Journal of Social Sciences Review (JSSR) DOI: https://doi.org/10.54183/jssr.v3i1.164

How to Cite This Article: Khan, S., Saeed, S., Khan, S., & Ibrar, M. (2023). Impact of Bacteriological Water Quality on Water-Borne Diseases and its Health Costs among Students of the Institutions. *Journal of Social Sciences Review*, 3(1), 510-518. https://doi.org/10.54183/jssr.v3i1.164

Impact of Bacteriological Water Quality on Water-Borne Diseases and its Health Costs among Students of the Institutions

Shadman Khan	Department of Civil Engineering, University of Engineering & Technology, Peshawar, KP, Pakistan.
Salman Saeed	National Institute of Urban Infrastructure Planning, University of Engineering & Technology, Peshawar, KP, Pakistan.
Salman Khan	Institute of Management Sciences, Peshawar, KP, Pakistan.
Muhammad Ibrar	Software College, Shenyang Normal University, Shenyang, China.

Vol. 3, No. 1 (Winter 2023)
Pages: 510 – 518
ISSN (Print): 2789-441X
ISSN (Online): 2789-4428

Key Words

E.coli Bacteria, Total Fecal Coliform Bacteria, Total Plate Count, Hygiene Practices, Water-borne Diseases, WBDs Costs

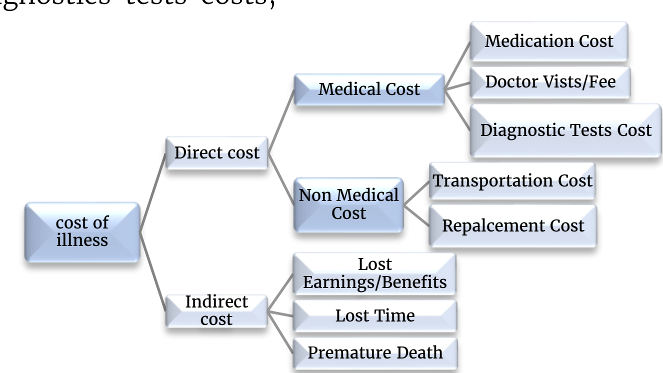
Corresponding Author:

Shadman Khan
Email: Shadman571989@gmail.com

Abstract: *In the developing world, a substantial revenue ($0.7 billion per annum in Pakistan (Resources & Tel, 2018), while in India, $0.6 billion is lost due to WBDs per year (Pathak, 2015) is spent, by citizens as well as the state, on the treatment of avoidable Water-borne diseases (WBD), which is often far greater than the investment required to improve water quality. Many agencies, like Public Health Engineering, WASA, PCSIR, PCRWR, etc., are carrying out water quality tests regularly and publish their findings periodically. However, none of these studies, so far, have included the disease incidence, direct and indirect costs borne by the citizens as well as the state due to poor water quality and poor hygiene practices such as environmental hygiene, personal hygiene, and water and food hygiene. From the result analysis of E.Coli, Total Fecal Coliform Bacteria (TFCB), and Total Plate Count (TPC) Tests, it was found that only 5.13 % of samples of water were contaminated with E.Coli and TFCB, but from the surveys, it was concluded that the disease incidence is more in the study area*

Graphical Abstract: (Cost of Illness)

The cost of illness consists of direct costs and indirect costs. The direct cost consists of the medical cost and the non-medical cost. Further, the medical cost consists of the medication costs, doctor visits (fee), and diagnostics tests costs, while the non-medical cost consists of the transportation cost and replacement costs. The indirect cost consists of lost earnings/benefits, lost time, and premature death.



Introduction

Water is the key and basic requirement for human beings on all planets. Without water, life will be impossible on this planet.70% or more of the human body cell or somatic cell is composed of water (Malik et al., 2012). The term water quality is utilized to depict the state of the water, including its physical, Chemical, and bacteriological parameters (Diersing et al., 2009). The quality of water is defined according to the need of an organism and the purpose for which it is used (Johnson et al., 1997).

The quality of water, especially the bacteriological water quality, has been continuously worsening in developing countries due to an enormous increase in industrialization and urbanization. When such water contaminated by pathogenic organisms such as bacteria and viruses etc., is used by humans, it causes various illnesses such as water-borne diseases, water-washed diseases, water-based diseases, and water-related vector-borne diseases(Solomon et al., 2011).

