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ECONOMIC IMPACT OF WATER POLLUTION ON HUMAN HEALTH: A CASE STUDY OF KEHAL, KPK, PAKISTAN

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ABSTRACT

The present study analysis the impact of water pollution on human health and the economic burden of illness due to water borne diseases in Union Council Kehal, Abbottabad. Primary data was collected by survey in the targeted area. Two types of data were collected: i). Relative data was collected by solving well organized questionnaires for estimating incident and cost of illness. ii). Water samples were collected from drinking water sources of households. The data showed the presence of water pollutants and incidents of diseases. The cost of illness was calculated by medical cost and its marginal effects. While marginal willingness to pay was calculated by combining the estimated values of workday loss and cost of illness. The results showed that marginal willingness to pay to reduce the impact of sickness is Rs 71.68, while total welfare loss the community is 296,352 PKR per year.

Keywords: *Water borne diseases, E. Coli, Economic burden, Cost of illness, Marginal willingness to pay, Welfare loss*

INTRODUCTION

Water is considered as one of the important elements for living, no life is possible on the earth's surface without water. Water supports life and helps humans, flora, and fauna with surviving on the earth's surface. About 71% of earth's surface is covered with water and it is the most abundant element existing on the earth (USGS, 2016). It exists in the form of rivers, oceans, spring water, ponds, glaciers, and underground water. Despite having water in such a huge quantity, only 3% of it is fresh water, which is not all accessible (Williams, 2014).

Water is an essential element for living and it is one of the endangered elements due to human activities. Global warming is depriving human being form their right to have clean and safe drinking water. Industrialization, urbanization, and overpopulation are some other alarming issues, triggering the problem of safe drinking water. Too many people on the earth have no access to clean water. Many of the world's population is facing water scarcity, and they are compelled to drink unsafe water. It is estimated that about 84.2 billion people die annually due to unsafe drinking water, poor hygiene and sanitation (WHO, 2018). The demand for water is increasing by 1% every year in the result of increasing population. But the water reservoirs are falling off to meet global demand for water.

The current scenario of water (regarding water pollution and availability of water) forced international forums to think about environmental and health hazards of water pollution. In order to combat the consequences of water pollution and scarcity UNDP have set some guidelines. According to 2030 agenda (SDGs) of UNDP, it is stated that drinking water (safe and affordable) and sanitation (adequate and equitable) should be accessible for all. Water quality should be improved by reducing pollution, removing dumping and minimizing release of dangerous chemicals and materials into water channels (UNDP, 2015).

Water borne pathogens are the main concern of water management authorities. These pathogens have several pathways through natural and manly managed water resources. Household and industrial wastes contaminate drinking water. Both public health and the environment are likely to get harmed due to heavy metal, detergent and sewerage water contamination. In most of the developing countries people are using untreated and contaminated water for drinking and cleaning purposes, which can cause acute and chronic diseases. Common water borne diseases which people are prone to, are Gastrointestinal diseases, typhoid fever, cholera, hepatitis A, hepatitis E etc. (WHO, 2018).

Different pathogenic strains of E Coli are widely associated with water borne diseases. Out of these pathogenic strains, shiga toxin-producing E. coli (STEC) and E. coli O157:H7 (also called as enterohaemorrhagic E. coli or EHEC), contribute towards the asymptomatic infections to severe bloody diarrhea. Gastrointestinal (GI) diseases are also attributed to Campylobacters and Yersinia enterocolitica (Sharma et al., 2003).

Canada reports 20.5 million cases of indigenous GI. Giardia, Cryptosporidium, Campylobacter, E. coli and norovirus were chosen as index for water borne pathogens. The results showed that norovirus, Cryptosporidium, Campylobacter, Giardia, and E. coli O157 contribute 73%, 13%, 10%, 3·5% and 0·6% respectively to the GI diseases (Murphy et al., 2016). A study was carried out in 2015 at Gwangju Metropolitan City, that 188 students of three different schools had diarrhea and vomiting after attending school camp. The microbiological techniques revealed the presence of enterohemorrhagic Escherichia coli, enteropathogenic E. coli and enteroaggregative E. coli strains in patient's stools and water samples from the camp site (Park et al., 2015). A statistical analysis in Montreal, Canada showed that 65 % of families experienced at least one episode of GI symptoms and about 23 percent of individuals had at least one episode of GI illness (Payment et al., 1991). E Coli is one of the most common pathogenic bacteria causing diarrhea. Diarrhea is one of the main diseases causing deaths every year (Guerrant et al., 1983).

