

## IMPACT OF WATER, SANITATION AND HYGIENE (WASH) INTERVENTION ON TYPHOID INCIDENCE IN KHYBER PAKHTUNKHWA PAKISTAN

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### ABSTRACT

Typhoid fever, a bacterial infection caused by *Salmonella Typhi*, remains a significant public health concern in developing Asian countries, including Sri Lanka, India, and Pakistan. Pakistan has estimated 11 million cases and 60,000 deaths annually. The disease is primarily transmitted through contaminated water, food, and poor sanitation, highlighting the need for improved hygiene and infrastructure. Furthermore, the emergence of antibiotic-resistant *Salmonella Typhi* strains has complicated treatment, emphasizing the importance of effective antibiotics and vaccines in controlling and preventing typhoid fever.

**Objective:** The aim of our research to find the impact of water, sanitation and hygiene intervention on typhoid patients.

**Materials and Methods:** This was a cross-sectional study with a sample size of 400 participants calculated through calculator.net website. Data was collected through questionnaire which was structured questionnaire. It was ethically approved by BMC research society. Data was analyzed through SPSS v-27.

**Results:** The study included 400 participants with 53.3% males and 46.8% females. Urban residents comprised 53.8% of the sample, while 46.3% were from rural areas. A personal history of typhoid was reported by 23.0% (n=92) of participants. The most common timeframe for previous illness was 1–2 years ago (10.8%), followed by within the last year (3.5%), within the past 6 months (2.5%), and currently experiencing symptoms (1.0%). Family history of typhoid was more prevalent, with 48.3% reporting one or more affected family members. Most commonly, one (25.5%) or two (13.5%) family members were affected, with a smaller percentage reporting three or more.

Water sources were primarily tap (46.0%) and well water (45.0%), with 9.0% relying on bottled water. Only 41.8% reported treating their drinking water. Sanitation conditions showed 73.5% used flush toilets, 21.3% pit latrines, and 5.3% other types. Half had access to a functioning sewer system, and 55.3% had proper drainage; 20.3% reported no drainage system. Hygiene practices were generally positive, with 83.8% regularly washing hands before meals and after using the toilet, and 78.8% using a clean towel for hand drying. Regarding treatment, 30.8% used antibiotics, 12.5%

received combined treatment (antibiotics, rest, hospitalization), while 52.3% had never received treatment, likely reflecting those who had never contracted typhoid or had limited healthcare access.

**Conclusion:** This study highlights the significant burden of typhoid fever in Khyber Pakhtunkhwa, Pakistan, and emphasizes the need for improved water, sanitation, and hygiene (WASH) practices to control its transmission. Effective WASH interventions can significantly reduce the incidence of typhoid fever, saving lives and reducing healthcare costs.

**Keywords:**

Typhoid Fever, Water, Sanitation, and Hygiene (WASH), Khyber Pakhtunkhwa, Pakistan, Salmonella Typhi, Infectious Diseases, Public Health, Epidemiology.

**INTRODUCTION:**

Typhoid fever is more common in developing countries of Asia like Sri Lanka, India, Pakistan and other countries. It is common in urban than in rural areas. There are more than 23 million cases with more than 3 laces deaths each year. Representing 1-6% mortality rate [1,2]. The causative agent of typhoid fever is a gram-negative bacteria named *Salmonella typhi*. A lot of varieties animals can be infected with salmonella, but only human have salmonella typhi and salmonella paratyphoid associated with typhoid fever. The live stock animals are not the vectors of typhoid fever [3,4]. Typhoid fever is transmitted through contaminated water and poor sanitation. It is transmitted with sustenance polluted with fecal material. [5,6]. The ratio of typhoid fever is high in under developing countries due to poor hygiene and sanitation and non-availability of sage water.[7]. The recent observations show the development of resistance against the anti-typhoid medicines (Ampicillin, chloramphenicol) among the typhoid salmonellae especially in Southeast Asia, including Pakistan. [8,9]. World health organization recommend three types of vaccines to control and prevent typhoid fever (TCV, IUPV and OLA Ty12aV). [10]. People with chronic conditions like gastroenteritis, intestinal Parasites, inflammatory bowel disease are more Susceptible to typhoid fever [11,12]. When salmonella is ingested, it is asymptomatic for to 14 days. During this period there is only fever. After this the temperature rises to 40c0 and rash develops on the neck and abdomen including headache, abdominal pain, splenomegaly hepatomegaly etc. [13,14]. Ampicillin, Trimethoprim sulfamethoxazole, Ciprofloxacin to be used to treat fever and

demonstrates poor potency against *salmonella typhi* and its introduction has been associated with rapid emergence of resistance is *Salmollae*. [15]. As compared to above antibiotics nowadays the effective antibiotics for typhoid is our ceftriaxone, ceftriaxone and class fluoroquinolones.

**Results:**

A total of 400 participants were included in this study. The age distribution showed that the majority were between 16 and 22 years old (68.8%,  $n = 275$ ), followed by those aged 23–28 years (26.3%,  $n = 105$ ), and a smaller group aged 29–35 years (5.0%,  $n = 20$ ). A significant association was found between age and variables such as personal and family history of typhoid fever, time since last infection, number of affected family members, treatment received, and complications experienced ( $p = 0.000-0.003$ ).

The gender distribution was relatively balanced, with males accounting for 53.3% ( $n = 213$ ) and females 46.8% ( $n = 187$ ). Gender showed statistically significant associations with most variables, including having typhoid ( $p = 0.017$ ), treatment ( $p = 0.008$ ), and complications ( $p = 0.043$ ), but not with family history of typhoid ( $p = 0.212$ ).

Participants had varying levels of education, with the majority being undergraduates (62.3%,  $n = 249$ ), followed by postgraduates (23.3%,  $n = 93$ ), secondary-level (13.8%,  $n = 55$ ), and middle-level education (0.8%,  $n = 3$ ). Education level was significantly associated with all variables assessed ( $p = 0.000-0.024$ ).

Regarding residence, 53.8% ( $n = 215$ ) were from urban areas, and 46.3% ( $n = 185$ ) from rural settings. However, urban/rural status did not

show significant associations with most outcomes, except for time since last typhoid infection ( $p = 0.000$ ) and number of affected family members ( $p = 0.012$ ).

Geographically, the sample represented multiple districts, with Mardan (17.3%), Peshawar (15.5%), and Swabi (14.2%) being the most represented. District of living was significantly associated with all typhoid-related variables ( $p = 0.000$ ).

When asked "Have you ever had typhoid?", 23.0% ( $n = 92$ ) reported a personal history of typhoid, with 10.8% ( $n = 43$ ) having it 1-2 years ago, 3.5% ( $n = 14$ ) within 6-12 months, 2.5% ( $n = 10$ ) in the last 6 months, and 1.0% ( $n = 4$ ) currently experiencing symptoms. Personal history of typhoid was significantly associated with age, gender, education, district, diagnosis method, primary water source ( $p = 0.012$ ), handwashing frequency ( $p = 0.001$ ), preventive measures ( $p = 0.000$ ), and belief in hygiene ( $p = 0.020$ ).

Family history of typhoid was reported by 48.3% ( $n = 193$ ), with 25.5% ( $n = 102$ ) reporting one affected family member, 13.5% ( $n = 54$ ) two members, and smaller proportions reporting three or more. Family history had significant associations with age, education, district, diagnosis method, towel usage ( $p = 0.003$ ), water treatment ( $p = 0.011$ ), and hygiene beliefs ( $p = 0.000$ ).

Regarding diagnostic methods, 47.5% reported diagnosis through blood tests, 5.8% through physical examination, 1.5% via stool tests, and 2.3% cited other methods, while 43.0% ( $n = 172$ ) had never been diagnosed. Diagnostic method was significantly associated with all outcome variables ( $p = 0.000$ ).

Concerning water sources, 46.0% used tap water, 45.0% well water, and 9.0% bottled water. A significant association was found between drinking water source and history of typhoid ( $p = 0.012$ ), treatment received ( $p = 0.000$ ), and complications ( $p = 0.005$ ), but not with time of infection or family history.

Sanitation and hygiene conditions varied. While 73.5% used flush toilets, others used pit latrines (21.3%) or other facilities (5.3%). Sewer systems

were functional in 50.2% of homes. Proper drainage was available to 55.3%, partially available to 24.5%, and absent in 20.3%. Toilet facility, drainage, and sewer system had mixed associations, with drainage and sewer system showing marginal or no significance for some outcomes.

