic involvement of several organs as well as prolonged fever. The initial clinical manifestations are usually of a general character since they can comprise persistent fever, headache, malaise, and Abdominal discomfort. Late diagnosis and management may lead to severe outcomes, including intestinal perforation, gastrointestinal blood, and septicemia, which can be highly dangerous to cause lethal outcomes (Buckle et al., 2012).

The incidence and prevalence of typhoid fever depends on a number of environmental, behavioral, and demographic factors. Poor sanitation, unsafe drinking water, and poor sewage disposal form the determinants of the environment. Behavioral reasons, such as eating contaminated food materials, poor hand hygiene, and poor knowledge of food safety measures elevate the risks of the infection. The distribution of diseases is also influenced by demographic factors that include age, socioeconomic status, level of education and residential setting. The risk of exposure is greater among children, adolescents and people with lower socioeconomic bore since many of them lack access to health care facilities (John et al., 2010).

The epidemiological records have continuously indicated that the highest rates of typhoid fever are recorded in the urban slums and peri-urban regions where overcrowding and low hygienic standards are dominant. They have also reported seasonal changes where they have found most of such cases occurring during the monsoon season when there is a higher probability of contaminating the water sources. The identification of these demographic and environmental determinants is critical to understanding how they can be used to plan successful prevention strategies and optimise the use of healthcare resources.

It is with this view that the current study was conducted in order to examine the etiology, demographic determinants and risk factors associated with the occurrence of typhoid fever in the selected districts of Haryana. This research will offer evidence that can be used to conduct target interventions to improve the health of affected populations by analyzing clinical presentation, laboratory results, and sociodemographic phenomena of affected persons. The findings would be used to achieve better disease surveillance, early diagnosis, and development of effective prevention and control strategies in typhoid endemic areas.

Materials and Methods

Study Design and Setting

It was a cross-sectional epidemiological study, which was conducted in two districts of Rohtak and Bhiwani, Haryana, India between a period of time spanning July 2024 to June 2025. These districts possess rural and semi-urban population of various sanitation amenities and availability of safe drinking water, therefore, they can be used to determine epidemiology of typhoid fever in the endemic regions. The case study aimed at evaluating the etiological profile, risk factors and demographic determinants of typhoid fever via clinical, epidemiological, and laboratory-based research.

Population of the Study and Sample size

The eligibility of the patients was checked against the patients in outpatient and inpatient units of the chosen hospital, clinics, and diagnostic laboratories across the study area. People who reported to the hospital with clinical symptoms indicative of enteric fever were recruited in accordance with the inclusion criteria. The number of samples of suspected typhoid fever cases that were collected in the course of the study was 430 samples of venous blood. The sample size was set according to the availability of the patients and the possibility of the diagnosis within the specified time frame of the study.

Eligibility Criteria

Any patient aged over 18 months old of either sex were also permitted to participate in the study but must have had a minimum of three days of fever and one of the following gastrointestinal symptoms; abdominal pain, diarrhea or constipation, and a systemic manifestation of the illness including headache, anorexia and generalized weakness. The patients were not factored in the study that had had the antibiotic treatment more than 72 hours before the sampling date since there was a possibility of antibiotic exposures before the results were taken on the culture and the serology. Patients whose alternative diagnoses were confirmed (malaria, dengue or other acute febrile pictures) were also excluded to avoid overlapping of the diagnostic.

Ethical Consent and Approval.

This study was initiated by the committee of the Institutional Ethics reviewing and approving the study protocol. All adult participants gave informed consent in writing. In cases of participants under the age of 18 years, the participants received consent of their parents or legal guardians. Participant information was kept confidential and all the procedures were followed according to the rules of ethical standards of biomedical research on human participants.

Data Epidemiological Assessment and Collection.

The demographic, clinical, and epidemiological data were collected at the time of the enrollment with the use of a structured and pre-tested questionnaire. Data were collected in the form of age, sex, educational, occupational, socioeconomic, residential, drinking water source, sanitation amenities, food habits, hand washing, and past history of typhoid fever. Cases were also reported on a seasonal basis to determine the trends over time especially during the monsoon seasons.

Collection and Processing of Samples.

About 5-10 ml of venous blood was gathered under the strict aseptic conditions and using the sterile disposable syringes. The gathered samples were separated accordingly to go through the serological examination and microbiological culture as shown in figure 2. All specimens were transported and processed according to the standard laboratory protocols in order to guarantee the accuracy and reliability of results.

