



**PREVALENCE OF WATERBORNE DISEASES IN DISTRICT KARAK,
KHYBER PAKHTUNKHWA, PAKISTAN**

**Bibi Maryam¹, Sania Farooq¹, Anwar Ali¹, Shafi Ullah Gul¹, Kalim Ullah¹, Zaki
Ullah¹**

¹Department of Zoology, Government Post Graduate College Karak, Khyber Pakhtunkhwa,
Pakistan

ARTICLE INFO:

Keywords:

Contaminated water,
Prevalence, waterborne
diseases, Public health,
water sources

Corresponding Author:

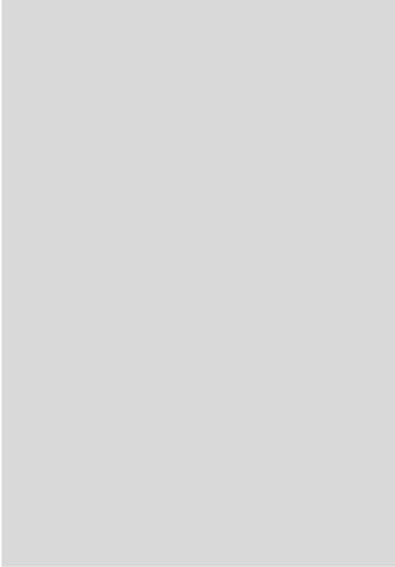
Shafi Ullah Gul,
Department of Zoology,
Government Post Graduate
College Karak, Khyber
Pakhtunkhwa, Pakistan
shafee.gul30@gmail.com

Article History:

Published on 02 August 2025

ABSTRACT

Waterborne diseases continue to pose a significant health threat in developing countries, particularly in rural areas with limited access to clean water, proper sanitation, and adequate water treatment. This study investigated the prevalence of waterborne diseases in relation to water sources, treatment methods, and sanitation conditions across three tehsils of District Karak, Pakistan. A descriptive cross-sectional survey was conducted, analyzing 582 reported cases from Karak, Takht-e-Nasrati, and Banda Daud Shah tehsils. The overall distribution of waterborne diseases indicated that diarrhea was the most prevalent, accounting for 14.3% (83/582) of cases, followed by cholera at 10.0% (58/582), and typhoid at 7.6% (44/582). Hepatitis A, *H. pylori*, and constipation represented smaller proportions of the total reported cases, specifically 2.6% (15/582), 1.0% (6/582), and 0.3% (2/582), respectively. Tehsil-wise data showed that Karak (n=180) reported diarrhea as the most frequent disease at 16.7% (30/180), followed by typhoid at 12.2% (22/180). In Takht-e-Nasrati (n=202), diarrhea was also the most prevalent at 9.9% (20/202), with cholera following at 6.9% (14/202). Banda Daud Shah (n=200) exhibited the highest disease burden, with diarrhea at 16.5% (33/200), cholera at 15.0% (30/200), typhoid at 8.0% (16/200), and hepatitis A at 4.0% (8/200). Notably, cases of *H. pylori* and constipation were exclusively observed in Banda Daud Shah. Regarding water sources, wells were the primary source, used in 66.7% (388/582) of cases. Other sources included



water tanks (13.4%, 78/582), tube wells (12.7%, 74/582), pressure pumps (9.4%, 55/582), bottled water (2.7%, 16/582), river streams (2.4%, 14/582), and natural sources (0.3%, 2/582). Water treatment practices were poorly adopted: only 9.1% (53/582) of respondents reported boiling water, 7.9% (46/582) used filtration, and just 1.4% (8/582) applied chemical treatment. Sanitation data revealed that flush toilets were widely used (93.1%, 542/582), while pit latrines (4.3%, 25/582) and open defecation (1.4%, 8/582) were still present in some households. In conclusion, diarrhea, cholera, and typhoid remain the most prevalent waterborne diseases in District Karak, with the greatest burden observed in Banda Daud Shah. Despite the high availability of flush toilets, the consumption of contaminated water continues to pose a serious public health risk.

1. Introduction

Water is essential for life, and safe drinking water is a basic human right. Yet, contaminated water is a major source of disease transmission globally, especially in developing countries. Every year, thousands of children die from water-related illnesses such as diarrhea, typhoid, and cholera (Cissé, 2019). Waterborne diseases, caused by pathogens from human or animal waste contaminating water, remain a leading cause of illness and death in the developing world (R. W. Herschy, 2012). These diseases present a significant public health challenge, particularly where sanitation is inadequate and clean water is scarce (UNICEF., 2007a). Contaminated water sources propagate pathogens causing diarrhea, gastroenteritis, typhoid fever, and hepatitis, imposing a considerable burden on healthcare systems (J. L. Howard, Bureau, Guay, Chong, & Ryan, 2021). Controlling waterborne diseases is complex due to factors like transmission dynamics, insufficient infrastructure, and limited resources (Morua, Halvorsen, & Mayer, 2011). In Pakistan, the situation worsened following floods that forced people to consume stagnant, polluted water, resulting in over 660,120 cases of diarrhea, typhoid, malaria, and dengue (Qamar

