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Assessing Drinking Water Quality, Accessibility, and Public Perception: Evidence from Khyber Pakhtunkhwa

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ABSTRACT

This study investigates the current status of drinking water supply, quality, and related public perceptions in Khyber Pakhtunkhwa. The required data was collected through structured questionnaire from 401 households in the study area. The main focus was to examine the sources of drinking water, responsible authorities, public satisfaction, and health implications. The findings of the study indicated that 59.10% of households rely on public taps for getting drinking water, while only 17.71% use both public and private sources. During the survey in the selected districts of the province the Water and Sanitation Company (WSSC) was identified as the primary water service provider (53.62%), followed by the Development Authority (37.91%). However, despite widespread access to public drinking water supply, 68.08% of respondents reported issues related to water, while 73.07% had experienced waterborne diseases, which actually shows a significant health concern. In exploring the issues of drinking water, the respondents expressed dissatisfaction with the quality (68.83%) and as well as quantity (68.58%) of water. It was also come to noticed that the key concerns included poor taste (42.39%), color (30.17%), and smell (18.20%). By elaborating the reasons of contamination, the households claimed that major causes of poor water quality were the use of suction pumps (34.16%), rusted pipelines near sewerage lines (29.93%), and unprotected sources (24.19%). Although 52.62% had knowledge of water treatment methods, the rest lacked awareness, further increasing vulnerability to health risks.

The study concludes that while institutional frameworks for water supply exist, the system faces challenges in infrastructure, quality control, and community trust. Therefore, it can be suggested based on the findings that stakeholders need to upgrade infrastructure, regulatory action on suction pumps, improved water quality monitoring. Beside that public awareness campaigns, and enhanced inter-agency coordination also needed. Addressing these issues is essential to ensure safe, reliable, and accessible drinking water for all residents in the Khyber Pakhtunkhwa.

INTRODUCTION

The access to clean drinking water is essential for health and survival. Despite the fact that the drinking-water target set forth in the Millennium Development Goals (MDGs) has been

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achieved, but now it simply calls for halving the proportion of people lacking access to safely managed drinking water. As currently many households still rely on the drinking water sources that may be unsafe or poorly treated. This raises serious health and safety concerns. Currently worldwide approximately 785 million people do not have access to safe and healthy drinking water. On the other hand, approximately two billion individuals have only access to drinking water source which is contaminated with faeces and are not suitable for drinking purpose. Even with improvement in water access, some of the developing nations still have issues and challenges in getting access to drinkable water (WHO, 2022).

Despite improved access, challenges persist in ensuring the cleanliness of drinking water. Many communities particularly in developing regions, still rely on unimproved water sources, leading to increased risks of contamination and waterborne diseases. The contaminated drinking water remains a major contributor to waterborne diseases. Diarrheal diseases, in particular, continue to affect millions of people globally, with a disproportionate impact on children in low-income countries.

Therefore, in the current study the household's perceptions regarding the current status of drinking water sources is gathered. This study explores what's households' perception about current drinking water source. Additionally, the association between water-related attributes and the incidence of water-borne diseases in Khyber Pakhtunkhwa is analysed. This information can help in guiding better policies and providing proper solutions for safe water access.

Literature Review

According to a recent report of WaterAid one in ten individuals still live without access to clean drinking water and one in four lacking access to a water supply at home which is safe for drinking (WaterAid, 2022). The unsafe water sources highly contribute to waterborne diseases. The contaminated water is a primary driver of diarrheal diseases, particularly in developing regions with limited infrastructure for water treatment and sanitation. The impact of water-related illnesses is disproportionately borne by vulnerable populations, including children and those living in poverty (Prüss-Ustün et al., 2014). In a multilevel regressors findings access to quality drinking water in Ghana the findings conformed that the people's access to better quality of drinking water significantly improves their health (Agbadi et al., 2019). That's why testing of water quality in the distribution system is required with the intention of generating information which ultimately be utilized to protect the health of human (da Luz & Kumpel, 2020). Similarly in studying the association between poor water quality and diarrheal disease among low and middle-income countries the association were found statistically significant

