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HEMATOLOGICAL VARIATIONS AND ASSESSMENT OF SOCIOECONOMIC STATUS IN HUMAN TYPHOID PATIENTS

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ABSTRACT:

Typhoid fever is a significant public health concern in both developed and under developed nations. It is initiated by *Salmonella enterica*, specifically serotype typhi, and a general infection primarily transmitted through contaminated food and water sources. This study aimed to gather epidemiological data on typhoid patients at THQ Hospital Renala Khurd, Okara, and analyze hematological parameters to understand the disease's impact. Data was collected from typhoid patients by questionnaire during interviews, and blood was obtained for hematological analysis. It was found that there was non-significant difference in typhoid prevalence across different age groups. However, significant differences were observed based on education status, with implications for disease transmission dynamics. Marital status did not significantly influence typhoid incidence, although there was a slight difference observed between married and unmarried individuals. Urban residence did not significantly affect typhoid prevalence. Smoking status was not significantly associated with typhoid. Only middle-class families were included in study, may limit generalizability to other socioeconomic groups. Diabetic patients had less prevalence of typhoid than non-diabetic individuals, shows non-significant differences. Significant differences were observed in typhoid incidence based on food consumption, with those eating from contaminated sources being more susceptible. Hematological analysis revealed variations in between case and controls, suggesting potential diagnostic value. To conclude, various risk factors influencing typhoid transmission, including education, smoking, and diabetes status. While urban residence did not significantly impact on typhoid prevalence. Some factors such as smoking and diabetes were less associated with typhoid.

Keywords: Typhoid, Disease, Humans, Socio-economic status, Hematology

1. Introduction

Typhoid fever is an emerging issue in developed countries. It is caused by Salmonella enterica, specifically the serotype Typhi (1). It is also transmitted through contaminated eatables, involving pathogens such as *S. enterica* subtypes *S. Typhi* and the less infectious *S. Paratyphi* A, B, and C, which are known as typhoidal salmonella (2). Ingesting fecal-contaminated water and food can also lead to typhoid infection (3, 4). It is a major health issue in regions lacking proper water systems. Worldwide, 22 million new cases of typhoid are reported annually, with 200,000 resulting in death (5, 6) . Annually, Southeast Asia and Central South Asia report several hundred cases per 100,000 people (7). Pakistan, located in a high-prevalence area, has an incidence rate of 451.7 per 100,000 compared to India's 214.2 per 100,000 per year (6, 8). Typhoid may not always be easily diagnosed in clinical settings, making early detection crucial.

Laboratory testing depends on the stage of infection. Blood tests are effective in 70-75% of cases during the first week of infection and are currently the standard method for detection. Worldwide, rapid immunoassay tests have been used for some years, yielding variable results (9-12).

Socioeconomic status significantly influences the burden of typhoid fever. Individuals in lower socioeconomic classes often live near lakes and rivers and in environments with poor sanitation. In contrast, those in higher socioeconomic classes typically reside farther from water sources and in cleaner environments (13). Consequently, the lifestyles dictated by socioeconomic status clearly place people in different socioeconomic categories at varying levels of risk for typhoid. As noted by Watson and Edmunds (14), funding for vaccination programs, such as those from the World Health Organization (WHO), is often limited, making it difficult for these programs to reach the entire susceptible population. Generally, individuals in lower socioeconomic classes are less educated and therefore less likely to access vaccination programs. These socioeconomic factors collectively mean that higher-class individuals have better access to healthcare, are less likely to become infected, and recover more quickly if they do get infected, compared to lower-class individuals. Thus, incorporating socioeconomic factors into the modeling of typhoid epidemic dynamics is essential for accurately evaluating prevention strategies, including vaccination programs. The primary cause of spread for fever is by polluted water and the eating of food tainted with *S. typhi*. The highest incidence of fever is observed in South-eastern Asia and South-Central Asia (Wangdi et al., 2019). Recently, a large population-based study conducted in 5 Asian nations (Pakistan, China, India, Indonesia, and Vietnam) confirmed the highest ratio of enteric fever in region. Annually, about 1.6 million children under the age of 5 die due to waterborne diseases, with 84% of these deaths occurring in rural areas. It was estimated that in 2015, 1.7 billion rural residents lacked access to safe drinking water and adequate sanitation levels (Pirsaheb, Sharafi, Ahmadi, & Moradi, 2017).