It is estimated that about 4 billion diarrheal diseases occur every year, which is responsible for 2 to 3 million deaths annually, out of which children are greatly affected in developing countries (Kosek et al., 2003). Globally, due to a lack of proper sanitary systems, improper disposal of wastes, and lack of clean potable water for drinking purposes, cooking purposes, and washing purposes, more than 801000 deaths occur annually (Liu et al., 2012) and according to WHO report 829000 deaths occur due to diarrhea annually developing countries (World Health Organization, 2019). (Peter H. Gleick, 2015) estimated that 135 million individuals will be affected by WBDs by 2020.

According to (Butt & Khair, 2014), every year, every family needs to hold up to Rs. 10,494 expense of water-borne diseases. (Hartlapp, 2019) concluded that 20% of samples of water were found contaminated with total coliform bacteria, and Escherichia coli are responsible for WBDs.

There are many sources for the contamination of bacteriological quality of water has been reported in the urban and rural areas of Pakistan. Such contamination of the bacteriological water quality may be due to leakage of pipes as shown in figure 1, pollution from sewerage pipes as shown in figure 2, the problem within the distribution system and shallow water tables (Khan et al., 2011).

Figure 1
Leakage from Pipes

Thus communicable illnesses caused due to pathogenic microbes, i.e., bacteria viruses, protozoa, and helminths (Parasitic worms, otherwise called helminths, are enormous macro parasites; grown-ups can, for the most part, be seen with the unaided eye. Most of them are intestinal worms that are transmitted through the soil and taint the intestinal tract, while some of them are parasitic worms, for example, schistosomes that dwell in veins. Some of them are Ectoparasites, e.g., leeches, while others are endoparasites, e.g., flatworms) (CDC, 2014).

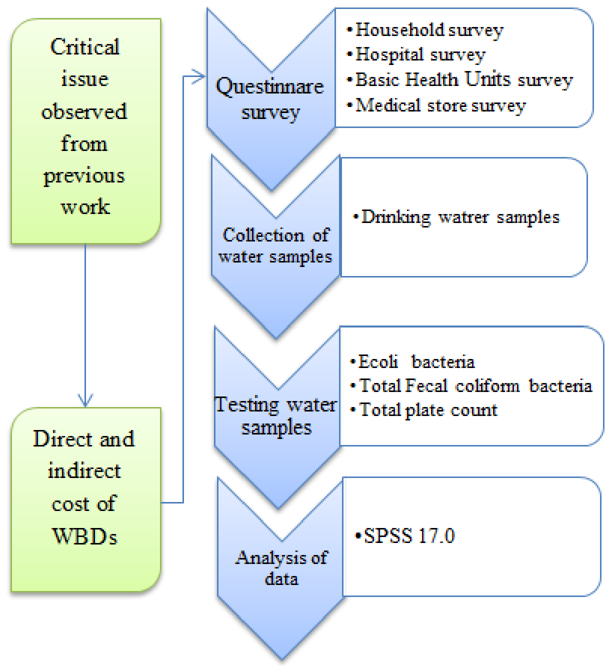
Figure 2

Disposal of Waste Water

The prevention of impurities is very difficult and costly due to a lack of social awareness among the communities, especially in rural areas. So, the amount of cost incurred on the treatment of water is similar to other water resource investments. However, drinking water benefit estimation is undersized practically. The primary aim of this research was to find the correlation between water quality parameters, disease incidence, and hygiene practices. Furthermore, an estimate of direct and indirect costs, to citizens as well as to the state, due to WBDs was also investigated. The schematic representation of the study is shown in Figure 3.

Figure 3

Schematic presentation of the critical issues observed in the current literature.