Water treatment practices were lacking—only 41.8% treated their drinking water, while 58.3% did not. This variable showed significant association with nearly all outcomes except for personal history of typhoid fever ( $p = 0.921$ ).

Hand hygiene was generally good, with 43.5% always washing hands before meals and after toilet use, and 40.3% doing so most of the time. However, 10.8% admitted to only sometimes washing hands, 4.5% rarely, and 1.0% never. Handwashing frequency was strongly associated with all typhoid outcomes ( $p \leq 0.001$ ), while the use of clean towels (78.8%) had significant associations with family history and treatment outcomes but not with complications.

In terms of preventive measures, significant associations were found across all outcome variables ( $p = 0.000$ ), suggesting a strong link between typhoid prevention efforts and infection and recovery patterns.

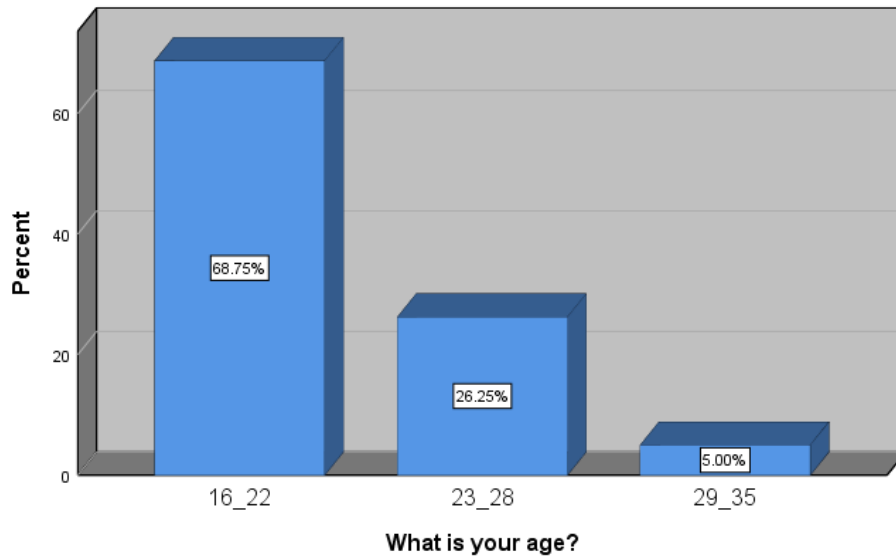
Treatment methods varied among those who had contracted typhoid. Antibiotics were used by 30.8% ( $n = 123$ ), while 12.5% received a combination of antibiotics, rest, and hospitalization. Only 2.3% received rest and hydration alone, and 2.3% were hospitalized. Interestingly, 52.3% reported they never received any treatment—likely because they never contracted the illness. Treatment types had significant associations with all major socio demographic and hygiene-related variables.

Lastly, complications from typhoid treatment were significantly associated with age, gender, education, district, diagnosis method, water source, toilet type, hand hygiene, water treatment, preventive practices, and sanitation beliefs. However, no significant association was found with urban/rural residence ( $p = 0.880$ ), towel use ( $p = 0.848$ ), functional sewer systems ( $p = 0.750$ ), or proper drainage ( $p = 0.150$ ).

**What is your age?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	16_22	275	68.8	68.8	68.8
	23_28	105	26.3	26.3	95.0
	29_35	20	5.0	5.0	100.0
	Total	400	100.0	100.0	

**What is your age?**



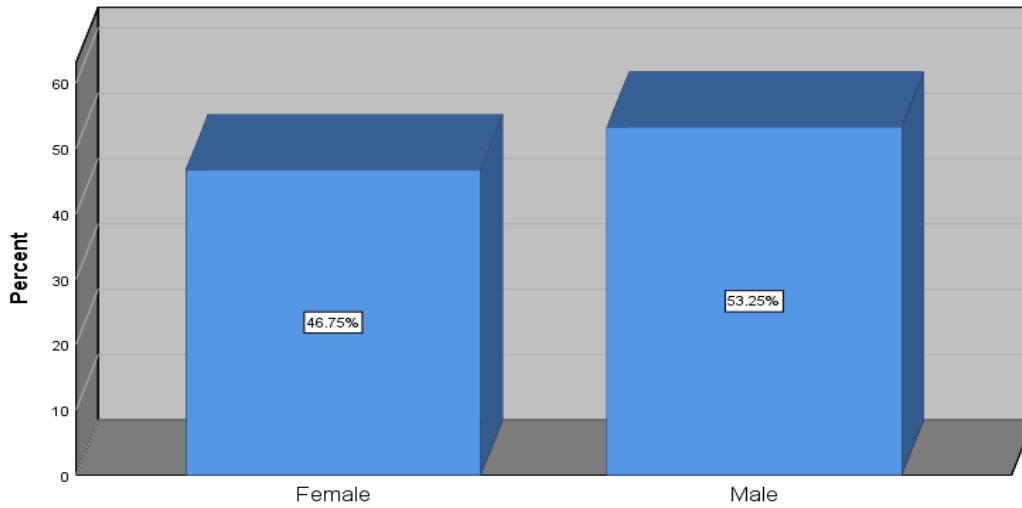
The age distribution of respondents shows that the majority (68.8%) fall within the 16-22 age range, followed by 26.3% in the 23-28 age group. A small percentage (5.0%) are aged between 29-

35 years. This indicates that most respondents are relatively young, with the highest concentration in the 16-22 range.

**What is your gender?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	187	46.8	46.8	46.8
	Male	213	53.3	53.3	100.0
	Total	400	100.0	100.0	

**What is your gender**



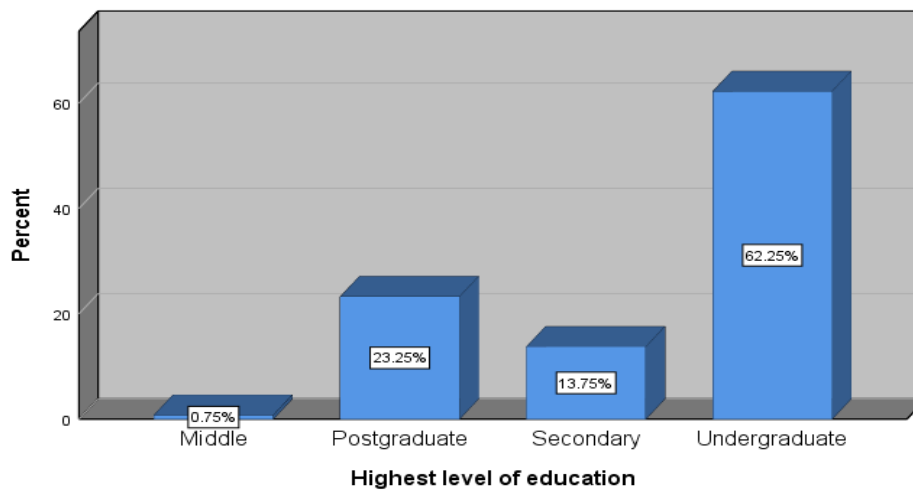
**What is your gender**

Out of the 400 respondents, 53.3% are male and 46.8% are female, showing a slight male majority in this sample.

**Highest level of education**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Middle	3	.8	.8	.8
	Postgraduate	93	23.3	23.3	24.0
	Secondary	55	13.8	13.8	37.8
	Undergraduate	249	62.3	62.3	100.0
	Total	400	100.0	100.0	

**Highest level of education**



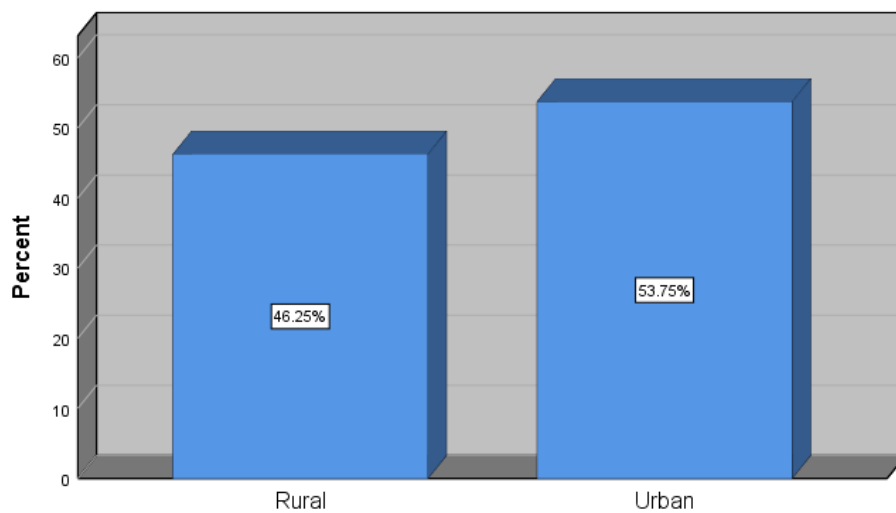
A significant portion of respondents (62.3%) reported having completed undergraduate education, while 23.3% have a postgraduate

qualification. Secondary education was reported by 13.8% and only 0.8% had completed middle school.