et al., 2022). Globally, unsafe water accounts for 30% of the 4 billion illnesses reported annually (Clasen et al., 2014). Contaminated water acts as a carrier for bacteria, viruses, or parasites transmitted via the fecal–oral route, while chemicals in water also contribute to disease (Leclerc, Schwartzbrod, & Dei-Cas, 2002). Around 15% of the world’s population lives in water-stressed regions, with 2.5 billion lacking sanitation, and 2 to 2.5 million dying annually from diarrhea. In rural Africa and South Asia, inadequate sanitation and water access cause chronic illness and death (Momba, Baloyi, Mpenyana-Monyatsi, & Kamika, 2017). In Khyber Pakhtunkhwa (KP), Pakistan, rapid population growth and poor infrastructure make it a hotspot for waterborne diseases.

In Pakistan, both urban and rural areas face inadequate sanitation and clean water supplies. Drinking water is often contaminated with *E. coli*, *Enterobacter*, *Salmonella*, and *Clostridium*, exacerbated by limited public awareness. Surveys indicate 43.2 million people lack sanitation facilities, and 52.8 million lack access to safe drinking water. Currently, only 65% of the population has access to safe water, with urban areas at 65% and rural areas at 30% sanitation coverage. The

country's growing population and industrialization are further degrading water quality. Waterborne diseases account for 80% of illnesses and 33% of deaths in Pakistan (Bakar, Razak, Akbar, Daud, & Ali, 2021).

This study aimed to assess water resource utilization, disease prevalence, treatment practices, and sanitation facilities in Karak, Takht-e-Nasrati, and Banda Daud Shah tehsils. It investigated disease distribution, water sources, treatment methods, and sanitation patterns in these regions.

2. Review of Literature

Water quality assessments in Pakistan's canals, wells, and supply schemes reveal widespread contamination by pathogens and chemicals like sodium and iron, leading to gastroenteritis, diarrhea, renal issues, and skin ailments (Memon et al., 2011). Chemical pollutants from industrial, municipal, and agricultural waste also contaminate water. Heavy metals such as lead, mercury, arsenic, and cadmium, along with pesticides like DDT and BHC, are linked to gastrointestinal, renal, cardiovascular, respiratory, reproductive disorders, and cancer (Azizullah, Khattak, Richter, & Häder, 2011).

Cholera, caused by *Vibrio cholerae*, leads to severe diarrhea and dehydration, with untreated cases reaching 50% mortality. Typhoid and paratyphoid fevers, caused by *Salmonella* species, spread through contaminated water, with some patients remaining carriers after treatment (Ashbolt, 2004). Shigellosis, caused by *Shigella* species, primarily affects children under five and can lead to severe gastrointestinal symptoms. Giardiasis and cryptosporidiosis, caused by *Giardia lamblia* and *Cryptosporidium parvum*, respectively, are prevalent in developing countries and linked to prolonged diarrhea. Other protozoan infections like cyclosporiasis and helminthic diseases such as dracunculiasis and schistosomiasis add to the disease burden. Viral infections, including hepatitis A and E,

have caused significant outbreaks in Pakistan (Khan, Rehman, & Abrar ul Haq, 2015)

The persistence of waterborne diseases in Pakistan is due to multiple factors. Unsafe domestic water exposes people to arsenic and toxins, while unprotected water sources become contaminated by waste and industrial effluents. Poor sanitation practices and lack of hygiene awareness worsen the issue; only 26% of households clean their water bottles regularly. Inadequate water treatment systems in rural areas leave communities vulnerable to infections from pathogens like *E. coli* and *Salmonella*. Monsoon flooding further contaminates water supplies, as observed in southern Lahore, where bacterial contamination rose from 62.5% to 75% during the rainy season. In 2010, floods in Khyber Pakhtunkhwa caused 1,600 deaths and left 14 million people exposed to waterborne infections. Climate change and global warming also contribute to increased flooding and droughts, favoring disease outbreaks (Marmo & Rosati, 2017).

Improving water quality in Pakistan requires more wastewater treatment plants and repairs to existing ones. Upgrading the sewerage system is critical to prevent contamination of water sources. Public awareness campaigns on hygiene practices are vital for reducing disease spread. Reverse osmosis (RO) is currently used for water purification but has limitations such as high energy requirements and inability to remove some contaminants (Borji, Ayoub, Bilbeisi, Nassar, & Malaeb, 2020). Carbon nanotube (CNT) membranes offer a promising, eco-friendly alternative due to their ability to remove micropollutants and pathogens while preventing biofouling, making them cost-effective and sustainable (Yekani et al., 2024).

3. Materials and Methods

3.1. Study Area and Design

The study was conducted in District Karak, focusing on three tehsils: Karak, Takht-e-Nasrati, and Banda Daud Shah. A descriptive cross-sectional design was used to evaluate the

prevalence of waterborne diseases, water source usage, treatment methods, and sanitation practices. It aimed to provide a detailed understanding of waterborne diseases and their environmental links in these areas.