Methodology

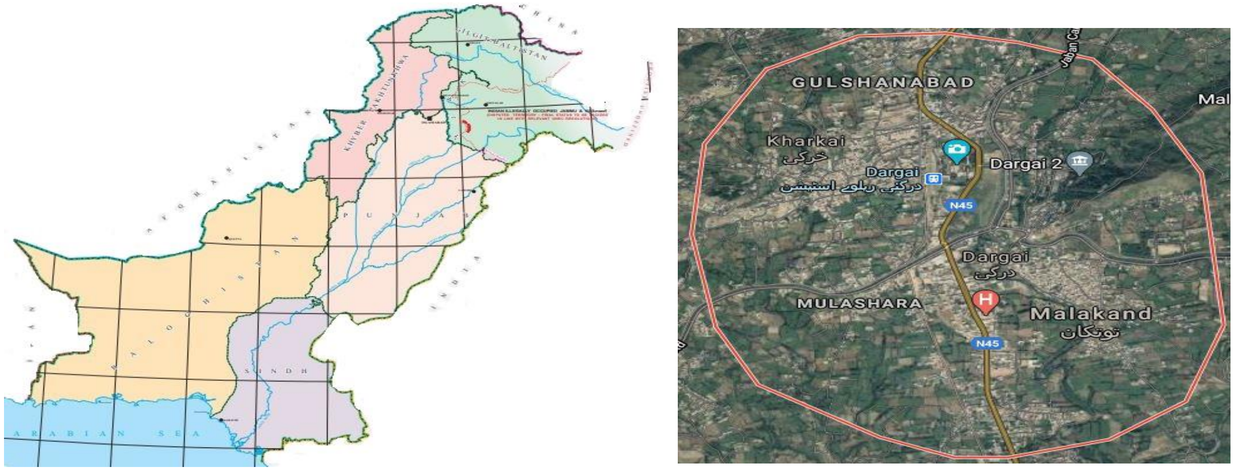
To achieve the objectives of the study, various questionnaire surveys were conducted at households, hospitals, basic health units, and medical stores to collect data regarding water-borne diseases and their health costs. Various bacteriological tests were also performed to know about the microbiological parameters of the water samples collected from the household.

Study Area (Tehsil Dargai)

The study area is tehsil Dargai which has an area of 952 $km^{2.}$ Its population is 304,112, and it is divided into 13 union councils. This area was selected because of the increased number of water-borne diseases in the area during the summer months.

Figure 3

Map of Pakistan & Satellite image of the study area



Sampling Design

Taking the overall population is very difficult and time-wasting. For this purpose, sampling has been used as a tool for conducting research. The sample data has been collected by using a questionnaire survey from households, hospitals, basic health units, and medical stores regarding the direct and indirect cost of water-borne illness for June, July, and August 2018.

Sample

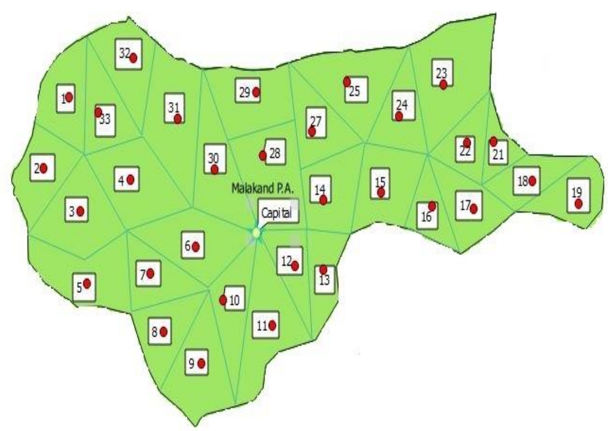
A sample of 219 households, 13 BHUs, 1THQ hospital (21 doctors), and 68 medical stores were surveyed to collect data for the direct and indirect cost of WBDs for June, July, and August 2018.

Selection of Points for Water Sampling

The whole area to be surveyed is divided into 33 polygons, as shown in the figure to ensure the randomness of data, and 219 houses were randomly surveyed. Within the household to be surveyed, drinking water samples would be collected from every 6th home as there are 13 union councils in the tehsil Dargai so three samples per union council would be collected for testing its bacteriological parameters.

Figure 4

Sampling points



Survey Questionnaires

For the calculation of the cost of the ailment of the WBDs, various surveys and questionnaires were used at the household level, hospitals, basic health units, and medical stores to collect the data regarding WBDs and their health costs during the summer months, i.e., June, July, and August.