(Venkataramanan et al., 2020). Further added that fetching water for household needs can also cause injuries, during survey it was noted that about 13 % of respondents reported at least one water-fetching injury. Similarly, the importance of the distance, duration and source of drinking water cannot be ignored. As the quality of drinking water is influenced by its source, time duration of water storage and place, and the distance from the source(Boateng et al., 2013). On the other hand, research in developing countries showed about 14,000 deaths per day as a result of water contamination (Owa, 2014). Waterborne diseases pose a severe public health threat in Pakistan, contributing to approximately 60% of all infant deaths. Additionally, an estimated 20% to 30% of hospital admissions across the country are linked to illnesses caused by contaminated water. Alarmingly, it is estimated that around 230,000 children in Pakistan lose their lives each year due to waterborne diseases such as diarrhea, cholera, typhoid, and hepatitis A and E. These staggering figures highlight the urgent need for improved access to clean drinking water, better sanitation infrastructure, and widespread public health awareness to prevent these avoidable tragedies (Rehman & Baig, 2017).

The people's access to safely managed drinking water is fundamental to human health and overall well-being. The United Nations recognizes it as a basic human right, essential for achieving sustainable development. In the developing countries water safety still seems to be the fundamental concern for all the stakeholders (Vasquez et al., 2009). In case of Pakistan consumer tap water is highly contaminated, which results in yearly national income losses of between Rs. 25 to Rs. 58 billion (Nabeela et al., 2014a). The Joint Monitoring Programme (JMP) data indicated that in Pakistan, access to safe and clean drinking water increased from 35% of the total population in 2000 to 51% in 2022. But still half of population is unable to have safe and clean drinking water.

For the water providing companies the consumer feedback regarding their satisfaction is crucial for policy making. Particularly in case of Pakistan, due to rapid increase in industrialization along with high growth in population the quality of drinking water is declined. This decline in quality of drinking water result in the rise of waterborne diseases. The diseases include diarrhea, gastroenteritis and typhoid. In a study across 21 districts of Khyber Pakhtunkhwa, cases of bloody diarrhea were found in the Swat, Hangu, Karak, and Lakki Marwat regions. However, regions such as Peshawar, Swabi and Nowshera showed an increase in the acute watery diarrhea and typhoid (Atif et al., 2024). The findings highlighted the urgent need for targeted interventions and improved water safety procedures in these vulnerable regions. Similarly, another study indicates that the reason for waterborne diseases spread is microbial contamination and which causes a serious threat to human health of human(Khalid et al., 2018).

The contaminated water is among the thoughtful problems as it directly influences human health (Nabeela et al., 2014). Further add that the waste from municipal, industrial disposal, poor sanitary conditions and poor water supply services were the major causes of drinking water contamination.

Similarly, the WHO estimates that unsafe water and inadequate sanitation, contribute to the death of more than 1.6 million people annually due to diarrheal diseases (WHO, 2022). Similarly, lack of safe drinking water has a harmful consequence on output, low enrolment of girls and fatal infections associated with the use of contaminated water (Andres et al., 2018).

Methodology

Sampling and collection of Data

The Khyber Pakhtunkhwa (KP) province of Pakistan comprises 38 districts; however, the Water and Sanitation Services Companies (WSSC) operates in only seven of these districts: Peshawar, Mardan, Kohat, Mingora, Abbottabad, Bannu, and Dera Ismail Khan (DI Khan). In the current study, a stratified random sampling technique was employed. The population was divided into strata within each of the selected seven districts, ensuring representation across different geographic and demographic segments.