The complete blood count (CBC) is typically the initial diagnostic test ordered in various medical conditions, and it can offer valuable clues to aid in diagnosis. In addition to facilitating diagnosis, the hematological manifestations revealed by the CBC can also assist in monitoring the response to therapy and tracking the progression of the disease (15). Typhoid fever is known to induce significant hematological changes that can be instrumental in diagnosing the illness. Hematological manifestations such as pancytopenia, bicytopenia, and unicytopenia are well-documented in cases of typhoid fever, further emphasizing the importance of hematological evaluation in the diagnostic process (16). The purpose of this study was to gather epidemiological data on typhoid patients at THQ Hospital Renala Khurd, Okara, and analyze hematological parameters to understand the disease's impact.

2. Materials and methods

Source of Data

Tehsil Headquarter Hospital, Renala Khurd, Okara was selected to examine the clinical characteristics and certain hematological parameters of typhoid patients. The data of around 1000 patients will be gathered during the research period. Hematology study will be carried out by blood samples obtained from 15 typhoid patients and 15 healthy individuals between June 2023 and July 2024.

Ethical certificate and consent to participate

This study was directed according to the Declaration of Helsinki, and signed consent forms were acquired from all participants. Approval for the research was obtained from Institutional Review Board at the University of Okara. Informed consent form was obtained from patients to participate in this study.

Clinical characteristics

The questionnaire Performa was designed for interview of patients for data collection on their demography. The questions asked during interview are as follows: Age, Gender, Education, Marital status, Residence, Smoking, Economic status and Sugar status of people were asked. Any missing information that occurred during the study was excluded from the analysis.

Collection of Blood Samples

As each individual reported at the laboratory, a cleaned syringe and needle will be used to collect more or less 2-3 mL of blood. This will be done by well-trained laboratory personnel (17). During collection the blood samples will be stored in ice box and then transported to the laboratory for hematology. The blood of 15 people with no symptoms of typhoid will be collected for control cases and 15 people with typhoid will be collected to compare the hematological variations in patients.

Hematological characteristics

Hematological parameters i.e., RBCs, PCV, HB, WBCs, and Platelets was determined by sysmex KX- 21N automated hematology analyzer machine (18).

Statistical analysis

SPSS version 20 software will be used for results. To find out prognosticator of typhoid fever chi square and logistic regression model were utilized. Results will be significant if $P<0.05$ (19) .

3. Results

This study was conducted in THQ Renala Khurd for the clinical characteristics and hematological changes among typhoid patients.

Clinical characteristics

Among the people the Age, Gender, Education, Marital status, Residence, Smoking, Economic status and Sugar status of people were asked.

Age and Gender status

There were number of people in different age groups. Three age groups were selected during the study i.e., 15 to 40y, 41 to 70y and 71 to 100y. In the age group 15 to 40y about 31.73% of people were observed with typhoid and shows p value more than 0.05 i.e., (p>0.05, 0.15) and shows non-significant differences, in 41 to 70y age group about 44.24% of people were observed with typhoid and shows p value more than 0.05 i.e., (p>0.05, 0.95) and shows non-significant differences, in 71 to 100y age group of people about 24.02% were observed with typhoid and shows p value more than 0.05 i.e., (p>0.05, 0.14) and shows non-significant differences. The age groups show mean and standard deviation i.e., 51.91±21.72. This is indicated in table 1.

Table 1: Occurrence of Typhoid by age and gender

Age in years	Gender	No. of patients	Percentage %	Total %	P-value	Mean±Std
15 to 40 years	Male	84	8.41	31.73	0.15	51.91±21.72
	Female	233	23.32			
41 to 70 years	Male	131	13.11	44.24	0.95	
	Female	311	31.13			

71 to 100 years	Male	80	8.01	24.02	0.14	
	Female	160	16.02			
	Total Males	295	29.53			
	Total Females	704	70.47			
		999	100.00	100.00		

Education status

There were number of people in different education groups. Three education groups were selected during the study i.e., illiterate, middle and secondary. Among illiterate about 4% of people were observed with typhoid i.e., ($p<0.05$, 0.00) and shows significant differences, among middle about 62.46% of people were observed with typhoid i.e., ($p<0.05$, 0.01) and shows significant differences, secondary about 33.53% of people were observed with typhoid i.e., ($p<0.05$, 0.00) and shows significant differences. This can be seen in table 2.

