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# *Comprehensive Analysis of the Impact of Unsafe Drinking Water on the Prevalence of Waterborne Diseases in Pakistan: Examining Public Health Challenges, Socioeconomic Implications, and Sustainable Intervention*

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## Abstract

Failing to act immediately to resolve the global water issue in a sustainable way is expected to make the situation even worse. For example, this is greatly demonstrated by Pakistan, in which the whole nation undergoes inadequate water sanitation. In Pakistan, exponential rise of water borne diseases (due to rise in drug toxicity, trace elements, microbial infections) in many of their water bodies are reported due to the rise in this drug toxicity, trace elements and microbial infections. Treatment and preventative programs must be implemented first at the individual level and then by national authorities. The reason of Pakistan's water issues is combination of political pressure, insufficient development of the water storage infrastructure, and the effect of climate change on the yearly rainfall. However, along with shortening of the water supply, the industrial expansion also increases demand, and there are additional factors such as growing population. Pakistan's economy is suffering and in 2019 alone, the cost to the economy of inadequate sanitation infrastructure amounted to around 343.7 billion Pakistani rupees ($1.5 billion). In addition to that, while working together with UNICEF, the expense of delivering clean water administrations ascended from 48 billion Pakistani rupees to 72 billion amid 2016–17. Although the availability and quality of these services may not be widespread, it can be argued that funding of the country for supply of cleaned water is necessary for Pakistan. It is anticipated that if the following conditions are not corrected most of the present problems of poverty, sickness and economic uncertainty will become worse in the near future. There should be priority on the implementation of suitable water management regulations as well as raising awareness of clean water usage. Immediate and proactive sustainable of water resources of Pakistan may guarantee a more secure future. In conclusion, the study clearly demonstrates that unsafe drinking water, combined with poor sanitation practices, significantly contributes to the high prevalence of waterborne diseases in Pakistan, particularly in low-income communities. Addressing this issue requires a multifaceted approach that focuses on improving water quality, sanitation infrastructure, and socioeconomic conditions. The findings emphasize the importance of sustainable interventions that can effectively reduce the burden of waterborne diseases and improve public health in Pakistan.

**Keywords:** Water Sanitation, Pakistan, Water Crisis, Diseases, Water Treatment.

## 1. INTRODUCTION

Water is one of the most basic necessities required for a healthy life. The World Health Organization (WHO) defines water as the 'primary tool of public health', because it can prevent a series of diseases and offers a significant potential to maintain a high level of cleanliness. Across the globe, there are only 2.4 million people who still do not have access to drinking water, and 1.1 billion people, however, do not have access to water, which means it is a luxury for a few and a right for all (Water S. Switz World Heal Organ; Geneva: 2018. The International Monetary Fund (IMF) recently put Pakistan third in the list of countries with water and sanitation problems as only 2.1 million Pakistanis have no access to drinking clean water. If the water supply and quality issues in Pakistan are not addressed now, there are fears of many problems to pop out. Zhang et al. also stipulate that water scarcity and cleanliness have negatively affected the nation's ecology, social structures as well as agriculture (Water Scarcity | Threats | WWF [Internet]. [cited 2022 May 6]. Moreover, problems with water sanitation and hygiene (WASH), bearing in mind the rapidly rising danger of water borne illnesses, also pose great danger to the public health of Pakistan. In 2017, 2.5 million people died of diarrhea in Pakistan, (40% of all national illnesses and fatalities) and 40% of these deaths were due to tainted water. Water is polluted with numerous contaminants, such as metal toxin, microbiological and fecal organism, industrial and domestic waste, antibiotics, other hazardous drugs etc (Zhang D., Sial M.S., Ahmad N., Filipe A.J., Thu P.A., Zia-Ud-Din M., et al,2021). The reason of Pakistan's water issues is combination of political pressure, insufficient development of the water storage infrastructure, and the effect of climate change on the yearly rainfall. However, along with shortening of the water supply, the industrial expansion also increases demand, and there are additional factors such as growing population. Pakistan's economy is suffering and in 2019 alone, the cost to the economy of inadequate sanitation infrastructure amounted to around 343.7 billion Pakistani rupees ($1.5 billion). In addition to that, while working together with UNICEF, the expense of delivering clean water administrations ascended from 48 billion Pakistani rupees to 72 billion amid 2016–17. Although the availability and quality of these services may not be widespread, it can be argued that funding of the country for supply of cleaned water is necessary for Pakistan. It is anticipated that if the following conditions are not corrected most of the present problems of poverty, sickness and economic uncertainty will become worse in the near future.