Water pollution and scarcity not only lead to health issues but also it is associated with socio-economic issues. About 80% of water is used for irrigation out of which 50% is wasted. Which leads to water pollution and scarcity for the rest of the community (Knox et al., 2012). Due to unhealthy, unequal, and insufficient distribution of water resources, the private sector made steps to provide safe water in the form of bottled and tanker water. But this increased the cost of water collection and distribution, which in turn put extra burden on consumers. In many countries in Europe and America water is treated as an economic good and is regulated by privatized ownership. Although this privatized system has equitized the water distribution among masses, the price of water is so high, which economically burdened the masses. The public sector is now considering the water issues in different countries by providing masses with cheap and accessible water but still it does not match the health standards, so people are still forced to use expensive bottled water (Rogers et al., 2002).

Water pollution not only brings health issues, but it also puts economic burden on masses. People annually spend huge amounts of their incomes on taking avertive measures and curing water borne diseases, which cost billions of dollars of annual welfare loss. It is reported in a study that in California coastal water pollution resulted in public health burden of $3.3 million annually (Dwight et al., 2005). In Nigeria about 12% of GDP is required just for eradication of malaria which burdened the deprived people of Nigeria (Galadima et al., 2011). There is no planned and structured water system in Pakistan. Both surface and ground drinking water sources are continuously contaminated with micro-organisms and toxic metals. Pakistan has not made remarkable steps to attain sustainable development related to water management, and international drinking water standards are continuously being violated. Microbial and toxic metal are pollutants putting public health in great danger (Azizullah et al., 2011).

2. Literature Review

Previous studies give evidence that water pathogens and high metal concentration in drinking water are associated with range of diseases. Water pathogens are the factors causing fatal diseases like diarrhea, cholera, and other Gastrointestinal diseases. While heavy metals are associated with cancerous diseases, lungs, kidneys, cardiovascular, nervous and endocrine disfunctions. The economic burden of water pollution and water borne diseases is inevitable. Masses are not only forced to buy high price purified water, but they also spend billions of dollars to cure water borne diseases every year. Pathogenic diseases like diarrhea and cholera cause billions of deaths each year. Following chapter is divided into three subheadings:

i. **Medical Perspective:** in which the proof of incident of water borne diseases is given related to diseases due to water pathogens and heavy metals.

ii. **Economic Perspective**: explaining the economic impact of water borne diseases. This section will brief the economic methodologies used in literature to calculate the economic burden communities are bearing due to water borne illness.

2.1 Medical Perspective

An epidemiology study was made in Philippines to illustrate water crises, water pollution and its impact on public health. It was argued that in Philippines water borne diseases were increased by one third in the time of five years. People are suffering from cholera, diarrhea, and skin diseases. Not only people are suffering from water borne diseases, but animals are also experiencing toxic buildups within fatty tissues of their bodies (Andrews, 2018).

Davies et al., (2014) took time series data for 16 provinces in Cambodia. They tried to find the relationship of flood water and diarrheal diseases in children. This time series data was taken from the year 2001 to 2012. This data was analyzed by using Quasi-Poisson Distribution. This study found that flood water is significantly associated with diarrheal diseases in two provinces.

A meta study was made to find the association between E coli and diarrhea in order to support the previous literature. This research conducted 20 studies and used relative risk (RR) method to find out the relationship between risk and incidents. It was concluded that out of 20 studies 14 studies showed a positive relationship between E coli and diarrhea at the confidence interval of 95%. This study further stated that there is no significant relationship between thermo tolerant or fecal coliforms (FC) and diarrhea (Gruber et al., 2014).

Research was made to investigate the concentrations of various pollutants in drinking water and health risk in Charsadda district in Pakistan. The standard method was used to analyze the concentration of pollutants in water samples. Water samples were collected from dug-wells, tube-wells and hand pumps which were the most common sources of drinking water and analyzed for physical parameters, anions, heavy metals and coliform bacteria using standard method. The results showed concentrations of nitrate, sulfate, Pb, Cd, Ni and Fe exceeded permissible international water standards. Furthermore, the coliform bacterial contamination was also found in some sources of water, confirming the bacterial contamination of drinking water (Khan et al., 2013).

Fifteen samples of drinking water were collected from different areas of District Abbottabad for an Epidemiology Study. These samples were tested for coliforms, chlorides, total suspended particles (TSP) and other impurities and standard method was used to analyze the water samples. These samples were not found to be fit for drinking. Different tests showed that there is high level of coliforms, total suspended particles and other impurities. Water quality did not match international drinking water standards, it was also responsible for acute and chronic diseases (Khalid et al., 2011).

In Nigeria a retrospective study was made to test water quality for prevalence of water borne diseases. The study showed that the number of patients who were diagnosed with water borne diseases were 14.61%, 34.83% and 50.56% for the years 2005, 2006 and 2007, respectively. The water borne diseases that were consistently reported and diagnosed were cholera (3.37%), diarrhea (44.94%), dysentery (16.85%), and typhoid fever (34.83%). The quality of the water and the prevalence of water borne diseases were mainly related to the contamination of the river water (Nwidu et al., 2008).