**Where do you live?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rural	185	46.3	46.3	46.3
	Urban	215	53.8	53.8	100.0
	Total	400	100.0	100.0	

**Where do you live ?**



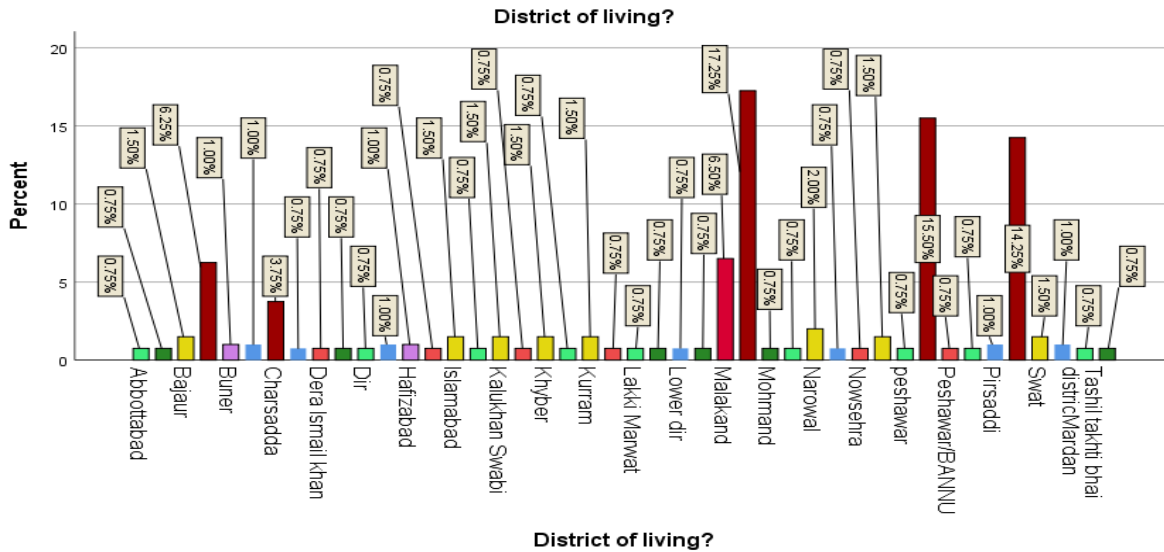
**Where do you live ?**

The respondents are divided between rural and urban areas, with 53.8% living in urban settings and 46.3% in rural areas.

**District of living?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Abbottabad	3	.8	.8	.8
	bajaur	3	.8	.8	1.5
	Bajaur	6	1.5	1.5	3.0
	Bannu	25	6.3	6.3	9.3
	Buner	4	1.0	1.0	10.3
	Chakwal	4	1.0	1.0	11.3
	Charsadda	15	3.8	3.8	15.0
	Chd	3	.8	.8	15.8
	Dera Ismail khan	3	.8	.8	16.5
	Dikhan	3	.8	.8	17.3
	Dir	3	.8	.8	18.0
	Dir upper	4	1.0	1.0	19.0

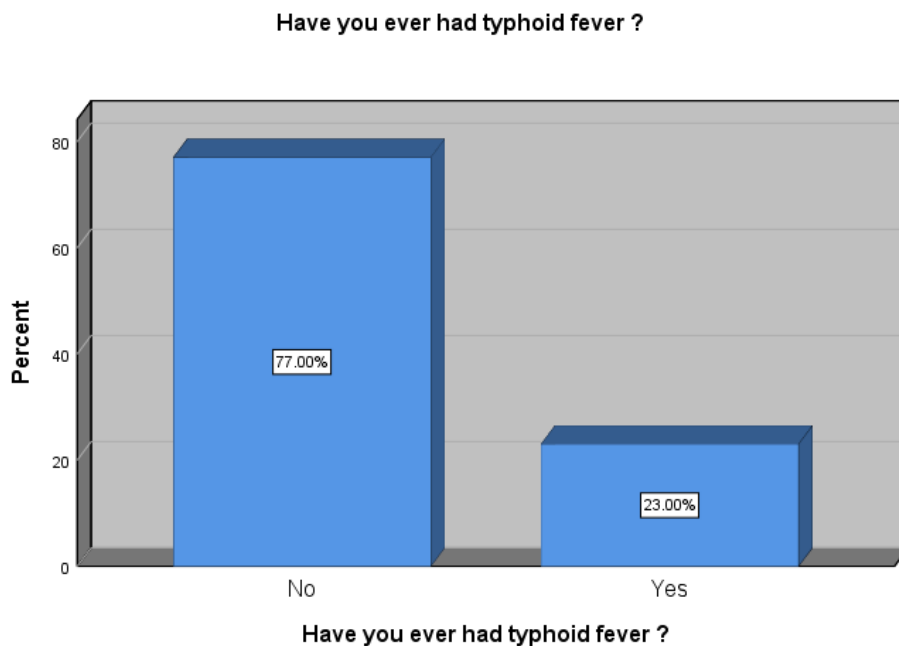
Hafizabad	4	1.0	1.0	20.0
Hangu	3	.8	.8	20.8
Islamabad	6	1.5	1.5	22.3
ISLAMABAD	3	.8	.8	23.0
Kalukhan Swabi	6	1.5	1.5	24.5
Karak	3	.8	.8	25.3
Khyber	6	1.5	1.5	26.8
KPK	3	.8	.8	27.5
Kurram	6	1.5	1.5	29.0
Lakki marwat	3	.8	.8	29.8
Lakki Marwat	3	.8	.8	30.5
LAKKI marwat	3	.8	.8	31.3
Lower dir	3	.8	.8	32.0
malakand	3	.8	.8	32.8
Malakand	26	6.5	6.5	39.3
Mardan	69	17.3	17.3	56.5
Mohmand	3	.8	.8	57.3
Muzaffargarh	3	.8	.8	58.0
Narowal	8	2.0	2.0	60.0
North Waziristan	3	.8	.8	60.8
Nowsehra	3	.8	.8	61.5
Nowshera	6	1.5	1.5	63.0
peshawar	3	.8	.8	63.7
Peshawar	62	15.5	15.5	79.3
Peshawar/BANNU	3	.8	.8	80.0
Peshawer	3	.8	.8	80.8
Pirsaddi	4	1.0	1.0	81.8
Swabi	57	14.2	14.2	96.0
Swat	6	1.5	1.5	97.5
Takht bhai Mardan	4	1.0	1.0	98.5
Tashil takhti bhai districMardan	3	.8	.8	99.3
Yes	3	.8	.8	100.0
Total	400	100.0	100.0	



The district distribution of respondents is quite diverse, with the most significant number coming from Mardan (17.3%), followed by Peshawar (15.5%) and Swabi (14.2%). Other districts like Malakand (6.5%), Bannu (6.3%), and Nowshera (1.5%) also contributed smaller portions.