Table 2: The education status of Typhoid patients

Education	Gender	No. of people	Percentage %	Total %	P-value
Illiterate	Male	0	0.00	4.00	0.00
	Female	40	4.00		
Middle	Male	203	20.32	62.46	0.01
	Female	421	42.14		
Secondary	Male	243	24.32	33.53	0.00
	Female	92	9.21		
Total		999	100.00		

Marital status of patients

There were number of people in different marital groups. Married or Unmarried groups were selected during the study. Among married group about 44.74% of people were observed with typhoid. Among unmarried about 55.26% of people were observed with typhoid. This shows non-significant differences i.e., ($p<0.05$, 0.78). This can be seen in table 3.

Table 3: The marital status of Typhoid patients

Marital status	Gender	No. of patients	Percentage %	Total %	P-value
Married	Male	134	13.41	44.74	0.78
	Female	313	31.33		
Unmarried	Male	161	16.12	55.26	
	Female	391	39.14		
		999	100.00		

Residence and economic status of people

There were number of people in different residence areas. Urban and rural areas were selected during the study. Among urban areas about 57.66% of people were observed with typhoid. Among rural areas about 42.34% of people were observed with typhoid. This shows non-significant differences i.e., ($p<0.05$, 0.58). This can be seen in table 4. During the study, only middle class families were observed. In the study, about 29.53% of males were observed and 70.47% of females were observed.

Table 4: Indicates the residence of typhoid patients

Residence	Gender	No. of patients	Percentage %	Total %	P-value
Urban	Male	174	17.42	57.66	0.58
	Female	402	40.24		

Rural	Male	121	12.11	42.34	
	Female	302	30.23		
		999	100.00		

Smoking and sugar status of typhoid patients

There were number of people who were smokers or non-smokers. Smokers or non-smokers were selected during the study. Among smokers about 43.94% of people were observed with typhoid. Among non-smokers about 56.06% of people were observed with typhoid. This shows non-significant differences i.e., (p=0.06). This is shown in table 5.

Table 5: Smoking status of Typhoid patients

Smoking	Gender	No. of patients	Percentage %	Total %	P-value
Smokers	Male	115	11.51	43.94	0.06
	Female	324	32.43		
Non-Smokers	Male	180	18.02	56.06	
	Female	380	38.04		
		999	100.00		

There were number of people with sugar and non-sugar status. Sugar and non-sugar people were selected during the study. Among sugar patients about 56.46% of people were observed with typhoid. Among non-sugar people about 43.54% of people were observed with typhoid. This show non-significant differences i.e., (p=0.65). The figure 1 shows the sugar status and frequency of typhoid patients.