Bacteriological Tests

The experimental work consists of finding the bacteriological quality of water by performing E-Coli, Total Plate Count, and Total fecal Coliform Bacteria (TFCB) only to find out whether the water is contaminated with microbial contamination or not. A total of 39 water samples were tested for the above-mentioned tests.

Figure 5
Dilequa Absence Presence Kit

Figure 6
Uncontaminated and Contaminated Water Samples

Hospitals and BHUS Survey

Hospitals and BHUs questionnaires were conducted to find out the cost of medicines used by hospitals for treating WBDs and also to examine the patient's records of admissions in the medical ward during summer months to estimate the number of patients admitted due to WBDs illness and their average stay period in the hospital. Semi-structured interviews were conducted with hospital doctors and other management to collect relevant information about WBDs. From hospitals and BHUs, data will be collected through the following questionnaire.

WBD Survey Questionnaire for Medical Stores

A survey questionnaire was also used at 68 medical stores to collect data regarding WBD medicines used and their costs during June, July, and August 2018.

Dependent Variables

Incidence of diarrhea, dysentery, cholera and enteric fever are the dependent variables used for measuring the direct and indirect costs of WBD.

Independent Variable

The hygiene practices in adults, hygiene practices in children, and education levels were the independent variables used in the sample t-test. These variables were selected to know about the personal hygiene of the people in the study area. Although there is no relation between water quality and hygiene practices having almost the same consequences, it is quite indistinguishable that water-borne diseases are caused due to poor water quality or hygiene practices. Also, the education level was selected as the independent variable to know the literacy level of the people in the area because as the education level increases, the incidence of WBDs decreases, as shown in Table 4.10.

Research Hypothesis

We have tested various hypotheses from 3000 rupees and increased the value further to 10000 and found from Table 4.13 that the null hypothesis is accepted for dysentery and rejected for diarrhea, cholera, and enteric fever, so we accepted the alternative hypothesis in the case of diarrhea, cholera, and enteric fever. The purpose of the hypothesis testing was to find out the plausible values for the money lost due to WBDs during the summer months of June, July, and August.

Analysis

Direct & Indirect Costs

Figure 7 shows the direct cost composed of medical costs and non-medical costs of the household surveyed during June, July, and August. It was concluded from the result that the total direct cost was 5.20m, comprised of medical cost (5.14m) and non-medical cost (0.058m).

Figure 7

Direct costs

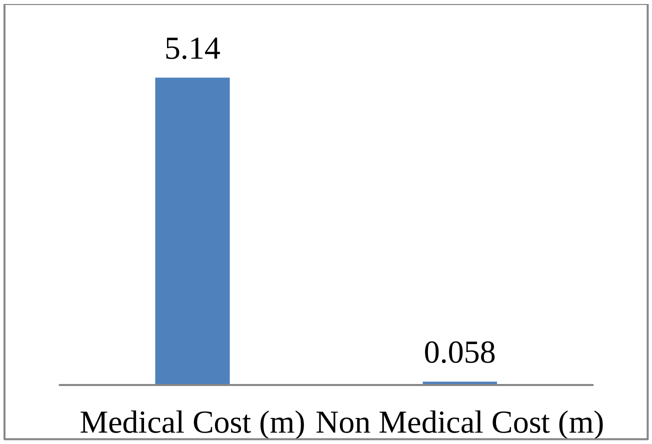


Figure 8 gives the indirect cost composed of lost earnings/benefits (13.75m), lost time/study (0.089), and premature death (0) due to WBDs during the study area during June, July, and August 2018. Figure 9 demonstrates that the total cost consists of 73% indirect cost and 27% direct cost.