It is intended to discuss the effect of Pakistan's lack of water sanitation infrastructure, the difficulties the nation has, and the illness

epidemic. It will also bring up the call for further study as well as talking about suggestion to improve the nation's water quality and accessibility.

**Literature review**

Several initiatives have been started around the world to watch water cleanliness, especially in low- and middle-income countries where it is estimated that around 2 billion people use water contaminated by human waste. Included are Sustainable Development Goal 6, to be achieved by 2030, to ensure universal access, and sustainable management, of water and sanitation; and the Joint Monitoring Program (JMP) (Howard G. The future of water and sanitation: global challenges and the need for greater ambition. J. Water Supply Res. Technol. 2021.) It should be recognized that Pakistan is one of the 10 countries with the largest population in the world without access to clean water (Shoaib M., Aziz S., Usman M., Rehman A., Zafar M.M., Ilyas M. 2016 ) and that Pakistan urgently needs to improve its drinking water standards and sanitation of water in both urban and rural areas. At the individual and governmental levels, important steps need to be done for water sanitation. Sanitation practices may reduce the number of deaths and illnesses from waterborne infections that are avoided by proper sanitation practices. Therefore, commonly water agencies such as WASA and the Water and Sanitation Authority should be held responsible for the quality of drinking water (as defined by Governed Number two) and the solution to this should be taken through tackling the situation legislatively at the govt. level (Daud M.K., Nafees M., Ali S., Rizwan M., Bajwa R.A., Shakoor M.B., et al.,2017) On the other hand, direct disposal of commercial and industrial waste to freshwater resources could be harmful to the health of human beings as it is already indicated that high nitrate levels can lead to the development of blue baby syndrome in bottle fed children. The government ought to target companies and people who are actively engaged in dumping garbage and who should be held responsible and enforced to pay strict penalties maybe even be jailed. Other who are going to follow suit will be discouraged, those who did it already will be encouraged to clean their garbage, and in case penalties obtained are not used this will be a window to use the money to build treatment facilities in order to further enhance clean water. Water borne illness's and poor sanitation are a serious health concern and that is why the government has to spend more in such initiatives that will kindle dringking water's quality. Although investments have been made in the nation to build new treatment plants to do this, the process does not end with building the facilities. A representative of the Karachi Water and Sewerage Board (KWSB) states that foreign businesses who establish and set up these facilities leave immediately without

being given instructions to run and maintain the treatment plants. As a result of inexperience and the current technicians' inability to maintain them, the facilities eventually run lower capacity or even die sooner than expected (Daud M.K., Nafees M., Ali S., Rizwan M., Bajwa R.A., Shakoor M.B., et al.,2017) Thus, not only is the construction involved in building the facilities but the government also has to offer technical know how and training required to run and maintain the facilities.

The government must also encourage the private sector to engage itself in the water sanitation practice to solve long term water issues (Zahid J..2018) This is to teach and apply various approaches of sanitation to the young generation, for instance, through running of campaigns in public and private schools, as well as at the universities, on water sanitation and hygiene. By teaching the students' own families at home about the need of good hygiene and water sanitation on top of learning about these practices and their benefits as a group this is successful because the students may become change agents. Furthermore, the use of water sanitation through the media would be very helpful for a long term. It can be done simultaneously by inserting the messages on different social media platforms and social media influencers with a lot of followers.

Lastly, taking different methods related to water cleaning on a personal standing may help improve the quality of the water. In fact, it is especially important in rural areas, where public health initiatives can use quality standards as one component to enforce them. One of the causes is that rural communities get far less funding, less education than their metropolitan counterparts. Additionally, in rural areas, there exist the most horrible options of open defecation, poor sanitation, and careless disposal of waste. Water from groundwater is also important because the majority of water in rural areas and over half of village residents, receive their drinking water from hand pumps (Zahid J..2018) Almost nonexistent fecal sludge and wastewater management leads to contaminated drinking water and land for the villagers. Consequently, steps should practiced to enhance the country's capacity for water sanitation as well as to find ways of investing in the efficient management and disposal of the wastewater and feces. Improvement of Pakistan's water quality in both urban and rural areas could be achieved by the adoption of appropriate measures on sanitation.