3.2. Study Population and Sample Size

The study population included individuals diagnosed with waterborne diseases in the selected tehsils. A total of 582 cases were reviewed: Karak (n=180), Takht-e-Nasrati (n=202), and Banda Daud Shah (n=200). This sample size enabled an effective analysis of disease distribution in the region.

3.3. Data Collection Methods

Data were gathered using structured questionnaires and hospital records.

3.4. Questionnaires

Participants or their guardians provided details about demographics, disease history (including Diarrhea, Cholera, Typhoid, Hepatitis A, *H. pylori*, and Constipation), water source utilization (e.g., wells, tube wells, tanks, streams, bottled water, and natural springs), household water treatment (boiling, filtration, chemical treatment), and sanitation facilities (pit latrines, flush toilets, and open defecation).

3.5. Hospital Records

Hospital data on confirmed waterborne disease cases were collected to ensure accuracy and completeness, supporting a comprehensive analysis.

3.6. Data Analysis

Descriptive statistics, including frequencies and percentages, were used to analyze disease prevalence, water use patterns, treatment methods, and sanitation facilities in the three tehsils. Results were presented in tables and illustrated with bar graphs for clarity and comparison.

4. Results

4.1. Distribution of Waterborne Diseases in Three Tehsils

Among the 582 reported cases, Diarrhea was the most common (83 cases, 14.3%), followed

by Cholera (58 cases, 10.0%) and Typhoid (44 cases, 7.6%). Hepatitis A, *H. pylori*, and Constipation were less frequent.

In Karak Tehsil, Diarrhea accounted for 16.7% (30/180), Typhoid 12.2% (22/180), Cholera 7.8% (14/180), and Hepatitis A 1.1% (2/180). Typhoid was most common here compared to other tehsils.

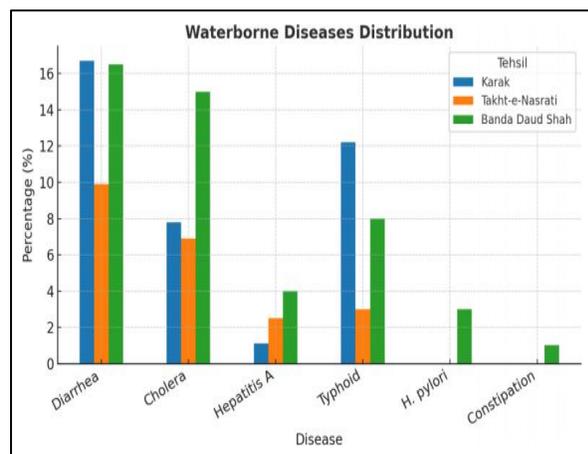
Takht-e-Nasrati reported 202 cases, with Diarrhea (9.9%, 20/202) as the most frequent, followed by Cholera (6.9%, 14/202), Hepatitis A (2.5%, 5/202), and Typhoid (3.0%, 6/202). This tehsil consistently showed the lowest percentages for major diseases.

In Banda Daud Shah, of 200 cases, Diarrhea (16.5%, 33/200) and Cholera (15.0%, 30/200) were most prevalent, followed by Typhoid (8.0%, 16/200), Hepatitis A (4.0%, 8/200), *H. pylori* (3.0%, 6/200), and Constipation (1.0%, 2/200). Notably, *H. pylori* and Constipation were reported only in this tehsil.

Table 1: Distribution of Waterborne Diseases in Three Tehsils (N=582)

Disease	Karak (n=180) Cases (%)	Takht-e-Nasrati (n=202) Cases (%)	Banda Daud Shah (n=200) Cases (%)	Total (N=582) Cases (%)
Diarrhea	30 (16.7%)	20 (9.9%)	33 (16.5%)	83 (14.3%)
Cholera	14 (7.8%)	14 (6.9%)	30 (15.0%)	58 (10.0%)
Hepatitis A	2 (1.1%)	5 (2.5%)	8 (4.0%)	15 (2.6%)
Typhoid	22 (12.2%)	6 (3.0%)	16 (8.0%)	44 (7.6%)
<i>H. pylori</i>	–	–	6 (3.0%)	6 (1.0%)
Constipation	–	–	2 (1.0%)	2 (0.3%)

Figure 1: Distribution of Waterborne Diseases in Three Tehsils



4.2. Water Resource Utilization in Three Tehsils

This section presents the findings on the distribution of water resources utilized across the three tehsils of Karak, Takht-e-Nasrati, and Banda Daud Shah based on a total of 582 reported cases. The results clearly demonstrate that wells are the predominant source of water across all areas, followed by water tanks and public supply/tube wells. Less common sources include river streams, bottled water, pressure pumps, and natural sources.