Fig 8

Indirect Costs

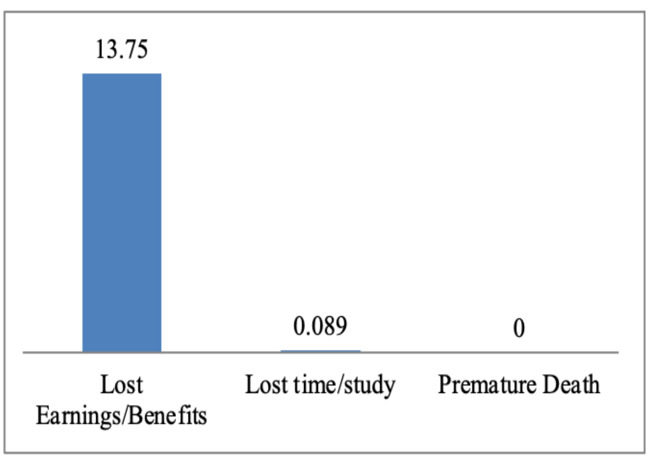
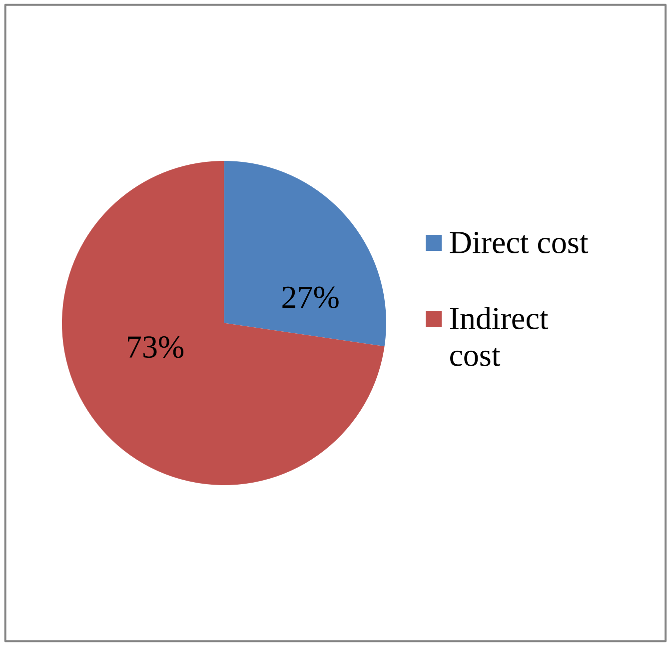


Figure 9

Direct and indirect costs

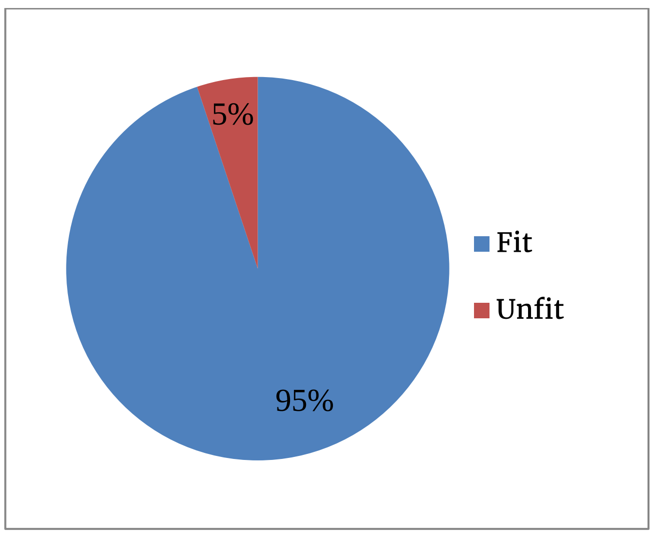


Fit and unfit drinking water samples

Figure 10 gives the percentages of the water samples fit and unfit for drinking purposes.

Figure 10

Fit vs. unfit drinking water samples



It was shown in the above graph that 95% of water samples were found fit, while 5% of the water samples were found unfit for drinking purposes.

Hypothesis

The following hypothesis was made for diarrhea, dysentery, cholera, and enteric fever.

Null Hypothesis: H_0 = Ten thousand rupees of a HH is lost due to diarrhea, dysentery, cholera, and enteric fever.

Alternate Hypothesis: H_1= Thousands of rupees of a HH is not lost due to diarrhea, dysentery, cholera, and enteric fever.

Table 10 shows the one sample statistics in which the mean value of benefits lost due to diarrhea, dysentery, cholera, and enteric fever during June, July, and August is 23341, 8015, 16841, and 14597, respectively, and its standard deviation is 21892, 14961, 19362 and 16722 respectively while N shows the number of samples, which are 219. And the last column shows the mean and standard error.