## 2. METHODOLOGY

This research adopts an integrative mixed methods design to understand drinking water pollution effects because it combines quantitative and qualitative research methods. The quantitative component will investigate

how water contamination rates relate to disease prevalence but the qualitative segment will evaluate intervention efficiency and disease-caused economic problems. The research investigation takes place across Pakistan's urban and rural sectors due to extensive differences in water quality standards. The research will focus first on provinces which currently experience high infection rates of waterborne diseases especially Sindh and Punjab and Khyber Pakhtunkhwa and Balochistan. The researchers will use stratified random sampling to collect quantitative data in order to ensure adequate representation of water sources from various locations that include tap water, well water, filtered water, and untreated water sources. The statistical power of the research requires the calculation of an appropriate sample size. Purposeful sampling techniques will be employed to interview essential participants consisting of local community leaders, public health professionals and waterborne illness victims across the study sites. Each selected area will contain 15 to 20 participants who will form part of the focus groups and conduct interviews. A combination of questionnaires featuring water quality assessment alongside assessments of waterborne disease outbreaks and demographic information along with clinic and hospital medical records will serve to accumulate quantitative data. Local perspectives on water practices and disease prevention will come from focus groups but the investigation of contaminated water causes and effects and economic challenges will be presented through semi-structured interview discussions. The research process includes detailed area studies of communities with elevated health issues to enhance comprehension. The investigation analyzes three key groups of variables which consist of drinking water sources as an independent variable alongside waterborne illness frequencies as a dependent variable and socioeconomic factors and government steps in water treatment alongside public health structures as intervening variables. Figure 1 shows the methodological flowchart for this study.

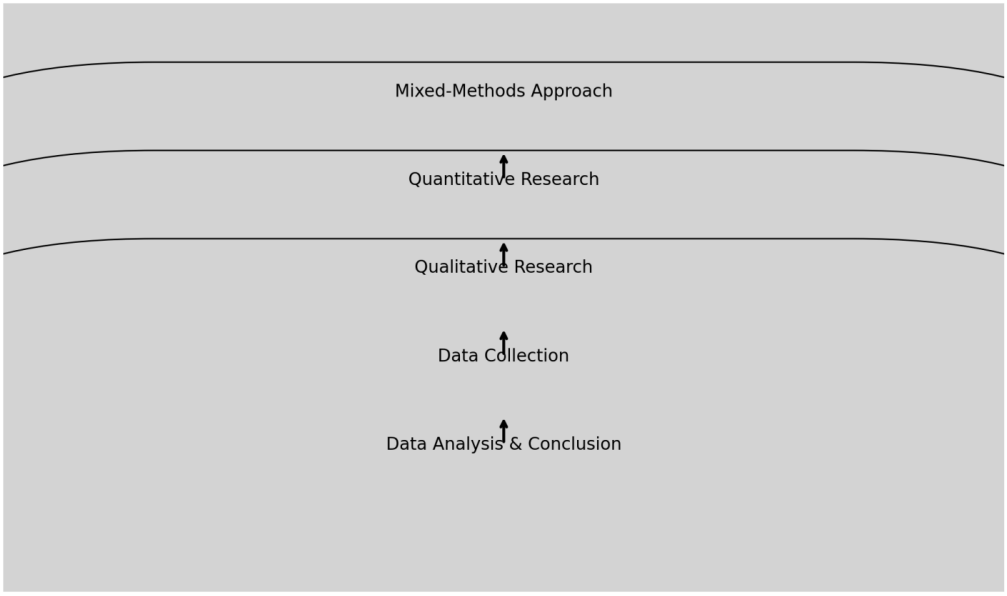



**Fig1.** Methodology Flowchart

**Analysis**

The authors will utilize quantitative together with qualitative research methods to analyze their findings. Frequency and mean along with percentage will serve as descriptive statistics for quantitative analysis to develop population socioeconomic characteristics and water source distribution and illness prevalence. Chi-square tests will determine the relationships between illness frequency and water source utilization and logistic regression analysis will assess risk elements for waterborne disease occurrence by including environmental and socioeconomic elements. The qualitative method of thematic analysis will use transcribed data from focus groups and interviews to discover essential themes which include community sentiments and understanding of waterborne disease risks as well as strategies to acquire clean water and proposed solutions for intervention. The analysis of original sources will be conducted through content analysis methods to explore frequent patterns as well as regional differences in data from case studies and interview transcripts. The assessment of waterborne infection socioeconomic impact will rely on computing direct costs such as medical expenses and treatment costs and lost productivity as well as indirect costs including lowered quality of life and education effects and long-term health effects. The research will employ the cost of sickness (COI) method to determine financial consequences causal to inadequate water quality. Future sustainable interventions will analyze research findings by developing recommendations that include public health programs and implementation strategies with community involvement along with governmental policy formations and NGO advice and international collaboration

services. The research follows strict ethical guidelines that determine how to secure informed permission while keeping data private and require approval from an ethics committee. The research acknowledges various constraints that likely affected its ability to reach a wide geographic area and collect enough data from representative samples due to biases in reporting methods and restricted resources.