In Karak Tehsil, the dominant water source is wells, used in 58.9% of cases (106/180). Public supply/tube wells follow with 26.7% (48/180 cases). Other reported sources include bottled water at 4.4% (8/180 cases), river streams at 2.2% (4/180 cases), and pressure pumps and natural sources at 1.1% (2/180 cases each). Water tanks remain the least used at 1.1% (2/180 cases).

In Takht-e-Nasrati, wells serve the majority at 61.4% (124/202). Water tanks are also significant, reported in 28.7% (58/202 cases). Pressure pumps are used in 9.9% (20/202 cases). Both river streams and bottled water contribute 4.0% (8/202 cases each), while public supply/tube wells make up 2.0% (4/202 cases). No cases of natural source usage were reported here.

In Banda Daud Shah, wells are the most relied upon source, providing water in 79.0% of the cases (158/200). Pressure pumps come next with a significant 16.5% (33/200 cases), followed by public supply/tube wells at 11.0% (22/200 cases), water tanks at 9.0% (18/200 cases), and river streams at 1.0% (2/200 cases). There were no cases reported for bottled water or natural sources in this tehsil.

Across all three tehsils, wells are the most frequently utilized water source, accounting for 66.7% (388/582) of total cases. Water tanks are the second most used at 13.4% (78/582 cases), followed by public supply/tube wells at 12.7% (74/582 cases). Pressure pumps constitute 9.4% (55/582 cases) of the total reported sources. Less common sources include bottled water at 2.7% (16/582 cases), river streams at 2.4% (14/582 cases), and natural sources, which are the least utilized at 0.3% (2/582 cases).

Table 2: Distribution of Water Resources in Three Tehsils

Water Resource	Karak (n=180)	Takht-e-Nasrati (n=202)	Banda Daud Shah (n=200)	Total (n=582)
Well	106/180 (58.9%)	124/202 (61.4%)	158/200 (79.0%)	388/582 (66.7%)
Water Tank	2/180 (1.1%)	58/202 (28.7%)	18/200 (9.0%)	78/582 (13.4%)
Public Supply/Tube Well	48/180 (26.7%)	4/202 (2.0%)	22/200 (11.0%)	74/582 (12.7%)
River Stream	4/180 (2.2%)	8/202 (4.0%)	2/200 (1.0%)	14/582 (2.4%)
Bottled Water	8/180 (4.4%)	8/202 (4.0%)	–	16/582 (2.7%)
Pressure Pump	2/180 (1.1%)	20/202 (9.9%)	33/200 (16.5%)	55/582 (9.4%)
Natural Source	2/180 (1.1%)	–	–	2/582 (0.3%)

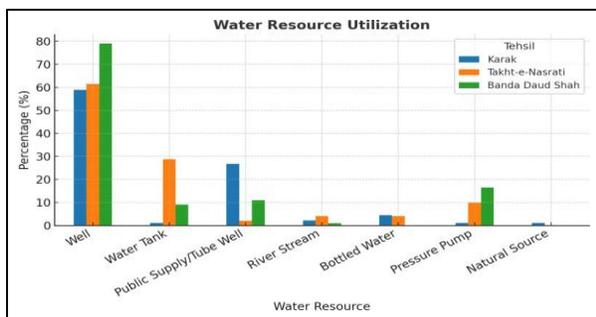


Figure 2 Distribution of Water Resource Usage Across the Three Tehsils

4.3. Water Treatment Practices in Three Tehsils

This analysis highlights the use of various water treatment methods across the three tehsils based on 582 reported cases. While usage is generally low overall, boiling is the most commonly reported method within each tehsil.

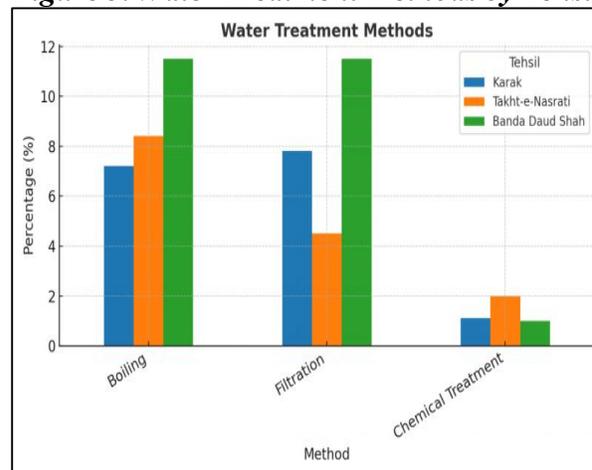
In Karak, 13 out of 180 respondents (7.2%) reported boiling as their primary treatment method. Filtration was used by 14/180 individuals (7.8%), while only 2/180 (1.1%) used chemical treatment. In Takht-e-Nasrati, boiling was practiced by 17/202 people (8.4%), filtration by 9/202 (4.5%), and chemical treatment by 4/202 (2.0%). In Banda Daud Shah, boiling was most reported (11.5%, 23/200 cases), followed closely by filtration (11.5%, 23/200 cases). Only 2/200 people (1.0%) used chemical treatment.