**Have you ever had typhoid fever ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	308	77.0	77.0	77.0
	Yes	92	23.0	23.0	100.0
	Total	400	100.0	100.0	

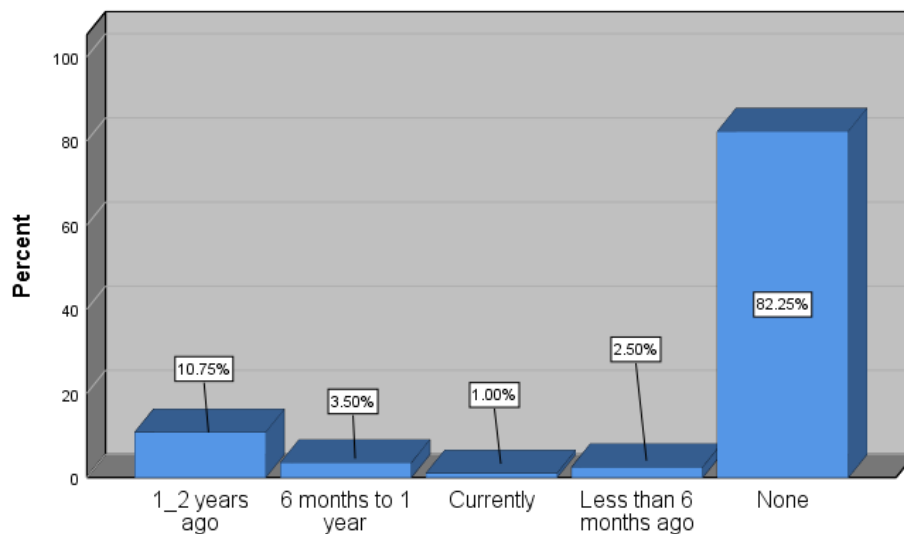


Of the 400 respondents, 23% reported having had typhoid fever, while 77% indicated that they have never been infected

**How long ago did you have last typhoid fever ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1_2 years ago	43	10.8	10.8	10.8
	6 months to 1 year	14	3.5	3.5	14.2
	Currently	4	1.0	1.0	15.3
	Less than 6 months ago	10	2.5	2.5	17.8
	None	329	82.3	82.3	100.0
	Total	400	100.0	100.0	

**How long ago did you have last typhoid fever ?**



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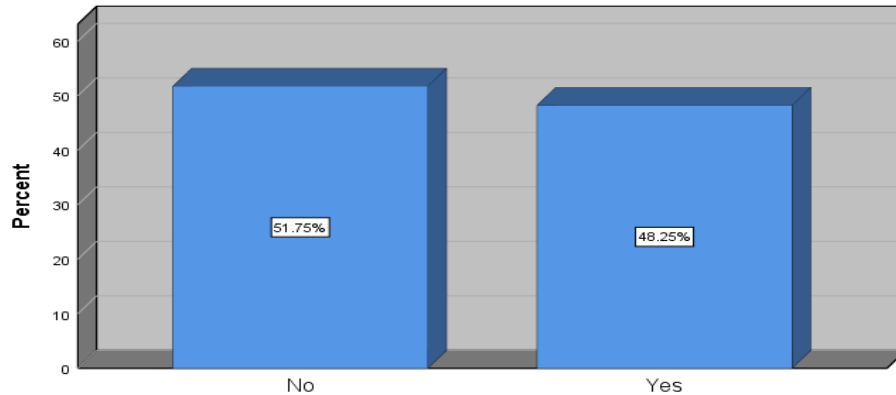
Among those who had experienced typhoid fever, 10.8% reported it occurred 1-2 years ago, 3.5% within the past 6 months to 1 year, and 2.5% less than 6 months ago. A small portion (1.0%)

mentioned that they are currently suffering from typhoid. A majority (82.3%) had not reported a recent infection.

**Have any of the family members had typhoid fever in the past ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	207	51.7	51.7	51.7
	Yes	193	48.3	48.3	100.0
	Total	400	100.0	100.0	

Have any of the family members had typhoid fever in the past ?



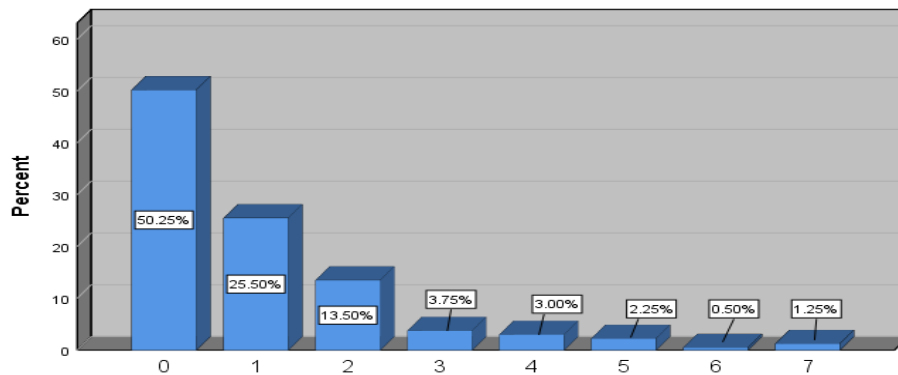
Have any of the family members had typhoid fever in the past ?

About 48.3% of respondents had a family member who experienced typhoid fever, while 51.7% did not.

If yes ,then how many family members experience it ?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	201	50.3	50.3	50.3
	1	102	25.5	25.5	75.8
	2	54	13.5	13.5	89.3
	3	15	3.8	3.8	93.0
	4	12	3.0	3.0	96.0
	5	9	2.3	2.3	98.3
	6	2	.5	.5	98.8
	7	5	1.3	1.3	100.0
	Total	400	100.0	100.0	

If yes ,then how many family members experience it ?



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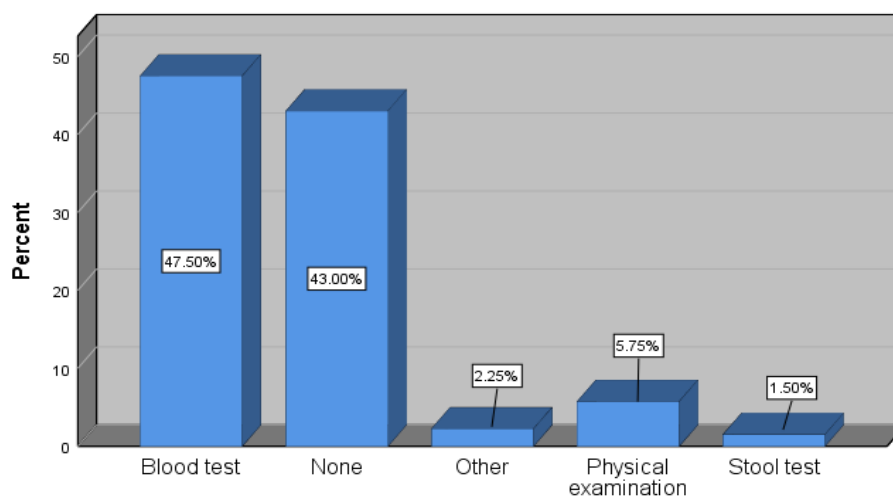
Of those who had family members with typhoid fever, the largest group (50.3%) reported that no one else in their family had it. However, 25.5%

reported one family member had been affected, and smaller percentages indicated 2 or more family members had experienced it.

### How was the diagnosis of typhoid fever?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Blood test	190	47.5	47.5	47.5
	None	172	43.0	43.0	90.5
	Other	9	2.3	2.3	92.8
	Physical examination	23	5.8	5.8	98.5
	Stool test	6	1.5	1.5	100.0
	Total	400	100.0	100.0	

### How was the diagnosis of typhoid fever?



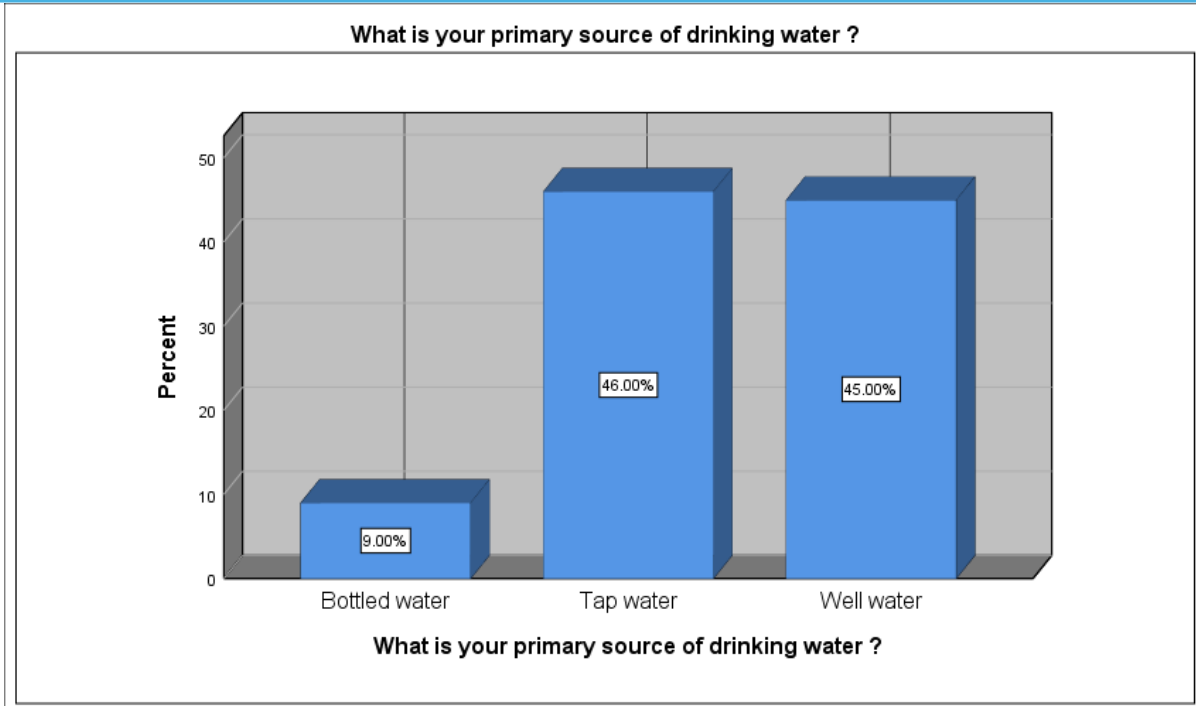
### How was the diagnosis of typhoid fever?