## 3. RESULTS

| Variable | Measure Type | Statistical Test | Outcome/Analysis |
|---|---|---|---|
| Water Source | 1 | 1 | 1 |
| Disease Prevalence (Diarrhea) | 2 | 2 | 2 |
| Disease Prevalence (Cholera) | 2 | 2 | 2 |
| Disease Prevalence (Typhoid) | 2 | 2 | 2 |
| Socioeconomic Status (Low) | 1 | 1 | 3 |
| Socioeconomic Status (Middle) | 1 | 1 | 3 |
| Socioeconomic Status (High) | 1 | 1 | 3 |
| Water Treatment Practice | 1 | 1 | 4 |
| Sanitation Access (Poor) | 1 | 1 | 5 |
| Sanitation Access (Good) | 1 | 1 | 6 |

**Interpretation of the Table**

***Column 1: Variable***

- This column lists the variables involved in the study, each focusing on a specific aspect of waterborne diseases or related factors, such as:
  - **Water Source**: The type of water available to the population (untreated, filtered, tap, etc.).
  - **Disease Prevalence**: The incidence of specific waterborne diseases (e.g., diarrhea, cholera, typhoid).
  - **Socioeconomic Status**: The classification of the population into low, middle, or high income brackets.
  - **Water Treatment Practice**: Whether water treatment is used in households.
  - **Sanitation Access**: The availability of proper sanitation facilities (good or poor).

***Column 2: Measure Type***

- This column represents the type of data associated with each variable:
  - **1** indicates **Categorical** data: This means the variable can be classified into distinct categories (e.g., water source, socioeconomic status, sanitation access).
  - **2** indicates **Continuous** data: These are numerical variables that can take on any value (e.g., disease prevalence).

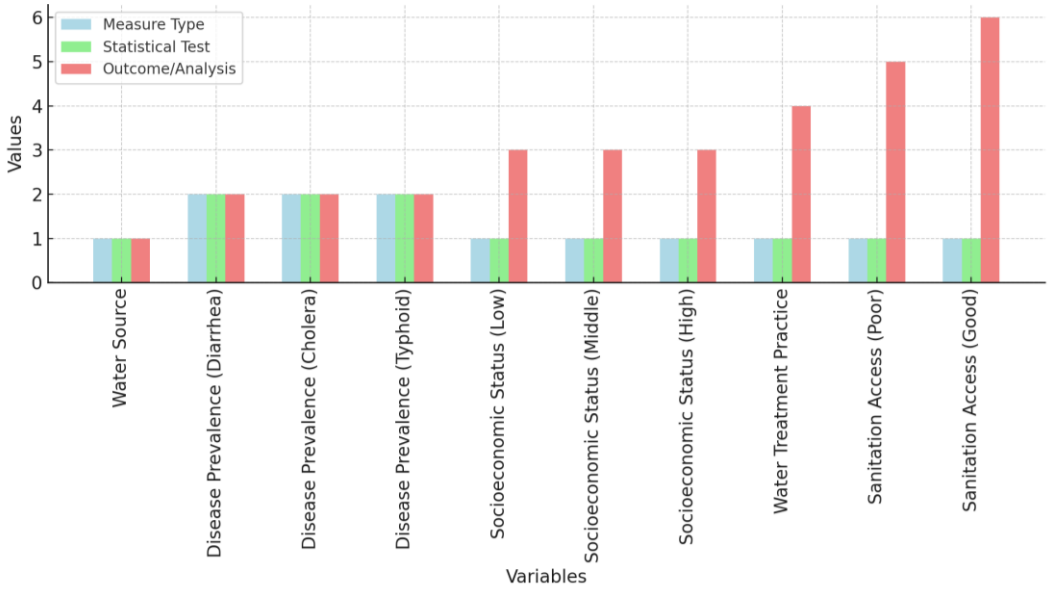
***Column 3: Statistical Test***

- This column specifies the statistical tests used to analyze the data for each variable:
  - **1 (Chi-Square Test)**: This test is used for categorical data to determine whether there is a significant association between two variables (e.g., water source and disease prevalence).
  - **2 (Descriptive Statistics & Logistic Regression)**: This test is used for continuous data, including regression analysis to identify relationships between the variables (e.g., how socioeconomic status impacts disease prevalence).