Boiling is most commonly reported in Banda Daud Shah (23/200, 11.5%), followed by Takht-e-Nasrati (17/202, 8.4%) and Karak (13/180, 7.2%). Filtration is equally common in Banda Daud Shah (23/200, 11.5%) as boiling, while lower in Karak (14/180, 7.8%) and lowest in Takht-e-Nasrati 9/202, (4.5%). Chemical treatment is least used in all tehsils, ranging from 1.0% to 2.0%.

Table 3 Distribution of Water Treatment Methods in Three Tehsils (N=582)

Water Treatment Method	Karak (n=180)	Takht-e-Nasrati (n=202)	Banda Daud Shah (n=200)	Total (n=582)
Boiling	13/180 (7.2%)	17/202 (8.4%)	23/200 (11.5%)	53/582 (9.1%)
Filtration	14/180 (7.8%)	09/202 (4.5%)	23/200 (11.5%)	46/582 (7.9%)
Chemical Treatment	2/180 (1.1%)	4/202 (2.0%)	2/200 (1.0%)	8/582 (1.4%)

Figure 3. Water Treatment Methods by Tehsil

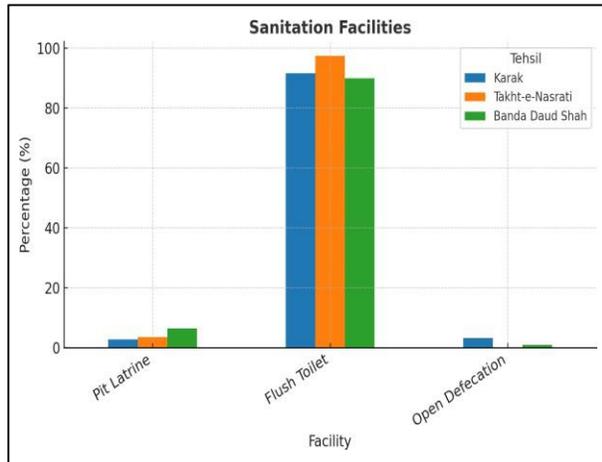


4.4. Sanitation Facilities in Three Tehsils

This section details the sanitation facilities used in three tehsils, based on 582 reported cases. The analysis reveals that flush toilets are the most commonly used sanitation facility across all three tehsils.

In Karak Tehsil, out of 180 respondents, 91.7% (165/180 cases) reported using flush toilets. Open defecation was reported in 3.3% of cases (6/180), while only 2.8% (5/180 cases) used pit latrines. In Takht-e-Nasrati, flush toilets were even more common, used by 97.5% (197/202). Pit latrine usage was 3.5% (7/202 cases), and no cases of open defecation were reported. In Banda Daud Shah, 90.0% (180/200) reported using flush toilets. Pit latrines were used by

6.5% (13/200 cases), and 1.0% (2/200 cases)



reported open defecation.

Table 4 Distribution of Sanitation Facilities in Three Tehsils (N=582)

Sanitation Facility	Karak (n=180)	Takht-e-Nasrati (n=202)	Banda Daud Shah (n=200)	Total (n=582)
Pit Latrine	5/180 (2.8%)	7/202 (3.5%)	13/200 (6.5%)	25/582 (4.3%)
Flush Toilet	165/180 (91.7%)	197/202 (97.5%)	180/200 (90.0%)	542/582 (93.1%)
Open Defecation	6/180 (3.3%)	0/202 (0.0%)	2/200 (1.0%)	8/582 (1.4%)

Figure 4: Sanitation Facilities Used by each Tehsil

5. Discussion

Water is essential for life, and access to clean drinking water is one of human's fundamental rights. Among many other factors, the contamination of food and water is a major source of disease transmission. Every year thousands of children lose their lives due to contaminated sources of water. These sources cause acute diarrhea diseases, typhoid, cholera, and so on, which are termed as waterborne diseases. Waterborne diseases are the most common diseases caused by unsafe drinking

water and remain a leading cause of illness and death in the developing world. Waterborne diseases (WBDs) are those diseases which generally arise from contamination of water by human or animal feces or urine infected by pathogenic viruses or bacteria and are directly transmitted when unsafe water is drunk or used in food preparation (R. Herschy, 2012). Waterborne diseases pose significant public health challenges worldwide, particularly in regions with inadequate sanitation infrastructure and limited access to clean water (UNICEF., 2007b). Contaminated water sources serve as breeding grounds for pathogens, leading to the transmission of diarrhea, gastroenteritis, typhoid fever, and hepatitis. These diseases not only cause immense suffering but also impose a substantial economic burden on healthcare systems and society at large (G. Howard, 2021).