Figure 1: Blood sample collection

Figure 2: Culture sample collection

Diagnostic Methods of the Laboratory.

All of the samples were tested with four known diagnostic techniques to improve the diagnostic accuracy and to enable the ability to compare:

Typhidot Test:

The Typhidot is a fast immunochromatographic assay that is applied to the qualitative detection of both IgM and IgG antibodies to *Salmonella enterica serovar typhi*. It is important to note that this test is mostly effective in the early diagnosis of the disease in the acute phase of infection where results can be obtained within a short period (Choo et al., 1999).

Widal Test:

Agglutination test Widal slide agglutination test was done to identify anti-somatic (O) and flagellar (H) antigens in *Salmonella typhi*. Agglutination titers were recorded and the serum samples were tested in serial dilution after incubation. Since typhoid fever was endemic in the study area, 1:160 was taken as the level of antibody that showed evidence of infection (Olopoenia et al., 2000).

Blood Culture:

The reference diagnostic method was blood culture. Blood samples were inoculated into the right culture media and incubated using automated blood culture systems. 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. Standard biochemical tests were also used to prepare positive cultures and label them with the *Salmonella typhi* (Parry et al., 2011).

ELISA :

ELISA was utilized as one more quantitative approach to the study of the anti-Salmonella antibodies. 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). This test aided the corroboration of the diagnosis and comparison of serological responses in various demographic groups and categories of exposures.

Data Analysis and Statistical Processing:

All the acquired data were inputted into a computerized database where they were compared against. To describe demographic variables, laboratory findings, and distribution of risk factors, the descriptive statistical

analysis was conducted. Findings were reported as percentages so that they could be easily interpreted and compared epidemiologically.

Result

From a total of 430 suspected samples 113(26.3%) were found to be infected with *Salmonella typhi* by Typhidot, Widal, blood culture and ELISA were performed to understand the age specific and socioeconomic distribution of Typhoid fever and its risk factors (Figure 3-7). The small margin better exhibited more prevalence of male (53.1%) than female (46.9%). Most of the cases were recorded in people who were of young age group (56.6%). The vast majority of the patients who were affected were in the middle socioeconomic group (43.4%). The most significant risk factors were found to be poor food hygiene (76.9%), poor sanitation (63.7%), and drinking of contaminated drinking water (38%).

Figure 3: Typhidot card showing control line and IgM, IgG test lines

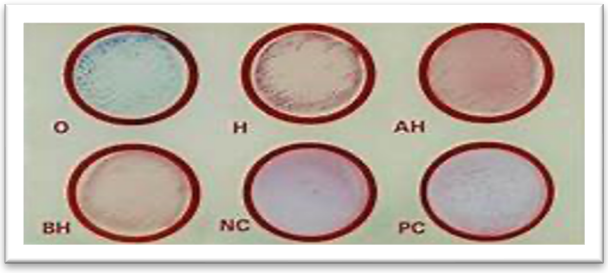

Figure 4: Widal slideshowing agglutination in O and H antigen

Figure 5: *Growth of Salmonella typhi* on Blood Agar

Figure 6: Biochemical test results

Figure 7: ELISA plate reading

Age-wise Distribution

There was an age based distribution where the greatest number of confirmed cases (56.6%) were in young people of 15 to 40 years. Minimum number of cases (7.1%) were seen in elder people who were more than 60 years old (Figure 8).

Age (years)	Number of cases	Percentage %
0–15	20	17.70%
15–40	64	56.60%
40–60	21	18.60%
>60	8	7.10%

Table 1: Distribution of Confirmed Cases of Typhoid by age

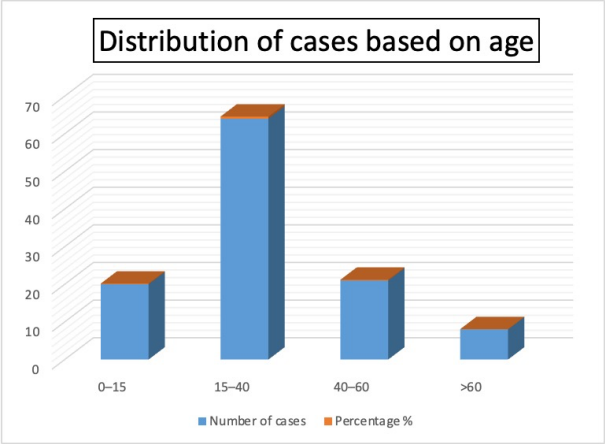

Figure 8: Distribution of cases based on age

Socioeconomic Distribution

The majority of the confirmed typhoid cases were shown to be among the middle socioeconomic population. The cases were then preceeded by the cases of the lower socioeconomic group with the least cases recorded among the people in higher socioeconomic status (Figure 9).