To determine the appropriate sample size for the study, the following formula was applied Given below:

$$Sample\ Size = N/((N-1)\delta\text{^}2 + 1)$$

This methodological approach underscores the importance of careful planning and methodological rigor in CVM studies, ultimately bolstering the credibility and validity of research outcomes in the field (Wang et al., 2018; Yamane, 1967). In the above equation the sample size is for the representation of n, while capital N is the total number of known populations, and δ is the sampling error which is acceptable.

According to Population Census (2017), the total populations and urban population as showed in Table No. 14.067 million while urban population is 4.08 million. The sampling error δ is set to 0.01. The statistical theoretical sample size for seven districts of KP is about 401 households. So, 401 questionnaires were filled by the respondents.

The final data were collected through using a well-structured questionnaire. It included questions on household socioeconomic characteristics, drinking water sources its attributes, and health issues related to waterborne diseases. Before the final data collection, the questionnaire was pretested through pilot survey to ensure validity reliability. Then minor adjustments were made based on the pretest. After finalization of the questionnaire, the data

collection was carried out in the study area. The raw data were then coded and organized for analysis.

Analysis

The data analysis was conducted in two stages. In the first stage, descriptive analysis was performed. In the second stage, frequency tables were derived. For the analysis the Stata software was employed.

Results and Discussion

In this portion the current status of drinking water in the study area were examined. The questions like what is the current source of water and if public then who is responsible for water supply in your area. Similarly questions like what's the current perception regarding the quality, quantity, pressure and distribution of current supply were analysed. From all the gather information the frequency tables are formed to understand the current status.

Current Source of Drinking water Frequency **Table:1**

CSODW	Freq	Percent	Cumulative
BOTH PUBLIC & PRIVATE	71	17.71	17.71
Bring from shops	11	2.74	20.45
PRIVATE BORE/HAND PUMP	70	17.46	37.91
PUBLIC TAP	237	59.10	97.01
UNPROTECTED WELL	12	2.99	100.00
Total	401	100	

The frequency table shows that most of the households (59.10%) rely on public taps for drinking water. A significant portion (17.71%) uses both public and private sources. Another 17.46% depend on private boreholes or hand pumps. A small number (2.99%) rely on unprotected wells, which may result in health risks. Only 2.74% buy water from shops, possibly due to limited access to safe sources. While public water supply is the main source, many households still use private or alternative options, indicating possible concerns about access, quality, or reliability.

Water source if Public Frequency **Table:2**

IPWAR	Frequency	Percent	Cumulative
CANTONMENT BOARD	22	5.49	5.49
DEVELPMENT AUTHORITY	152	37.91	43.39
Private Bore	12	2.99	46.38
Water & Sanitation Company	215	53.62	100
Total	401	100	

The data indicates that the majority (53.62%) of respondents identified the Water & Sanitation Company as the authority responsible for water services in their locality. The Development Authority follows with 37.91%, while the Cantonment Board accounts for 5.49%. A small

percentage (2.99%) rely on private boreholes. This suggests that formal public institutions manage most water services, with minimal dependence on private sources.

Descriptive Statistics of Water Characteristics

The descriptive statistics in table 2 provide an overview of the variables showing the drinking water characteristics. Issues related drinking water (IRDW) is reported by 68.1% of respondents (Mean = 0.681, SD = 0.467). The quality of water (QUALDW) affects 31.2% of respondents (Mean = 0.312, SD = 0.464). The Quantity of water (QUANTDW) impacts 31.4% of respondents (Mean = 0.314, SD = 0.465). About 52.6% of respondents are aware of the water treatment techniques (WTT), Mean = 0.526, SD = 0.5). Waterborne disease experience (WBDISEASE) is reported by 73.1% of respondents (Mean = 0.731, SD = 0.444). The respondent's satisfaction from the distance to the water sources (DWSOUR) account for 42.9% (Mean = 0.429, SD = 0.496).

These variables highlight key aspects of water quantity, water treatment knowledge, water quality, and health-related experiences among the respondents.