A total of 582 cases were analyzed to identify the prevalence of various waterborne diseases in three tehsils of district Karak, Karak, Takht-e-Nasrati, and Banda Daud Shah. The overall distribution of waterborne diseases across the three tehsils revealed that Diarrhea was the most prevalent, accounting for 83/582 cases (14.3%), followed by Cholera with 58/582 cases (10.0%), and Typhoid with 44/582 cases (7.6%). Hepatitis A, H. pylori, and Constipation constituted a smaller proportion of the total reported cases. Within Karak Tehsil, out of 180 reported cases, Diarrhea was the most frequent condition (30/180 cases, 16.7%). This was followed by Typhoid fever (22/180 cases, 12.2%), Cholera (14/180 cases, 7.8%), and Hepatitis A (2/180 cases, 1.1%). Karak Tehsil notably exhibited the highest rate of typhoid fever (22/180, 12.2%) among the three tehsils. Takht-e-Nasrati Tehsil reported 202 waterborne disease cases. Diarrhea was the most prevalent disease, observed in 20/202 cases (9.9%). Cholera accounted for 14/202 cases (6.9%), followed by Hepatitis A with

5/202 cases (2.5%), and Typhoid fever with 6/202 cases

(3.0%). This tehsil consistently showed the lowest percentages across the major waterborne diseases identified. Banda Daud Shah Tehsil recorded 200 waterborne disease cases. Here, Diarrhea was highly prevalent (33/200 cases, 16.5%), closely followed by Cholera (30/200 cases, 15.0%). Other reported diseases included Typhoid fever (16/200 cases, 8.0%), Hepatitis A (8/200 cases, 4.0%), *H. pylori* (6/200 cases, 3.0%), and Constipation (2/200 cases, 1.0%). Importantly, *H. pylori* and Constipation cases were exclusively observed in Banda Daud Shah Tehsil. A study carried out in Khyber Pakhtunkhwa gathered data from rural health units which reported similar results that 34% people had diarrhea, 25% had cholera, 19% had dysentery, 14% had typhoid and around 8% people had hepatitis during the study period (Shah, Khan, Kanwal, & Bernstein, 2016). In Pakistan, the drinking water quality is being eroded due to the threatening growth of population size and rapid industrialization. Contaminated water is the primary source of several diseases such as diarrhea, gastroenteritis, and typhoid (Rahmat et al., 2023). Work done in Dhaka city, Bangladesh (91) suffered from diarrheal diseases, then jaundice (31) along with other waterborne diseases. Virus is one of the main cause of diarrhea in this subcontinent (Folorunso, Chukwu, & Tongo, 2015)

In Karak Tehsil, the dominant water source is wells, used in 58.9% of cases (106/180). Public supply/tube wells follow with 26.7% (48/180 cases). Other reported sources include bottled water at 4.4% (8/180 cases), river streams at 2.2% (4/180 cases), and pressure pumps and natural sources at 1.1% (2/180 cases each). Water tanks remain the least used at 1.1% (2/180 cases). In Takht-e-Nasrati, wells serve the majority at 61.4% (124/202). Water tanks are also significant, reported in 28.7% (58/202 cases). Pressure pumps are used in 9.9%

(20/202 cases). Both river streams and bottled water contribute 4.0% (8/202 cases each), while public supply/tube wells make up 2.0% (4/202 cases). No cases of natural source usage were reported here. In Banda Daud Shah, wells are the most relied upon source, providing water in 79.0% of the cases (158/200). Pressure pumps come next with a significant 16.5% (33/200 cases), followed by public supply/tube wells at 11.0% (22/200 cases), water tanks at 9.0% (18/200 cases), and river streams at 1.0% (2/200 cases). There were no cases reported for bottled water or natural sources in this tehsil. A study carried out in KPK majority of the people used household water supply for their domestic purposes, and few had wells. As household water supply is time-bounded, people of the area used different methods to store water like majority used plastic bottles whereas few used mud pots. Studies also showed that the drinking water an area is turbid, and bad in taste. It has been seen that esthetically pleasing water will be chosen by people even if it is unsafe for health (Eslami, Ghaffari, Barikbin, & Fanaei, 2017). Another study that was conducted on preventing diarrhoeal occurrence in a high-risk rural Kenyan population through point-of-use chlorination, safe water storage and rainwater harvesting found that chlorinating stored water used for drinking to improve its quality and use of narrow mouthed and covered containers to prevent stored water from contamination all decreased diarrhoeal risk to the population and encouraged good health (V. Garrett et al., 2008).

In Karak, 13 out of 180 respondents (7.2%) reported boiling as their primary treatment method. Filtration was used by 14/180 individuals (7.8%), while only 2/180 (1.1%) used chemical treatment. In Takht-e-Nasrati, boiling was practiced by 17/202 people (8.4%), filtration by 9/202 (4.5%), and chemical treatment by 4/202 (2.0%). In Banda Daud Shah, boiling was most reported (11.5%, 23/200 cases), followed closely by filtration

(11.5%, 23/200 cases). Only 2/200 people (1.0%) used chemical treatment. Boiling is most commonly reported in Banda Daud Shah (23/200, 11.5%), followed by Takht-e-Nasrati (17/202, 8.4%) and Karak (13/180, 7.2%). Filtration is equally common in Banda Daud Shah (23/200, 11.5%) as boiling, while lower in Karak (14/180, 7.8%) and lowest in Takht-e-Nasrati 9/202, (4.5%). Chemical treatment is least used in all tehsils, ranging from 1.0% to 2.0%. Similar findings in Bolivia and Bangladesh found that improving water quality through chlorine disinfection and storage in an appropriate container significantly improved the microbiological quality of non-piped household drinking water and reduced the risk of waterborne diarrhoeal diseases (Fonyuy, 2014).