The majority of respondents (47.5%) reported that their typhoid fever was diagnosed through a blood test. Physical examination was cited by 5.8%, while stool tests accounted for only 1.5%.

Notably, 43% indicated that they had not received any diagnosis or testing for the condition.

### What is your primary source of drinking water ?

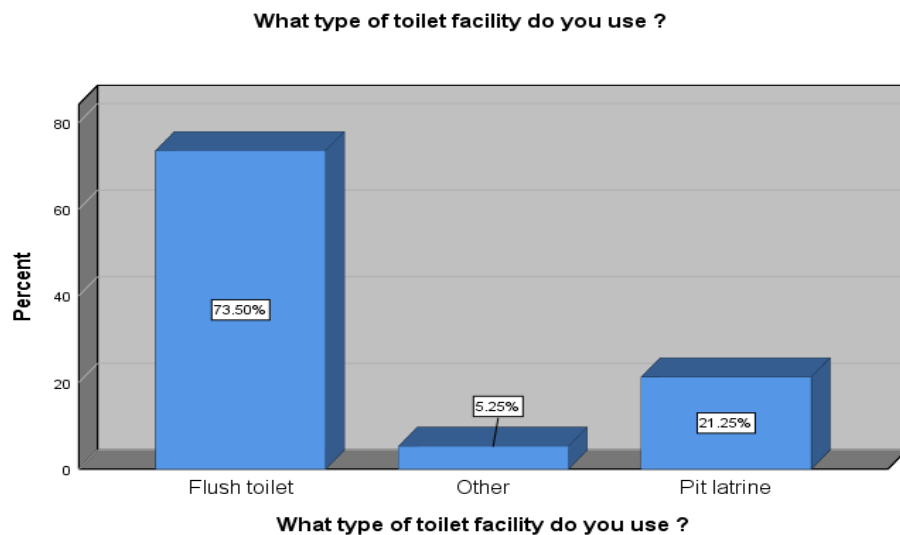
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Bottled water	36	9.0	9.0	9.0
	Tap water	184	46.0	46.0	55.0
	Well water	180	45.0	45.0	100.0
	Total	400	100.0	100.0	



The primary sources of drinking water for respondents are predominantly tap water (46.0%) and well water (45.0%). Bottled water is consumed by 9.0% of the respondents.

**What type of toilet facility do you use ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Flush toilet	294	73.5	73.5	73.5
	Other	21	5.3	5.3	78.8
	Pit latrine	85	21.3	21.3	100.0
	Total	400	100.0	100.0	

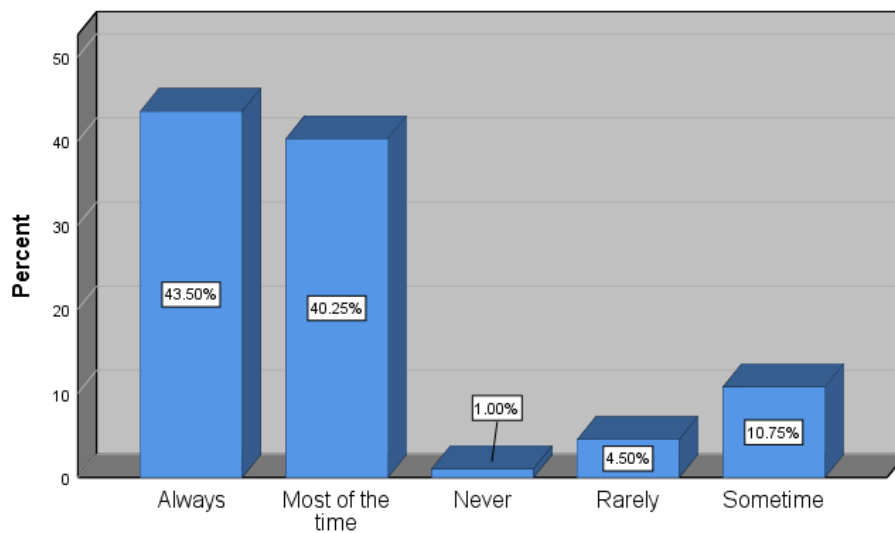


The majority of respondents (73.5%) use a flush toilet, while 21.3% rely on pit latrines, and 5.3% use other types of toilets.

**How often do you wash your hands with soap and water ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	174	43.5	43.5	43.5
	Most of the time	161	40.3	40.3	83.8
	Never	4	1.0	1.0	84.8
	Rarely	18	4.5	4.5	89.3
	Sometime	43	10.8	10.8	100.0
	Total	400	100.0	100.0	

**How often do you wash your hands with soap and water ?**



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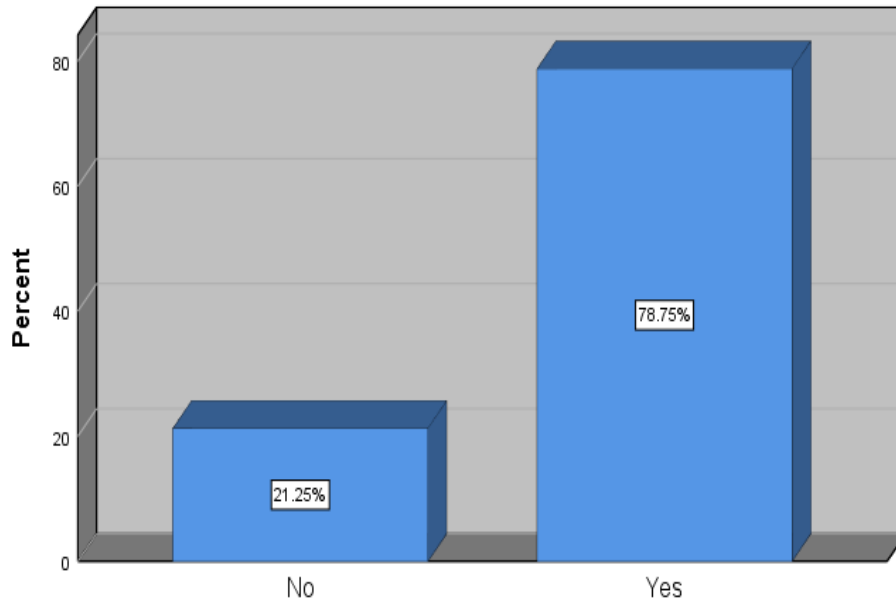
A large number of respondents (43.5%) reported always washing their hands with soap and water, while 40.3% wash most of the time. However,

4.5% wash hands rarely, and 10.8% wash sometimes.

**Do you use a clean towel to dry your hands after washing ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	85	21.3	21.3	21.3
	Yes	315	78.8	78.8	100.0
	Total	400	100.0	100.0	

**Do you use a clean towel to dry your hands after washing ?**



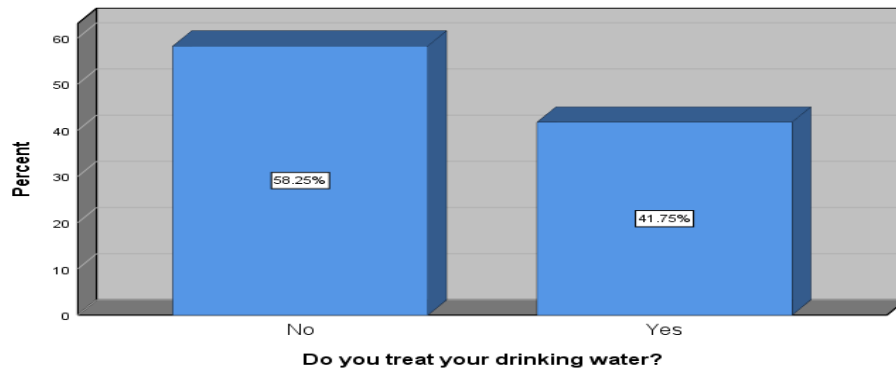
**Do you use a clean towel to dry your hands after washing ?**

The vast majority (78.8%) of respondents use a clean towel to dry their hands after washing, while 21.3% do not.