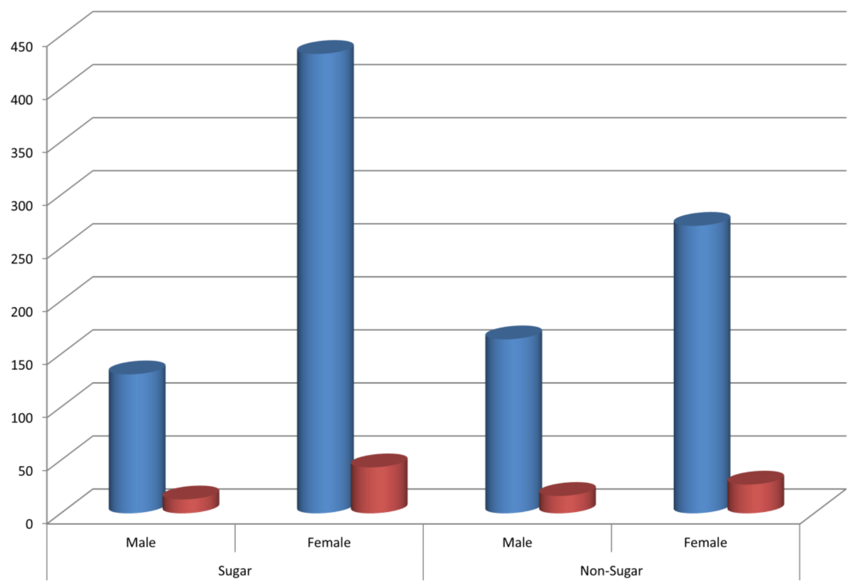

Figure 1: Frequency of sugar status among typhoid patients

Food consumption and drinking water sources

During the study, mostly people belong to rural areas; therefore they consume the food available in local areas or villages. They drink the water that is not clean in local areas due to which this effect on their health and causes typhoid. People mostly purchase the contaminated food available from local vendors. The people who consume food at home and buy from local areas with contamination in surrounding are more affected to typhoid. Their frequency was 55.56% while people who also eat fast food were 44.44%. This also shows significant differences. The people who use filtered water were less in number i.e., 43.44%, but the people who drink local water from their homes or native areas were in high frequency i.e., 56.56%. The differences among these were observed as significant. This can be seen in table 7.

Table 6: The food and drinking water sources

Food consumption	Gender	No. of patients	Percentage %	Total %	P-value
Homemade	Male	155	15.52	55.56	0.04
	Female	400	40.04		
Fast food	Male	140	14.01	44.44	
	Female	304	30.43		
		999	100		
Water source					
Filtered	Male	100	10.01	43.44	0.04
	Female	334	33.43		
Local	Male	195	19.52	56.56	
	Female	370	37.04		
		999	100		

Hematological analysis

The table 7 computes the hematological variations in control people as compared to typhoid patients. The mean and standard deviation of control was computed i.e., WBC, LYM (%), RBC, Hb, HCT, MCV, MCH, MCHC, PLT, and MPV, with values 4.03±1.42, 33.85±5.14, 4.82±0.45, 12.42±1.64, 40.48±4.73, 83.90±4.61, 25.74±2.12, 59.42±86.56, 285.50±104.44 and 13.89±9.10 respectively. The mean and standard deviation of control was computed i.e., WBC, LYM (%), RBCs, Hb, HCT, MCV, MCH, MCHC, PLT, and MPV, with values 9.20±2.83, 20.80±7.01, 4.89±0.80, 11.55±2.36, 40.61±6.68, 86.75±4.53, 25.46±2.26, 29.39±1.12, 301.10±119.70 and 9.19±0.64 respectively.

Table 7: Shows the hematological variations among typhoid patients

Test	**Normal values**	**Units**	**Mean±Stdev (Experimental)**	**Mean±Stdev (Control)**
WBC count (TLC)	5.00-11.60	x10^9/I	4.03±1.42	9.20±2.83
LYM	1.30-4.00	%	33.85±5.14	20.80±7.01
RBC	3.79-5.78	x10^12/I	4.82±0.45	4.89±0.80
Hb	11.5-17.3	g/dI	12.42±1.64	11.55±2.36
HCT (PVC)	34.00-53.90	%	40.48±4.73	40.61±6.68
MCV	84-98	fI	83.90±4.61	86.75±4.53
MCH	27.5-32.4	pg	25.74±2.12	25.46±2.26
MCHC	31.7-34.2	g/dI	59.42±86.56	29.39±1.12
Platelet count (PLT)	156-342	x10^9/I	285.50±104.44	301.10±119.70
Mean platelet volume (MPV)	8.3-12.1	FL	13.89±9.10	9.19±0.64

4. Discussion

In this work, the clinical characteristics and hematological parameters of people were studied in THQ Renala khurd, Okara.