In Karak Tehsil, out of 180 respondents, 91.7% (165/180 cases) reported using flush toilets. Open defecation was reported in 3.3% of cases (6/180), while only 2.8% (5/180 cases) used pit latrines. In Takht-e-Nasrati, flush toilets were even more common, used by 97.5% (197/202). Pit latrine usage was 3.5% (7/202 cases), and no cases of open defecation were reported. In Banda Daud Shah, 90.0% (180/200) reported using flush toilets. Pit latrines were used by 6.5% (13/200 cases), and 1.0% (2/200 cases) reported open defecation. Lower-income households are more prone to water-borne diseases due to lack of good quality water, shared households, lack of toilets, poor hygiene practices and unsafe sanitation systems (Subramanian, Idenal, Saiyed, Saxena, & Gerke, 2016). Sanitation interventions have been found necessary in preventing waterborne diseases occurrence. Sanitation facilities such as latrines, toilets effective drainage are crucial in separation of human fecal or other wastes which can contaminate water used by humans for drinking if not well managed. A study on spatial analysis of factors Responsible for Incidence of Water Borne Diseases in Ile-Ife, Nigeria found that most cases that were reported from water borne diseases were due to

factors like poor sanitation; where majority of the residents with illness were using open-pit toilets and were living near market center where large wastes were generated and improperly disposed in the nearby stream (Manetu & Karanja, 2021). According to Brooks et al. (2003) and Garrett et al., (2008) presence of latrines in a household was found to decrease diarrhea risk in Kenya. This is because the presence of a latrine ensures no open defecation which can contaminate water from open sources like river during run off hence reducing waterborne diseases infection. (P. Garrett, Williams, & Coupland, 2005).

6. Conclusion

This study provides a comprehensive overview of water-related health and infrastructure aspects in Karak, Takht-e-Nasrati, and Banda Daud Shah tehsils. The findings highlight several key conclusions. Diarrhea remains the most prevalent waterborne disease across all tehsils, followed by Cholera and Typhoid. The localized variations in disease prevalence, such as higher Typhoid rates in Karak and the exclusive presence of *H. pylori* and Constipation in Banda Daud Shah, suggest specific environmental or behavioral factors influencing disease distribution. Wells are the predominant water source, serving the majority of the population in all three tehsils. While widely used, the quality and safety of well water are crucial considerations for public health. Despite the reliance on various water sources, the adoption of water treatment practices remains generally low. Boiling and filtration are the most common methods, but overall utilization percentages are minimal, indicating a significant gap in household water safety measures. Chemical treatment is rarely used. The majority of households across the tehsils utilize flush toilets, indicating a relatively high level of access to improved sanitation facilities. This is a positive finding, with open defecation being minimal or non-existent in some areas. In conclusion, while

sanitation infrastructure shows promising development with widespread flush toilet usage, there is an urgent need to improve water quality and promote effective water treatment practices to reduce the burden of waterborne diseases in these tehsils. Interventions should focus on enhancing awareness and accessibility of safe water treatment methods to complement existing sanitation efforts.