Table 2: Socioeconomic condition of Typhoid Patients (n = 113)

Socioeconomic Status	Number of Positive Cases	Percentage (%)
Low	38	33.60%
Middle	49	43.40%
High	26	23.00%

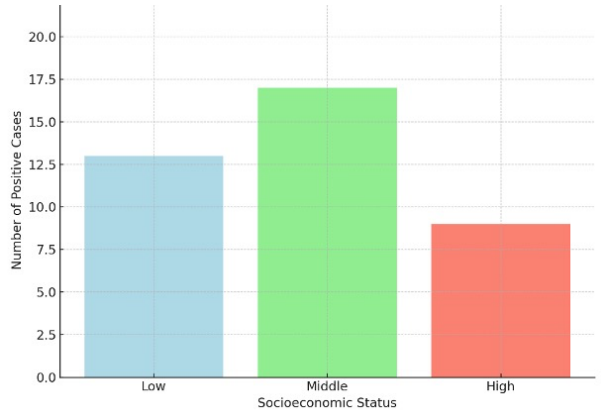

Figure 9: Bar chart of the number of cases of typhoid-positive by socioeconomic status.

The typhoid fever appeared in the middle socioeconomic group the most, having 43.4 percent of the cases. That is more than the lower income bracket at 33.6 percent and even higher still the higher one was at 23 percent. These figures indicate that it is not that the disease is confirmed to the poor. It has a wider scope, in a way on various levels. I believe that is one of the best parts, as you can imagine that it may be even worse to the ones at the bottom. The middle group which possesses the highest does feel slightly out of it, perhaps.

Risk Factors

In the infected persons, the following were the prominent risk factor are contaminated and unsafe water, poor hygiene and sanitation and poor food hygiene

Table 4: The Distribution of Key Risk Factors among typhoid Patients (n = 113)

Risk Factor	Patients number	Percentage (%)
Poor Food Hygiene	87	76.90%
Poor Hygiene and Sanitation	72	63.71%
Contaminated and Unsafe Water	43	38.05%

The most frequent risk factor (present in 76.9% of the cases) was inadequate food hygiene, then there was poor sanitation habits (64.1%), after which there was drinking contaminated or unsafe water (38.05%) showing in Figure 10. These findings reveal the significance of good food handling and food hygiene practices towards the prevention of typhoid fever among study group.

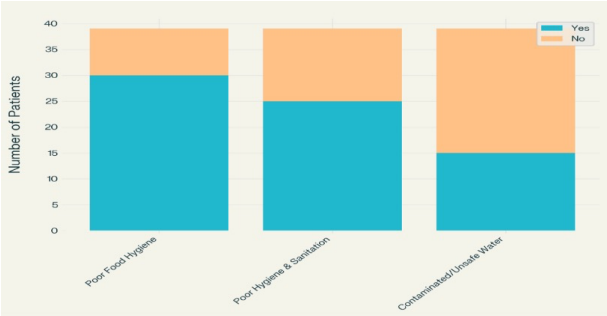

Figure 1: Distribution of the key Risk Factors associated with Typhoid Patients.

Discussion

The findings of the current research shows that typhoid fever remains a significant health concern to the population in semi-urban and rural localities like Rohtak and Bhiwani. The positivity rate of people who were tested in typhoid fever, 113(26.3%) were found infected with *Salmonella typhi*. There were 60 (53.1%) are males, and 53 (46.9%) are females according to my study.

(Ishtiaq et al., 2023) conducted a study in Bahawalnagar, Pakistan inspect the prevalence of typhoid fever covering demographic groups. Their finding with regard to gender showed remarkable higher occurrence of typhoid fever in females (51.46%) than males (48.54%). Other typhoid-infected areas in India have also reported similar improved levels of positivity, with no corresponding increase in the sanitation infrastructure and food safety practices following the improvements in clinical management.