**Do you treat your drinking water?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	233	58.3	58.3	58.3
	Yes	167	41.8	41.8	100.0
	Total	400	100.0	100.0	

**Do you treat your drinking water?**

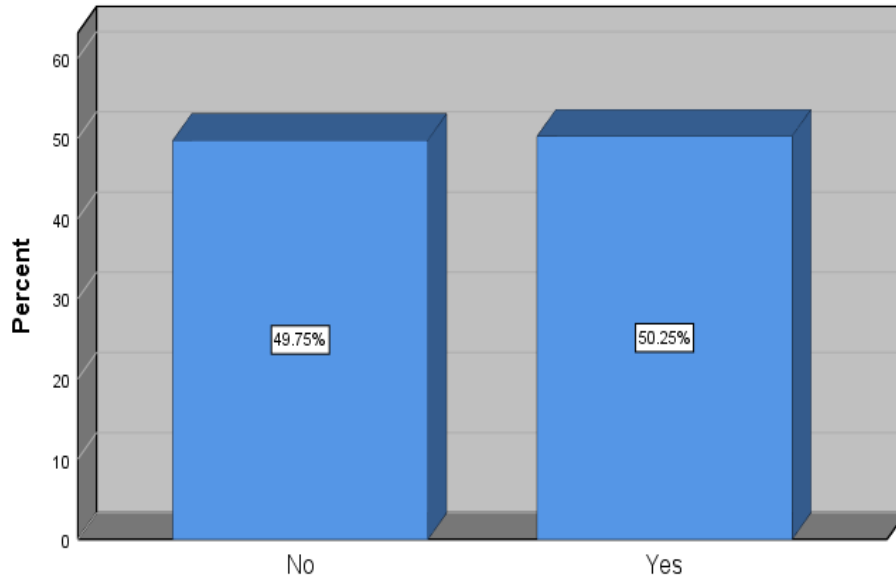


A little over half of the respondents (58.3%) do not treat their drinking water, while 41.8% do.

**Do you have a functional sewer in your community?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	199	49.8	49.8	49.8
	Yes	201	50.2	50.2	100.0
	Total	400	100.0	100.0	

**Do you have a functional sewer in your community?**



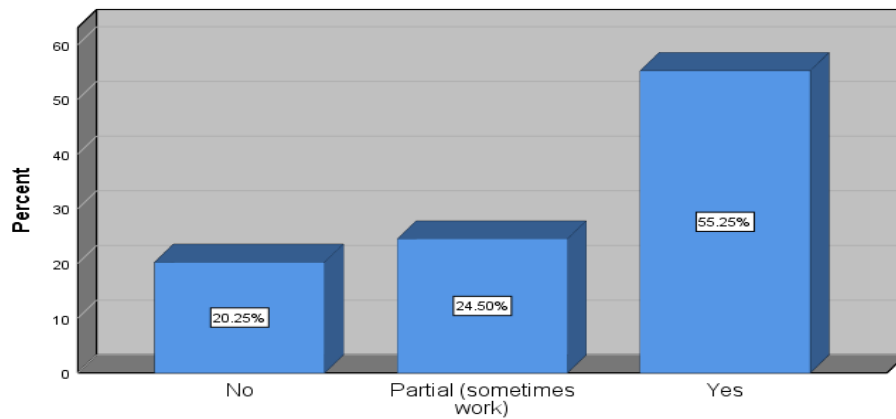
**Do you have a functional sewer in your community?**

The data shows that 50.2% of respondents have a functional sewer system in their community, while 49.8% do not.

**Is there a proper drainage system in your area ?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	81	20.3	20.3	20.3
	Partial (sometimes work)	98	24.5	24.5	44.8
	Yes	221	55.3	55.3	100.0
	Total	400	100.0	100.0	

**Is there a proper drainage system in your area ?**



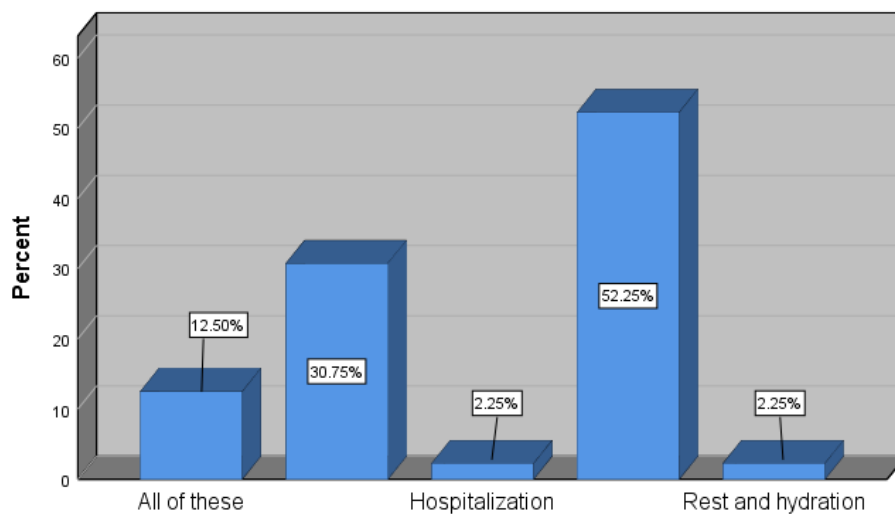
**Is there a proper drainage system in your area ?**

A majority of respondents (55.3%) reported having a proper drainage system, while 24.5% said their drainage system is partial, and 20.3% do not have one at all.

**What treatment did you receive for typhoid fever?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All of these	50	12.5	12.5	12.5
	Antibiotics	123	30.8	30.8	43.3
	Hospitalization	9	2.3	2.3	45.5
	None	209	52.3	52.3	97.8
	Rest and hydration	9	2.3	2.3	100.0
Total		400	100.0	100.0	

**What treatment did you receive for typhoid fever?**



**What treatment did you receive for typhoid fever?**

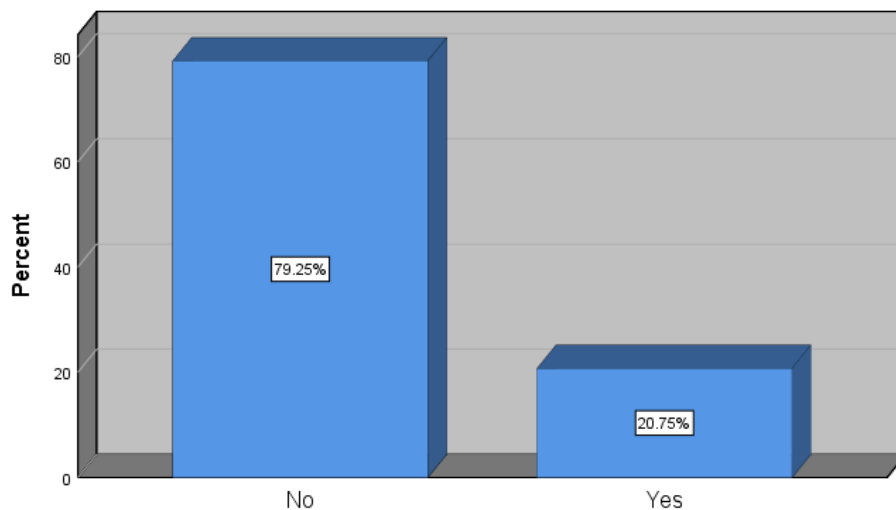
The treatment data shows that the most common treatments for typhoid fever were antibiotics (30.8%) and rest and hydration (2.3%). A

significant portion (52.3%) received no treatment at all, while only a few respondents were hospitalized (2.3%).