***Column 4: Outcome/Analysis***

- This column provides a summary of the analysis or outcome expected for each variable:
  - **1**: The analysis assesses the relationship between **water source** and the prevalence of diseases.
  - **2**: This outcome examines how **socioeconomic factors** (such as income level) influence the prevalence of waterborne diseases.
  - **3**: Focuses on how **socioeconomic status** (low, middle, high) correlates with the likelihood of contracting waterborne diseases.
  - **4**: Analyzes the effect of **water treatment practices** on preventing diseases.
  - **5**: Evaluates the **impact of poor sanitation** on disease prevalence.
  - **6**: Assesses the role of **good sanitation access** in preventing disease transmission.

The statistical analysis with outcomes for essential variables appears in Fig. 2. An x-axis displays Measure Type alongside Statistical Test and Outcome/Analysis in the same graph where each bar illustrates variable values. A visual display of value distributions exists within the provided graph.




## 4. CONCLUSION AND DISCUSSION

Research results revealed that contaminated drinking water strongly affects the occurrence of waterborne infections. The water supply and illness incidence relationship proved to be strong through chi-square statistical analysis. Households using untreated or polluted water from wells and rivers and unfiltered tap water sources experience greater occurrence of three water-related illnesses: cholera, typhoid and diarrhea. Water treatment methods including boiling and filtration together with chlorination prove essential because residences which consume treated water through filtering suffer significantly reduced cases of waterborne infections. Studies based on logarithmic regression show that families with low incomes encounter higher risks because they lack proper waste disposal systems and lack safe drinking water and have difficulty affording water filtration techniques. Better sanitation and water treatment systems receive higher priority from families that fall in the middle-income bracket despite their exposure to intermediate dangers. Higher-income families show less occurrence of waterborne infections due to their better infrastructure access for sanitation and healthcare and treatment systems. Research reveals that focused intervention programs should target low-income neighborhoods because illness occurrences directly follow societal economic levels.

Preventing illnesses requires the use of proper water purification techniques according to the study findings. The chi-square test results demonstrate significantly lower occurrences of waterborne infections within families that used water purification methods. Both water treatment programs and water safety education initiatives receive support from the obtained research data points. Data from chi-square tests revealed that communities with poor sanitation facilities like open defecation

and lacking sewage treatment experienced higher illness rates because these factors directly affected disease rates. The presence of sufficient bathrooms along with waste management systems and wastewater treatment plants led to reduced numbers of waterborne disease cases. The obtained data illustrates the urgent requirement to implement complete programs which address water-related infrastructure as well as sanitary systems.

The financial expenses related to waterborne illness create unprecedented financial burden for low-income families thus creating widened economic gaps between social groups. The therapy of these illnesses holds great potential for economic expansion most significantly within disadvantaged populations. The report underlines that Pakistan needs to enhance its public health system through improved water treatment solutions while simultaneously expanding sanitary facilities and accessible water supply. Water quality monitoring should be a priority while governments will also provide financial aid or incentives for water purification systems and run public health education programs for vulnerable groups.

Sustainable water treatment solutions that include chlorination pills together with solar disinfection devices and water purification systems must be developed to lower dependence on untreated water sources. Sanitary infrastructure including waste facilities and sewage systems along with latrines requires priority construction and maintenance activities mainly in regions without proper services. The successful execution of sanitation facility care programs alongside educational messages for water treatment methods and hygiene practice stands as a vital necessity. Through specific social policy measures that provide financial support to low-income families it becomes possible to improve access to clean water and proper sanitation particularly in unauthorized rural regions and informal urban areas.

**Limitations**

The research identified two main limitations through the study's restricted geographic focus on Pakistan's specific regions because these regions do not necessarily demonstrate water access conditions and disease occurrences similar to other areas. Underreporting from remote agricultural regions introduces research problems that might impact the accuracy of research outcomes. Research needs to evaluate water treatment and sanitation intervention outcomes into the future while tracking current water quality and disease situation trends. Studies should move forward by connecting waterborne disease control to established health policy structures to manage both water access and sanitary practices and healthcare facilities for enhanced health results.

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