Table 1 shows the results of the one-sample t-test. The first column shows benefits lost due to WBDs, the second column shows the t value, df shows the degree of freedom, and next is the significance level followed by mean difference and range of lower and upper range values. The results given for the row of benefits lost due to diarrhea ($t=9.0$, $df=218$, $p<0.001$) show that there is solid evidence of the difference between the test value (10000 rupees) and the mean value of money lost due to diarrhea (23341 rupees). The further output gives an estimate for the mean difference (13341 rupees) between the test value and the benefits lost due to diarrhea and constructs a 95% of CI for the mean difference (from 10425 rupees to 16256 rupees). It's a two-tail test which shows that we are 95% confident that the benefits lost due to diarrhea are not equal to 10000 rupees. Thus we conclude that more than ten thousand rupees are lost due to diarrhea in the summer months, So we reject our null hypothesis that ten thousand rupees of a HH are lost due to diarrhea.

Similarly, the loss of the benefits due to dysentery ($t= -2$, $df = 218$, $p>0.001$) shows that the money lost due to dysentery is not equal to the test value. Also, the t value confirms that the money lost due to dysentery is less than 10000 rupees. The mean difference between the test value and the benefits lost due to dysentery is -1985 and construct 95% of the Confidence interval for the mean difference from -3977 rupees to 8 rupees. In the case of dysentery, the result shows that less than ten thousand rupees are lost of a HH in the study area during June, July, and August 2018. Also, the benefits lost due to cholera ($t=5.2$, $df=218$, $p<0.001$) show that there is a solid reason for the difference between the test value (10000 rupees) and the mean money lost because of cholera (16841). The further result gives a range for the mean difference (6841 rupees) between the test value and the money lost because of cholera and builds a 95% of CI for the mean difference (from 4263 rupees to 9420 rupees). Also, the test results show that we are 95% certain that the money lost because of cholera is not equivalent to 10000 rupees, so we conclude that more than ten thousand rupees were lost due to cholera in the study area. Thus we reject our invalid speculation (hypothesis) that ten thousand rupees of a HH are lost because of cholera. Furthermore, the benefits lost because of enteric fever ($t=4.1$, $df=218$, $p<0.001$) show that there is a strong confirmation of the difference between the test value (10000 rupees) and the money loss in respect of enteric fever. Further results give output for the mean difference (4597 rupees) between the test value and the money lost on account of enteric fever and construct a 95% of CI for the mean contrast (from 2370 rupees to 6824 rupees). The test shows that we are 95% sure that the monetary loss due to enteric fever is not equal to 10000 and conclude that more than ten thousand rupees are lost due to enteric fever during the summer months in the study area. So we reject our hypothesis that six thousand rupees of a HH are lost as a result of enteric fever.

Table 1

Lost benefits due to diarrhea, dysentery, cholera, and enteric fever (One Sample Statistics)

	N	Mean	Std. Deviation	Std. Error Mean
Lost benefits diarrhea	219	23341	21892	1479
Lost benefits dysentery	219	8015	14961	1011
Lost benefits cholera	219	16841	19362	1308
Lost benefits enteric fever	219	14597	16722	1130

Table 2

Lost benefits due to diarrhea, dysentery, cholera & enteric fever (One sample test)

	Test Value = 10000					
					95% Confidence Interval of the Difference	
	T	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Lost benefits diarrhea	9.02	218	.000	13341	10425	16256
Lost benefits dysentery	-1.96	218	.051	-1985	-3977	8
Lost benefits cholera	5.23	218	.000	6841	4263	9420
Lost benefits enteric fever	4.07	218	.000	4597	2370	6824

Conclusions and Limitations

This chapter includes the conclusion, which is derived from the research study, and it also contains a recommendation which is based on the research study.

Conclusions

The following were the conclusions of this research work.