Frequency Table of Drinking Water Attributes **Table: 3**

Issue Related Drinking Water (IRDW)	**Freq**	**Percent**	**Valid Percent**
No	128	31.92	31.92%
Yes	273	68.08	100%
Knowledge of Drinking Water Treatment (WTT)			
No	190	47.38	47.38%
Yes	211	52.62	100%
Water Born Disease (WBDisease)			
No	108	26.93	26.93%
Yes	293	73.07	100%
Quality Of Drinking Water (Qualdw)			
No	276	68.83%	68.83%
Yes	125	31.17%	100%
Quantity Of Drinking water (QuantDW)			
No	275	68.58%	68.58%
Yes	126	31.42%	100%
Distance from Water Source (Dwsour)			
No	229	57.11%	57.11%
Yes	172	42.89%	100%

The frequency table presents respondents' satisfaction with various drinking water attributes. The majority (68.08%) reported facing issues related to drinking water, indicating significant dissatisfaction. Similarly, most respondents (73.07%) experienced waterborne diseases, suggesting poor water quality.

Regarding treatment knowledge, 52.62% had awareness, while 47.38% lacked it. This implies a nearly even divide in water treatment understanding. However, water quality and quantity

remained concerns, as 68.83% and 68.58% were dissatisfied, respectively. These results highlight widespread dissatisfaction with water availability and purity.

The distance to the water source also posed a challenge, with 57.11% satisfied and 42.89% dissatisfied. This suggests accessibility issues for a significant portion of respondents. The findings emphasize persistent concerns about water quality, availability, and related health impacts.

Perception Regarding Current Source of Drinking water Frequency **Table:4**

SIRDW	Frequency	Percent	Cumulative
All of the above	9	2.24	2.24
DISCRIMINATION IN WATER DISTRIBUTION	2	0.50	2.74
None of the above	89	22.19	24.94
PRESSURE IS VERY LOW	39	9.73	34.66
QUALITY OF WATER IS NOT GOOD	199	49.63	84.29
QUANTITY OF WATER AT HOME NOT SUFFICIENT	54	13.47	97.76
SOURCE OF WATER IS TOO FAR	9	2..24	100
TOTAL	401	100	

The data shows that the most common drinking water issue at home is poor water quality, reported by 49.63% of respondents. Insufficient water quantity follows at 13.47%, while 9.73% experience very low pressure. A small percentage (2.24%) cite issues like discrimination in distribution or distant water sources. Notably, 22.19% report no issues. This suggests that water quality is the primary concern, followed by supply limitations.

Perception Regarding Current Water Quality Frequency **Table:5**

PRQDW	Frequency	Percent	Cumulative
ALL OF THE ABOVE	10	2.49	2.49
WATER COLOUR IS NOT GOOD	121	30.17	32.67
WATER SMELL IS NOT GOOD	73	18.20	50.87
WATER TASTE IS NOT GOOD	170	42.39	93.27
None of the above	27	6.73	100
Total	401	100	

The data indicates that the most common concern regarding drinking water quality is its taste, reported by 42.39% of respondents. Water colour issues follow at 30.17%, while 18.20% mention an unpleasant smell. A small percentage (2.49%) report experiencing all these issues, whereas 6.73% have no complaints. This suggests that taste and appearance are the primary factors influencing negative perceptions of drinking water quality.

Reasons for Current Water Supply Frequency **Table:6**

RFCDW	Frequency	Percent	Cumulative
Sucking machine suck contaminated water	137	34.16	34.16
Distribution Pipes are rusted and are along with the sewerage line	120	29.93	64.09
Source of water is not protected	97	24.19	88.28
None of the above	47	11.72	100
Total	401	100	

The findings from this study reveal critical insights into the current drinking water conditions in the surveyed area. The majority of households (59.10%) rely on public taps as their primary source of drinking water. However, a notable portion still depends on private boreholes/hand pumps (17.46%) and a combination of public and private sources (17.71%), indicating gaps in reliability, accessibility, or trust in the public supply system. A small minority (2.74%) purchase drinking water from shops, likely due to concerns regarding the safety or quality of the available water.