**Did you face any complications during or after treatment?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	317	79.3	79.3	79.3
	Yes	83	20.8	20.8	100.0
	Total	400	100.0	100.0	

**Did you face any complications during or after treatment?**



**Did you face any complications during or after treatment?**

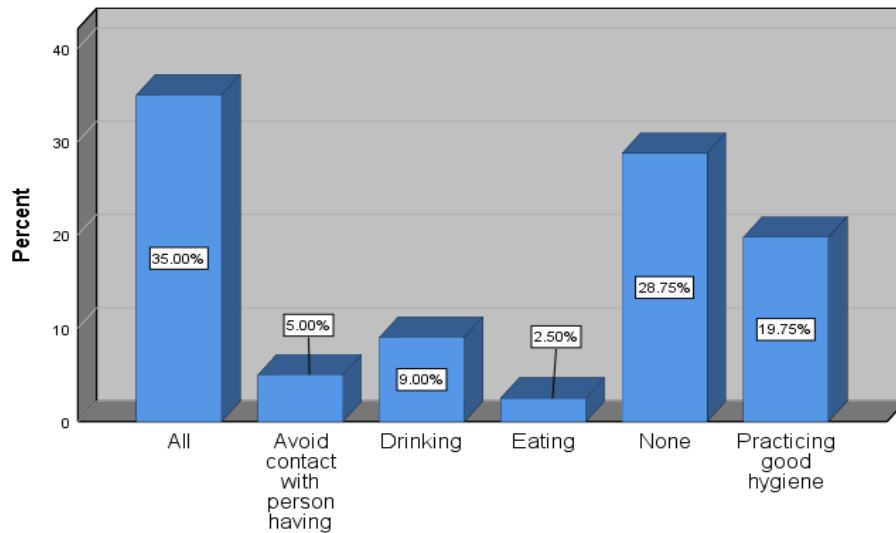
Most respondents (79.3%) did not experience any complications during or after treatment for typhoid fever. However, 20.8% faced

complications, pointing to a relatively low but significant occurrence of post-treatment issues.

**What measures do you take to prevent typhoid fever?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All	140	35.0	35.0	35.0
	Avoid contact with person having typhoid fever	20	5.0	5.0	40.0
	Drinking	36	9.0	9.0	49.0
	Eating	10	2.5	2.5	51.5
	None	115	28.7	28.7	80.3
	Practicing good hygiene	79	19.8	19.8	100.0
	Total	400	100.0	100.0	

**What measures do you take to prevent typhoid fever?**



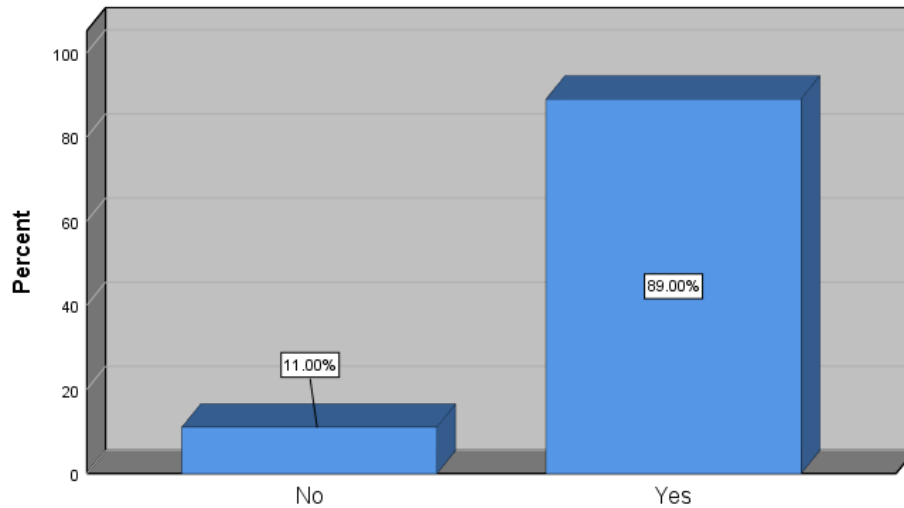
A large proportion of respondents (35.0%) practice all recommended measures to prevent typhoid fever. Other preventive measures include practicing good hygiene (19.8%) and avoiding

contact with people who have the fever (5.0%). A notable portion (28.7%) reported no preventive measures at all.

**Do you believe that poor sanitation and hygiene practices contribute to the spread of typhoid fever?**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	44	11.0	11.0	11.0
	Yes	356	89.0	89.0	100.0
	Total	400	100.0	100.0	

**Do you believe that poor sanitation and hygiene practices contribute to the spread of typhoid fever?**



**Do you believe that poor sanitation and hygiene practices contribute to the spread of typhoid fever?**

An overwhelming majority (89.0%) of respondents believe that poor sanitation and hygiene practices contribute to the spread of typhoid fever, while only 11.0% do not.

**Discussion:**

Typhoid fever remains a major public health concern in low- and middle-income countries, particularly in regions where access to safe drinking water, adequate sanitation, and proper hygiene practices is limited. Despite the availability of effective antimicrobial treatment and the recent introduction of typhoid conjugate vaccines, the disease continues to persist due to underlying structural, environmental, and behavioral determinants. This study provides comprehensive community-level evidence from Khyber Pakhtunkhwa (KP), Pakistan, by examining the prevalence of typhoid fever and its association with water, sanitation, and hygiene (WASH) conditions, demographic characteristics, and awareness and preventive practices.

**Burden of Typhoid Fever in the Study Population:**

The present study found that 23% of respondents reported a history of typhoid fever, indicating a substantial burden of disease within

the study population. This proportion is high for a community-based survey and reflects ongoing exposure to risk factors that facilitate transmission. Globally, typhoid fever is estimated to cause approximately 11–20 million cases annually, with an incidence ranging from 100 to 500 cases per 100,000 population in endemic regions (16–18). South Asia bears the highest burden, accounting for a significant proportion of these cases.

Community-based studies conducted in typhoid-endemic regions of South Asia have reported prevalence estimates ranging from 15% to 30%, particularly in areas characterized by unsafe water supplies and inadequate sanitation infrastructure (18,20). The prevalence observed in the current study therefore falls within the upper range of these estimates. In Pakistan, surveillance and hospital-based studies have reported varying prevalence rates, often between 10% and 25%, depending on study design, population, and diagnostic methods (19,21). The relatively high prevalence in this study may reflect persistent WASH-related challenges in KP, as well as under diagnosis and underreporting at the national level.

### **Age Distribution and Comparative Epidemiology:**

The age distribution of respondents shows that 68.8% were aged 16–22 years; making young individuals the most represented age group in the study. This finding is epidemiologically important, as adolescents and young adults are often at increased risk of typhoid fever due to greater mobility, social interaction, and reliance on food and water consumed outside the household. Globally, studies have shown that adolescents and young adults account for approximately 40–60% of community-detected typhoid cases in endemic settings (20).

Incidence estimates from South Asia indicate that adolescents may experience typhoid incidence rates as high as 300–600 cases per 100,000 populations, compared with lower rates among older adults (18). In Pakistan, several studies have reported that individuals under 25 years of age constitute more than half of confirmed typhoid cases, particularly in urban and peri-urban environments (21). The predominance of young respondents in this study is therefore consistent with regional and global trends and highlights the need to target this age group in prevention strategies, including hygiene education, safe food practices, and vaccination programs.

### **Gender Distribution and Exposure Patterns:**

This study identified a slight male predominance, with 53.3% male and 46.8% female respondents. Similar gender distributions have been reported in studies from Pakistan and neighboring South Asian countries, where males account for approximately 55–60% of typhoid cases, resulting in male-to-female ratios ranging from 1.2:1 to 1.5:1 (22,23). These differences are generally attributed to behavioral and occupational factors rather than biological susceptibility.

Men are more likely to work outside the home, travel frequently, and consume food from street vendors, all of which increase exposure to potentially contaminated food and water sources. Although the gender difference observed in this study is modest, it aligns with existing evidence and reinforces the importance of considering

gender-specific exposure patterns when designing public health interventions.

### **Urbanization and Typhoid Transmission:**

More than half of the respondents (53.8%) resided in urban areas, highlighting the role of urbanization in typhoid transmission in KP. Rapid and often unplanned urban growth in Pakistan has resulted in overcrowded residential areas, informal settlements, and overstretched water and sanitation infrastructure. Globally, urban typhoid incidence rates in low-resource cities have been reported to range between 150 and 400 cases per 100,000 populations, particularly in areas with aging water distribution systems (25).

In Pakistan, major typhoid outbreaks, including those caused by extensively drug-resistant *Salmonella Typhi*, have been reported predominantly in urban settings, with incidence rates exceeding 300 cases per 100,000 population during outbreak periods (26). These outbreaks have been linked to failures in urban water supply systems, including contamination of drinking water due to leaking pipelines and inadequate sewage disposal. The urban predominance observed in this study likely reflects similar infrastructural challenges and underscores that urban residence does not necessarily confer protection against enteric infections in low-resource settings.