On the basis of age analysis, the confirmed cases were more common in young people aged 15 to 40 years and older and least in elder people who were aged 60 and above according to present study. This tendency can be explained by the fact that there is a greater occupational exposure, mobility, and more likely to eat food prepared outside the home. Adults tend to be more subjected to the unhygienic environment because of working conditions, traveling, and eating food sold on the streets. Unlike research that has found greater incidence in children. The descriptive epidemiological work examined nine years of surveillance data of typhoid fevers in China. It gives a breakdown of the case proportions according to the age group indicating changes in the burden of younger (0-4 years) and older (>60 years) populations over the years (Xiao et al., 2026). The prevalence of adults in this research highlights the need to broaden prevention efforts not only in pediatrics but also in adults. An epidemiological study on typhoid fever universality in suspected cases in Pakistan that conducted subgroup analysis on the basis of age groups. It provided percentages of positive cases by age category of pediatrics 68.5% of positive typhoid cases were children below the age of 15 years. Among children, it was distributed as 13.8 in ages 1-4 years, 55.3 in ages 5-12 years and 30.7 in ages 12-15 years (Ahmad et al., 2024).

Most of the cases were found in individuals who were in middle socioeconomic bracket according to the study. This observation indicates that typhoid fever is not only limited to the poor but also spreads to middle-income earners especially in areas where sanitation and water quality is not ideal between communities. It was an observational study that examined the cases of typhoid in children in various residential environments (urban, rural, nomadic) in Punjab, Pakistan. Although it was not purely concerned with socioeconomic variables on their own, it identified a close relationship between low income and increased burden of typhoid (majority of the cases were reported as households with low income) and the environment including inadequate water supply and overcrowding. Such trends substantiate the correlation between poverty, living environment, and the probability of being infected with typhoid (Ambreen et al., 2026).

Poor infrastructure and irregular availability of clean water can counter the safeguarding qualities normally linked to a better socioeconomic position. The cross-sectional study evaluated clinical characteristics of typhoid fever and reported them in relation to socioeconomic status (SES) 125 culture-confirmed typhoid patients in Quetta, Pakistan. The low (56%), middle (32%), and high socioeconomic classes were formed by the income, education, and living circumstances (Zarak et al., 2021)

Risk factor assessment was done and poor food hygiene was found to be the number one cause of infection followed by lack of proper sanitation facilities and drinking of unsafe water. The risk factors of typhoid fever and found that demographic and socioeconomic factors were the most critical agents of the spread of typhoid alongside waterborne and foodborne transmission. Socioeconomic factors such as poor sanitation, low income, lack of clean water, overpopulated housing, and low education levels have been identified as some of the determinants that increase the risk of typhoid in low resource settings. A recent study highlights that the socioeconomic inequalities must be incorporated into a special public health initiative like improving water, sanitation and hygiene and vaccinating vulnerable populations (Okyere et al., 2025). These results restate the primary incidence of typhoid fever transmission through food- and water-borne mechanisms in endemic areas. Consumption of undercooked food, lack of hand hygiene and exposure to uncontrolled food peddling practices are prevalent semi-urban and rural environments. Besides, the lack of sanitation facilities and periodic water shortages predispose people to contamination and exposure to a greater degree.

Multidiscriptinary of the diagnostic tools such as Typhidot, Widal test, blood culture, and ELISA enhanced the accuracy of case detection in this study. Its reliance on a single diagnostic method in endemic regions can lead to under diagnosis or misclassification because of the previous administration of antibiotics, low bacteremia, cross-reactivity in serology, etc. By using a mixed diagnostic method, these limitations were addressed and the results were given a more precise estimate of the prevalence of the disease contributing to epidemiological validity of the result.

Conclusion

Typhoid fever is a major public health issue in the endemic areas like Rohtak and Bhiwani, which is a complex interaction of environmental, behavioral, and demographic factors. Lack of food hygiene, safe drinking water, insufficient sanitation and seasonal susceptibility perpetuate transmission even in the population with moderate socioeconomic status.

The results of this paper point to the importance of the integrated and multidimensional public health intervention. The emphasis should be placed on enhancement of sanitation, and secure access to safe drinking water, and enforcement of good food handling habits. Awareness programs on risk to exposure should be developed at the community level and include households, food handlers, and vulnerable populations. Improved disease monitoring especially during the monsoon season and combination methods in the diagnosis would enhance the area of early detection and increase remedial actions. All these endeavors are key in attaining a long-term decrease in the prevalence of typhoid fever in the high-risk societies.

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