Typhoid fever remains a significant infection in endemic regions and among travelers visiting these areas. While the incidence of typhoid fever has decreased in many middle-income countries, the majority of cases still occur in the Indian subcontinent and Southeast Asia (20). Inadequate personal hygiene and improper food handling practices can significantly contribute to the transmission of S. typhi. Certain food items stored at room temperature have been identified as conducive environments for the growth of Salmonella spp. Food handlers play a crucial role in spreading typhoid bacteria through various food products and water sources (21). They worked to study the typhoid carriers in relation to socio economic position amongst food handlers in Tamil Nadu, India. The work on the socio-economic status has been now conducted in Pakistan

In their study, the occurrence of typhoid was found to be 5.0%, which is consistent with findings from Central Ethiopia (4.1%) (22) among people with clinically same symptoms. Similar prevalence rates were also observed outside of Ethiopia, such as in Kenya among adult patients (6.3%) (23) and in Papua New Guinea across all age groups (4%) (24). Moreover, their findings were higher than those of a study in Mekelle, Ethiopia (1.6%) (25) but lower than those of a study conducted in Egypt (13.64%) (26). The difference were explained by change in geographical location (27, 28). In this study higher prevalence of typhoid was observed among females then males in Pakistan.

The highest incidence, 29 cases (11.16%), was recorded among males aged 10-25, whereas the lowest incidence, 10 cases (4.00%), was found among females aged 61-80. At the State Specialist Hospital in Akure, males aged 10-25 had the highest incidence at 14 cases (8.23%), and females aged 61-80 had the lowest at 3 cases (3.00%). In contrast, at the Federal Medical Centre in Owo, the highest incidence was 29 cases (17.06%) in males aged 41 to 60, and the lowest was 10 cases (41.67%) in females aged 10 to 25 (29). In this study, three age groups were selected during the study i.e., 15 to 40y, 41 to 70y and 71 to 100y. In the age group 15 to 40y about 31.73% of people were observed, in 41 to 70y age group about 44.24% of people were observed, in 71 to 100y age group of people about 24.02% were observed with typhoid.

About 558 patients with signs and symptoms of typhoid fever were enrolled in the study. The majority were females, making up 67.38% (376 out of 558) of the sample. Most participants were aged 11-20 years (219 out of 558, 39.27%) and were students. In terms of occupation, students were the largest group, representing 47.67% (n = 266) of the sample, followed by those working in the private sector at 25.80% (n = 144). Housewives accounted for 21.68% (n = 121) of the sample, while civil servants made up only 4.83% (n = 27). There was significant differences in distribution of typhoid fever between genders (P = 0.0148), with males having a higher infection rate (18.1%) compared to females (10.4%). Overall, the study included more female than male participants.

Marital status also showed a significant difference (P = 0.0025), with the prevalence of typhoid fever being higher among the unmarried population (19.2%) (30). At the Don Bosco Clinic, out of 250 sampled patients, 103 (41.20%) were married, and 147 (58.80%) were unmarried. Among the married, there were 57 males (55.34%) and 46 females (44.66%), while the unmarried group comprised 83 males (56.46%) and 64 females (43.54%). Of the 100 sampled patients, 48% were married and 52% were unmarried. Among the married, 54.16% were males and 45.84% were females. For the unmarried group, 63.46% were males and 36.54% were females. At the Federal

Medical Centre in Owo, 54.71% of patients were married and 45.29% were unmarried. Within the married group, 55.91% were males and 44.09% were females. In the unmarried group, 55.84% were males and 44.16% were females (29). In this study, among married group about 44.74% of people were observed with typhoid. Among unmarried about 55.26% of people were observed with typhoid. This shows p value more than 0.05 i.e., ($p<0.05$, 0.78) and shows non-significant differences.

According to the education, approximately half of the people had a secondary level of education (54.48%), tertiary level of education (31.18%), and primary level of education (13.97%). The least represented were individuals who never attended school (0.17%). In terms of marital status, married individuals were the most represented (56.27%), followed by single individuals (37.27%), with widows being the least represented (6.45%) (30). In this study, among illiterate about 4% of people were observed with typhoid and shows p value less than 0.05 i.e., ($p<0.05$, 0.00) and shows significant differences, among middle about 62.46% of people were observed with typhoid and shows p value less than 0.05 i.e., ($p<0.05$, 0.01) and shows significant differences, secondary about 33.53% of people were observed with typhoid and shows p value less than 0.05 i.e., ($p<0.05$, 0.00) and shows significant differences. The smoking and diabetes have no relation with typhoid. Their differences were observed non-significant in this study.