### **Drinking Water Sources and Household Water Treatment:**

Access to safe drinking water is a fundamental determinant of typhoid transmission. In this study, 91% of respondents relied on tap or well water, while only a small proportion used bottled water. Importantly, 58.3% of respondents did not treat their drinking water prior to consumption. Globally, unsafe drinking water is estimated to contribute to up to 70% of typhoid cases in endemic regions (27).

Studies from South Asia have shown that households relying on untreated tap or groundwater have 2–4 times higher odds of typhoid infection compared with those using treated or bottled water (21,27). In Pakistan,

water quality assessments have demonstrated that more than 60% of household water samples are contaminated with fecal coliforms, even in urban areas (28). The high reliance on untreated water observed in this study is therefore consistent with national data and highlights the continued importance of household-level water treatment interventions in areas where centralized water safety cannot be assured.

#### **Sanitation Infrastructure and Environmental Contamination:**

Sanitation conditions in the study population revealed that 21.3% of respondents used pit latrines, and 49.8% lacked access to a functional sewer system. Inadequate sanitation facilitates environmental contamination and increases the likelihood of fecal matter entering water sources. Globally, lack of improved sanitation has been associated with a 2–3 fold increase in typhoid risk, particularly in densely populated communities (29).

Countries with sanitation coverage below 60% consistently report higher typhoid incidence compared with that achieving near-universal sanitation (29). National survey data from Pakistan indicate that approximately 45–50% of households lack access to safely managed sanitation, a figure closely aligned with the findings of this study (30). Poor drainage systems and open sewage further exacerbate environmental contamination, particularly during the rainy season, increasing the risk of waterborne transmission.

#### **Hygiene Practices and Preventive Behaviors:**

Hygiene practices reported by respondents were suboptimal. Only 43.5% reported always washing their hands, and 28.7% reported taking no preventive measures against typhoid fever. Meta-analyses have shown that consistent handwashing with soap can reduce the risk of enteric infections by 30–40%, highlighting the importance of this simple preventive measure (31).

However, studies from South Asia indicate that regular handwashing with soap is practiced by only 40–50% of households, particularly in low-income settings (32). The findings of this study

are consistent with these reports and suggest that inadequate hygiene practices continue to play a significant role in sustaining typhoid transmission, despite widespread awareness of the disease.

#### **Awareness and the Knowledge–Practice Gap:**

A notable finding of this study was the high level of awareness regarding the role of sanitation and hygiene in typhoid transmission, with 89% of respondents acknowledging this link. While this level of awareness is encouraging, it did not consistently translate into protective behaviors. Similar knowledge–practice gaps have been documented in Pakistan and other South Asian countries, where awareness levels often exceed 80%, but consistent preventive practices remain below 50% (32).

This gap may be attributed to a combination of socioeconomic constraints, limited access to safe water and sanitation facilities, and competing daily priorities. These findings suggest that educational interventions alone may be insufficient and must be accompanied by structural improvements and community-based support to enable behavior change.

#### **Diagnosis, Treatment, and Health System Challenges:**

The diagnostic and treatment patterns observed in this study highlight important health system challenges. Although 47.5% of respondents reported blood testing, 43% reported no diagnostic testing, and 52.3% reported receiving no treatment for typhoid fever. Studies from Pakistan have reported that 30–50% of suspected typhoid cases are treated empirically without laboratory confirmation, while a significant proportion receive no formal treatment due to barriers in healthcare access (33).

Delayed or absent diagnosis and treatment increase the risk of complications and prolong bacterial shedding, thereby facilitating continued transmission within households and communities. Strengthening laboratory diagnostic capacity, improving access to healthcare services, and promoting timely

treatment are therefore critical components of typhoid control strategies.

#### Public Health Implications:

The findings of this study underscore the urgent need for integrated WASH interventions to reduce the burden of typhoid fever in KP. Evidence from global and regional studies suggests that countries achieving sustained improvements in water quality and sanitation have reduced typhoid incidence by 50–70% over time, even before the widespread introduction of vaccination programs (16–18,29). In KP, targeted investments in water treatment, sewerage expansion, drainage systems, and hygiene promotion could substantially reduce disease burden.

Vaccination programs, while important, should be implemented alongside WASH improvements to achieve long-term and sustainable control of typhoid fever. Community engagement and education programs that address the knowledge-practice gap may further enhance the effectiveness of these interventions.

#### Limitations:

This study has several limitations. The reliance on self-reported data may introduce recall bias, and the lack of laboratory confirmation for all reported cases limits diagnostic certainty. The cross-sectional design precludes causal inference. Despite these limitations, the study provides valuable quantitative evidence on WASH-related risk factors and situates local findings within global and national epidemiological contexts.

#### References:

Ukwenya AY, Ahmed A, Garba ES. Progress in management of typhoid perforation. *Int J Infect Dis*. 2004;35(1):2417-27.

Musher D, Mussher B. Contagious acute gastrointestinal infections. *N Engl J Med*. 2004;351(24):2417-27.

Wain J, Hendriksen Rs, Mikoleit Met al. Typhoid fever. *Lancet* 2014 385:45.

Cramp JA, Luby SP, Mintz ED, et al. the global burden of typhoid fever. *Bull world health organ*, 2004;82:346-353.

Penakalapati G, Sworthout J, Delahoy Mz, et al. Exposure o animal feces and human health: a systematic review and proposed research priorities. *Environ. Sei Technol* 2017;11:e0005376.

Vuckle Gc, walker CLF, Black RE, et al. typhoid fever and paratyphoid fever. Estimate global morbidity and mortality for 2010. *J. Glob. Health* 2012;2:10401.

Arif A, Naheed R. Socioeconomic determinats of diarrhea morbidity in Pakistan. *Aeademic Research International* 2010;2:490.

Szu SC. Derelopment of vicojugate. A new generation of typhoid vaccine. *Exp Rev Vaccines* 2013;12:1373-6.

Lin FY, Hova, Khiem HB, et al. the efficacy of Salmoneela typhi VI conjugate Vaccine in Two to Five years old children. *N Engl J Med* 2001;344:1263-9.

Crump JA, Mintz ED. Global trends in typhoid and paratyphoid fever. *Clin Infect Dis*. 2010;50(2):241-246.

Mogasale V, et al. Burden of typhoid fever in low-income and middle-income countries. *Lancet Glob Health*. 2014;2(10):e570-e580.

Stanaway JD, et al. Global burden of typhoid and paratyphoid fevers. *Lancet Infect Dis*. 2019;19(4):369-381.

Qamar FN, et al. Antimicrobial resistance in *Salmonella Typhi* in Pakistan. *J Infect Dev Ctries*. 2014;8(8):981-986.

Buckle GC, et al. Typhoid fever morbidity and mortality. *J Glob Health*. 2012;2(1):010401.

Khan MI, et al. Risk factors for typhoid fever in Karachi, Pakistan. *Epidemiol Infect*. 2012;140(4):665-672.

Siddiqui FJ, et al. Gender differences in enteric fever. *Trop Med Int Health*. 2006;11(11):1739-1746.

Sur D, et al. Risk factors for typhoid fever in urban slums. *Epidemiol Infect*. 2007;135(6):1039-1045.

UN-Habitat. *State of Pakistan Cities Report*. 2018.

- Marks F, et al. Typhoid fever in urban settings. *Curr Opin Infect Dis.* 2017;30(5):498-505.
- Klemm EJ, et al. Emergence of XDR typhoid in Pakistan. *mBio.* 2018;9(1):e00105-18.
- Luby SP, et al. Water quality and enteric infections. *Am J Trop Med Hyg.* 2015;93(4):711-718.
- Azizullah A, et al. Water pollution in Pakistan. *Environ Int.* 2011;37(2):479-497.
- Wolf J, et al. Burden of disease attributable to unsafe WASH. *Int J Hyg Environ Health.* 2019;222:765-777.
- Pakistan Bureau of Statistics. *PSLM Survey 2019-20.*
- Curtis V, Cairncross S. Handwashing and diarrheal disease. *Lancet Infect Dis.* 2003;3(5):275-281.
- Biswas D, et al. Knowledge-practice gap in hygiene. *BMC Public Health.* 2020;20:121.
- Wijedoru L, et al. Diagnostics for typhoid fever. *Cochrane Database Syst Rev.* 2017;5:CD008892.