References

- Ashbolt, N. J. (2004). Microbial contamination of drinking water and disease outcomes in developing regions. *Toxicology*, *198*(1-3), 229-238.
- Azizullah, A., Khattak, M. N. K., Richter, P., & Häder, D.-P. (2011). Water pollution in Pakistan and its impact on public health—a review. *Environment international*, *37*(2), 479-497.
- Bakar, A., Razak, N. F., Akbar, N., Daud, N., & Ali, K. (2021). *Removal of Cr (III) from industrial wastewater using coconut shell carbon and limestone as adsorbent*. Paper presented at the IOP conference series: Earth and environmental science.
- Borji, H., Ayoub, G. M., Bilbeisi, R., Nassar, N., & Malaeb, L. (2020). How effective are nanomaterials for the removal of heavy metals from water and wastewater? *Water, Air, & Soil Pollution*, *231*(7), 330.
- Cissé, G. (2019). Food-borne and water-borne diseases under climate change in low-and middle-income countries: Further efforts needed for reducing environmental health exposure risks. *Acta tropica*, *194*, 181-188.
- Clasen, T., Pruss-Ustun, A., Mathers, C. D., Cumming, O., Cairncross, S., & Colford Jr, J. M. (2014). Estimating the impact of unsafe water, sanitation and hygiene on the global burden of disease: evolving and alternative methods. *Tropical medicine & international health*, *19*(8), 884-893.
- Eslami, A., Ghaffari, M., Barikbin, B., & Fanaei, F. (2017). Assessment of safety in drinking water supply system of Birjand city using World Health Organization's water safety plan. *Environmental Health Engineering and Management*, *5*, 39-47. doi:10.15171/EHEM.2018.06
- Folorunso, S., Chukwu, A., & Tongo, O. (2015). Prevalence and Factors associated with Neonatal Jaundice: A case study of University College Hospital, Ibadan. *IOSR Journal of Dental and Medical Sciences*, *14*, 17-23.
- Fonyuy, B. (2014). Prevalence of Water Borne Diseases within Households in the Bamendankwe Municipality-North West Cameroon. *Journal of Biosafety & Health Education*, *02*. doi:10.4172/2332-0893.1000122
- Garrett, P., Williams, A., & Coupland, N. (2005). Investigating Language Attitudes : Social Meanings of Dialect, Ethnicity and Performance. *Language in Society*, *34*. doi:10.1017/S0047404505210163
- Garrett, V., Ogutu, P., Mabonga, P., Ombeki, S., Mwaki, A., Aluoch, G., . . . Quick, R. (2008). Diarrhea prevention in a high-risk rural Kenyan population through point-of-use chlorination, safe water storage, sanitation, and rainwater harvesting. *Epidemiology and infection*, *136*, 1463-1471. doi:10.1017/S095026880700026X
- Hersch, R. (2012). Water Quality for Drinking: WHO Guidelines. In (pp. 876-883).
- Hersch, R. W. (2012). Water quality for drinking: WHO guidelines. In *Encyclopedia of Lakes and Reservoirs* (pp. 876-883): Springer.
- Howard, G. (2021). The future of water and sanitation: global challenges and the need for greater ambition. *Journal of Water Supply: Research and Technology-Aqua*, *70*. doi:10.2166/aqua.2021.127
- Howard, J. L., Bureau, J., Guay, F., Chong, J. X., & Ryan, R. M. (2021). Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, *16*(6), 1300-1323.
- Khan, R. E. A., Rehman, H., & Abrar ul Haq, M. (2015). Determinants of rural household poverty: the role of household socioeconomic

- empowerment. *American-Eurasian J. Agric. & Environ. Sci.*, 15(1), 93-98.
- Leclerc, H., Schwartzbrod, L., & Dei-Cas, E. (2002). Microbial agents associated with waterborne diseases. *Critical reviews in microbiology*, 28(4), 371-409.
- Manetu, W., & Karanja, A. (2021). Waterborne Disease Risk Factors and Intervention Practices: A Review. *OALib*, 08, 1-11. doi:10.4236/oalib.1107401
- Marmo, F., & Rosati, L. (2017). Reformulation and extension of the thrust network analysis. *Computers & Structures*, 182, 104-118.
- Momba, M. N., Baloyi, L., Mpenyana-Monyatsi, L., & Kamika, I. (2017). Nanotechnology-based filters for cost-effective drinking water purification in developing countries. In *Water purification* (pp. 169-208): Elsevier.
- Morua, A. R., Halvorsen, K. E., & Mayer, A. S. (2011). Waterborne disease-related risk perceptions in the Sonora River Basin, Mexico. *Risk Analysis: An International Journal*, 31(5), 866-878.
- Qamar, K., Nchasi, G., Mirha, H. T., Siddiqui, J. A., Jahangir, K., Shaeen, S. K., . . . Essar, M. Y. (2022). Water sanitation problem in Pakistan: A review on disease prevalence, strategies for treatment and prevention. *Annals of Medicine and Surgery*, 82.
- Rahmat, Z., Zubair, A., Abdi, I., Humayun, N., Arshad, F., & Essar, M. (2023). The rise of diarrheal illnesses in the children of Pakistan amidst COVID-19: A narrative review. *Health Science Reports*, 6. doi:10.1002/hsr2.1043
- Shah, A., Khan, M. A., Kanwal, N., & Bernstein, R. (2016). Assessment of safety of drinking water in tank district: an empirical study of water-borne diseases in rural Khyber Pakhtunkhwa, Pakistan. 6. doi:10.6088/ijes.6047
- Subramanian, S., Idenal, M., Saiyed, S., Saxena, D., & Gerke, S. (2016). Urbanization and human health in urban India: Institutional analysis of water-borne diseases in Ahmedabad. *Health Policy and Planning*, 31, czw039. doi:10.1093/heapol/czw039 UNICEF. (2007a). Progress for children: a World fit for children: statistical review.
- UNICEF. (2007b). *The State of the World's Children 2008: Child Survival*: UNICEF.
- Yekani, M., Dizaj, S. M., Sharifi, S., Sedaghat, H., Saffari, M., & Memar, M. Y. (2024). Nano-scaffold-based delivery systems of antimicrobial agents in the treatment of osteomyelitis; a narrative review. *Heliyon*, 10(21).