- This study aimed to examine the effect of bacteriological water quality on water-borne diseases and to analyze the cost of the disease associated with the use of polluted water in tehsil Dargai district Malakand Khyber Pakhtunkhwa Pakistan.
- It shows the total cost of WBDs (164m), comprised of 20m from the HH survey, 0.5m from the hospital, 17m from BHU, and 126m from medical stores survey questionnaires.
- Similarly, it also shows the total cost of the Tehsil Dargai, which was 22984m during June, July, and Aug 2018.
- Estimates showed that households bear a higher cost of illness due to water-borne diseases. The analysis of the cost of illness of water-borne diseases revealed that sampled households incurred a direct cost of 5.20m (medical cost 5.14m and non-medical cost 0.058m) and indirect cost of 14m (lost earning/benefits 13.75m and lost time/study 0.089m) during the summer months in treating water-borne diseases. It also shows that the incidence and financial burden of water-borne diseases are more on the low-income group. Because the low-income group bore the comparatively higher cost of illness as a proportion of their total income, this indicates the need for better healthcare services to be provided at

public hospitals so the costs incurred on illnesses could be reduced.

Limitations

The following are the limitations of the study.

1. Such a study should be carried out in other months of the year to check the climatic effect on water quality and WBDs.
2. Due to the lack of written records with the households regarding WBDs, the cost estimates were made based on the respondent recall for June, July, and August.
3. The sample size was confined because of time and assets limitation.
4. The respondent's hesitance to give data on their salary may have under-expressed their wages.

References

Butt, M., & Khair, S. M. (2014). Cost of Illness of Water-borne Diseases : A Case Study of Quetta. *J. App. Em. Sc*, *5*(2), 133–143. https://doi.org/journal.buitms.edu.pk/j/index.php/bj/article/download/144/128

CDC. (2014). *CDC - Parasites - About Parasites*. Centers for Disease Control and Prevention.

Diersing, N., Keys, F., & Marine, N. (2009). Water Quality : Frequently Asked Questions. *Florida Keys National Marine Sanctuary*, 5–6.

Hartlapp, I. (2019). Gastrointestinal illness. *Oxford Handbook of Humanitarian Medicine*, 647–668. https://doi.org/10.1093/med/9780199565276.003.0038

Johnson, D. L., Ambrose, S. H., Bassett, T. J., Bowen, M. L., Crummey, D. E., Isaacson, J. S., Johnson, D. N., Lamb, P., Saul, M., & Winter-Nelson, A. E. (1997). Meanings of Environmental Terms. *Journal of Environmental Quality*, *26*(3), 581–589. https://doi.org/10.2134/jeq1997.00472425002600030002x

Khan, T. M., Muhammad, S., Khan, B., & Khan, H. (2011b). Investigating the levels of selected heavy metals in surface water of Shah Alam River a tributary of River Kabul, Khyber Pakhtunkhwa. *Journal of Himalayan Earth Sciences*, *442*, 71–79.

Kosek, M., Bern, C., & Guerrant, R. L. (2003). The global burden of diarrhoeal disease, as estimated from studies published between 1992 and 2000. *Bulletin of the World Health Organization*, *81*(3), 197–204. https://doi.org/10.1590/S0042-96862003000300010

Liu, L., Johnson, H. L., Cousens, S., Perin, J., Scott, S., Lawn, J. E., Rudan, I., Campbell, H., Cibulskis, R., Li, M., Mathers, C., & Black, R. E. (2012). Global, regional, and national causes of child mortality: An updated systematic analysis for 2010 with time trends since 2000. *The Lancet*, *379*(9832), 2151–2161. https://doi.org/10.1016/S0140-6736(12)60560-1

Malik, A., Yasar, A., Tabinda, A. B., & Abubakar, M. (2012). Water-borne diseases, cost of illness, and willingness to pay for disease interventions in rural communities of developing countries. *Iranian Journal of Public Health*, *41*(6), 39–49.

Pathak, H. (2015). Effect of Water-borne diseases on Indian Economy: A cost-benefit analysis. *Analele Universităţii Din Oradea, Seia Geografie*, *25*(1), 74–78.

Peter H. Gleick. (2015). Dirty Water: Estimated Deaths from Water-Related Diseases 2000-2020 Pacific. *Pacific Institute Research Report*, 1–12.

Solomon, A., Ahmed, Z., Biruktawit, K., Amare, D., Solomon, A., & Endalew, Z. (2011). Bacteriological analysis of drinking water sources. *African Journal of Microbiology Research*, *5*(18), 2638–2641. https://doi.org/10.5897/ajmr11.218

World Health Organization. (2019). Safe water, better health. 2019 update. In *Geneva: World Health Organization; 2019. License: CC BY-NC-SA 3.0 IGO. Photographs*