This analysis highlights the connection between different drinking water sources and the prevalence of waterborne diseases. Among those who rely on water boreholes, 20.43% experience typhoid fever, 17.45% suffer from diarrhea, 8.09% have dysentery, and 1.28% contract Hepatitis A. For individuals consuming sachet water, the rates are 25% for typhoid fever, 3.13% for diarrhoea, 6.23% for dysentery, and 3.13% for Hepatitis A. Spring water consumers report 17.24% for typhoid fever, 8.79% for diarrhoea, and no cases of dysentery or Hepatitis A. Among those using harvested rainwater, the rates are 13.64% for typhoid fever, 9.09% for diarrhoea, 4.55% for dysentery, and no cases of Hepatitis A. The high incidence of waterborne diseases, particularly among water borehole users, indicates a pressing need for improvements in water quality, such as implementing point-of-use water treatment facilities and regulating borehole drilling practices (31). In this study, it was found that the people who drink contaminated water were 56.56% while those who use filtered water were 43.44%. Those who eat homemade food constitute about 55.56% while those who eat fast food as well comprises of 44.44%. This factor play main role in the spreading of typhoid and different type of diseases.

In the majority of patients, hemoglobin levels are typically normal during the early stages of illness but tend to decrease as the illness progresses. Study (32) reported anemia in 42.9% of their prospective study participants, while study (33) observed anemia in 34% of their patients with enteric fever. Our findings regarding anemia were consistent with these studies. It's noteworthy that severe anemia is uncommon in typhoid fever, and its presence may raise suspicion of conditions such as intestinal hemorrhage, hemolysis, or other alternative diagnoses like malaria (32). While the results obtained in our study for anemia were similar to those reported in previous studies, statistically, these similarities were not significant. This lack of significance could potentially be attributed to the maturational arrest of cell lines in salmonella infection within the bone marrow (33). The hematological changes observed in patients with typhoid indicate that lymphocytosis and neutropenia were suppressed, as this show non-significant in values (34). While typhoid fever has been observed to have an effect on hematological parameters, our findings revealed a significant decrease in erythrocyte sedimentation rate (ESR) and hemoglobin concentration in both male and female patients with typhoid fever. This could potentially lead to anemia. Interestingly, our study also found that

platelet count (PLT) was higher in females compared to males, which aligns with findings from previous studies (35). In the current study, the mean and standard deviation of various hematological parameters were computed for both control subjects and typhoid patients. Among controls, the values were as follows: WBC 4.03±1.42, LYM (%) 33.85±5.14, RBC 4.82±0.45, Hb 12.42±1.64, HCT 40.48±4.73, MCV 83.90±4.61, MCH 25.74±2.12, MCHC 59.42±86.56, PLT 285.50±104.44, and MPV 13.89±9.10. On the other hand, typhoid patients exhibited different values for these parameters: WBC 9.20±2.83, LYM (%) 20.80±7.01, RBC 4.89±0.80, Hb 11.55±2.36, HCT 40.61±6.68, MCV 86.75±4.53, MCH 25.46±2.26, MCHC 29.39±1.12, PLT 301.10±119.70, and MPV 9.19±0.64. These findings indicate notable variations in hematological parameters between control subjects and typhoid patients.
The findings from this study align with previous research conducted by (36) and (37) which also examined hematological alterations associated with typhoid fever. These changes are likely attributable to the suppression of bone marrow activity and hemophagocytosis, which are key mechanisms through which Salmonella typhi affects patients with typhoid fever.

5. Conclusion

In conclusion, typhoid fever poses a significant health threat to all individuals and can lead to complications such as anaemia and other illnesses. Various risk factors, including residence location, and dietary factors, were observed to influence the spread of the disease. Some factors including smoking and diabetes have no relation with typhoid. Their differences were observed non-significant. The food consumption activities and the water drinking sources also show significant difference. Haematological analysis indicated notable differences in complete blood count between case studies and controls. Enhancing living conditions and promoting a healthier environment could aid in reducing the prevalence of typhoid fever. Additionally, promoting proper nutrition and food safety practices may contribute to better health outcomes for individuals at risk of typhoid infection.

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