When examining public water provision specifically, the Water and Sanitation Company emerged as the principal service provider (53.62%), followed by the Development Authority (37.91%) and the Cantonment Board (5.49%). This shows a significant reliance on institutional arrangements for water supply, but the presence of private borehole usage (2.99%) suggests that institutional service is not universal or fully trusted.

Water quality and health-related concerns are prevalent. Around 68.08% of respondents reported issues related to drinking water, and 73.07% experienced waterborne diseases, which aligns with dissatisfaction regarding water quality (68.83%) and quantity (68.58%). These figures indicate systemic issues in the drinking water supply chain that affect public health. Furthermore, 52.62% of the respondents are aware of water treatment methods, while the remaining population may be at increased risk due to lack of awareness.

A closer look at perceptions reveals that poor water quality is the most commonly cited issue (49.63%), followed by insufficient quantity (13.47%) and low pressure (9.73%). More specifically, taste (42.39%), colour (30.17%), and smell (18.20%) were identified as key water quality concerns, suggesting that both sensory attributes and safety are issues in public perception.

The root causes of these problems are perceived to be technical and structural. The most frequently mentioned reason for poor water supply is the use of sucking machines drawing in contaminated water (34.16%), followed by rusted distribution pipes near sewer lines (29.93%) and unprotected water sources (24.19%). These findings indicate that infrastructural

deterioration and contamination risks are contributing to both real and perceived issues with drinking water.

Conclusion

The study highlights a serious situation regarding the quality and reliability of drinking water in the KP surveyed area. Despite having public water supply coverage, a significant number of residents resort to private or alternative sources, suggesting gaps in trust and satisfaction. The high incidence of waterborne diseases, dissatisfaction with water quality and quantity, and concerns about infrastructure underline systemic issues in water provision.

The perceptions of poor taste, colour, and smell in water reflect deeper problems likely caused by aged infrastructure, unprotected water sources, and contamination through compromised distribution systems. While awareness about water treatment exists among over half the population, there remains a substantial portion lacking basic knowledge on how to ensure safe drinking water, further exacerbating the health risks.

Recommendations

To address the pressing issues identified in the study, a multifaceted and coordinated approach is essential. Authorities should prioritize the inspection and rehabilitation of water supply infrastructure by replacing rusted pipelines, ensuring that water pipes are not laid alongside sewerage lines, and securing water sources against contamination. One of the major contributors to water quality deterioration, the widespread use of suction pumps, must be regulated through strict monitoring and enforcement measures. Alongside these efforts, it is crucial to launch public awareness campaigns that inform communities about the health hazards associated with these practices.

Improving water quality monitoring and promoting transparency can help build public trust. This can be achieved by conducting regular water testing and making the results publicly accessible. The installation of community-level filtration systems may also offer practical solutions, particularly in areas where centralized quality control is inadequate. Furthermore, enhancing public knowledge through awareness campaigns, community workshops, and targeted education especially in households with low awareness of water treatment methods can significantly reduce vulnerability to waterborne diseases.

Institutional coordination also requires strengthening. While the Water and Sanitation Services Companies (WSSCs) are the main service providers, improved collaboration with entities like the Development Authority and Cantonment Board is necessary to ensure efficient, uninterrupted service delivery and to eliminate any overlap or gaps in responsibilities. In parallel, it is important to encourage the use of simple, cost-effective purification techniques

such as chlorination, boiling, and filtration at the household level, particularly in areas dependent on unprotected wells or mixed water sources.

Finally, investment in water storage infrastructure and booster stations is essential to enhance water pressure and ensure an adequate and continuous water supply. This is particularly important for neighborhoods that report low water pressure or are located far from primary supply lines. Addressing these challenges holistically will significantly improve water safety, reliability, and public health outcomes across Khyber Pakhtunkhwa.

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