A study was made to find out the toxicity of low dose mercury for human health. This study argued that multi pathways of mercury (air, water, foods etc.) encounter human body which in turn affects the health of humans. This study suggests that households having large fish intake are at greater risk of mercury intake. Also, occupational hazards of mercury for gold miners, chloralkali workers and dental surgeons are putting their health on stake (Zahir et al., 2005).

A study was presented to show the impact of mercury on human health and environmental quality. This study suggested that industrialization is increasing the level of mercury in the environment which is directly and indirectly ingested by humans and animals. This study further stated the sources of mercury in the environment which are: mercury vapors in air, drinking water, fisheries, florescent light bulbs, and other cosmetic products etc. Dose of mercury can affect the Central Nervous System (CNS), impair hearing, tunnel vision, acute kidney failure and gastrointestinal diseases (Hyman and Kohl, 2004).

2.2 Economic Perspective

In an area of Kehal, a survey study was made to estimate the economic cost of water contamination :Ecoli. 462 households were sampled in three buffer zones from the pollutant source. Using marginal willingness to pay approach $53 was the estimated annual cost of a household. Total annual welfare loss of the community due to lead contamination was estimated to be $42,000 (Sayal et al., 2016).

Contingent Valuation Method (CVM) was used, in Mytilene a city in Greece, to find out the willingness to pay for improvement of tap water quality. A sample of 152 citizens was taken during the spring of 2009 in the city. Citizens of Mytilene do not consume tap water due to water impurities. This study found that only 40% of the population intended to pay for better water facilities. The article also explained the reason for such a low rate for willingness to pay that people argued that they already pay huge amount in the form of state taxes (51.3%) (Polyzou et al., 2011).

This study used contingent valuation method to calculate economic cost of water sources, and marginal willingness to pay approach was used to calculate the amount households were willing to pay for improvement of water sources. This study categorized the households in three groups: first includes the one who are willing to pay less than Rs 50, second one includes households who are willing to pay between Rs 50 and Rs 100, while third category includes households who are willing to pay above Rs 100 per month in order to get improved water services (Haq et al., 2008).

The concentration of iron and sulfate in community water supplies of Minnesota was found to be at a risk level. A study was carried in 2005 to make an estimate of wiliness to pay of residents of Minnesota. The contingent valuation method was used to calculate willingness to pay. This study estimated that residents of Minnesota are willing to pay US$2.4 million and US$2.0 million for reducing the levels of iron and sulfate, respectively, in order to eliminate these impurities from drinking water (Cho et al., 2005).

In California a study was taken to find the economic cost of water borne diseases. The data was collected during randomized intervention follow-up epidemiological studies conducted at four beaches in the United Kingdom. It was estimated that the economic burden per gastrointestinal illness amounts to $36.58, the burden per acute respiratory disease was $76.76, the burden per ear ailment was $37.86, and the burden per eye ailment was $27.31. The study made cost benefit analysis in order to evaluate pollution abatement strategies (Dwight et al., 2005).

A study was made in America in 2005 in order to calculate the economic cost of methy mercury. This study used an environmentally attributable fraction (EAF) model to estimate the disease burden and the costs of methyl mercury exposure. This study was developed to find out the cost of IQ and productivity loss among the residents of USA. It was estimated that the community would loss 8.7 billion dollars annually in the result of loss of IQ. It also estimated that about 1.3 billion dollars attributes annually to mercury emission from American Power Plant (Trasande et al., 2005).

Health production function approach was used in a study in India to estimate economic cost of water borne diseases. A sample of 600 households in summer 1999, in Dehli was taken to analyze the existence of water contamination and water borne diseases. The laboratory tests showed that 35% of water samples do not match the international standard of coliforms count. It was estimated that Rs 71.43 was the average cost for a representative household over 15 days during the peak period for diarrheal illness (Dasgupta, 2004).

3. Objectives of the Research

Objectives of this study are:

1. To find out water pathogens and metals concentration in drinking water in the targeted area.
2. To analyze the impact of water contamination (E. Coli) on the health of people in the Union Council of Kehal, Abbottabad.
3. To calculate economic cost (Marginal Willingness to Pay) of water borne diseases in Kehal.
4. To calculate the welfare loss of the community.

3. RESEARCH METHODOLOGY

Economic valuation of health with change in environment is evaluated by the utility of human behavior. This human behavior is studied by the utility maximization theory. Households always want to maximize their utility. The theory of utility maximization is developed to estimate the probability of sickness (Dasgupta, 2004).

Utility Function

Utility function is given as follows:

U = U (X, H, Q, L, I)

Were,

U = Utility

X = Expenditures

H = Health (defined by sickness in this study)

Q = Environmental quality (Defined by pollutant in this study)

L = Leisure

I = Income

Utility is the function of expenditure, leisure and health, environmental quality, and income. It has a positive relationship with expenditures, environmental quality, and leisure. Household make choices between two or more options, at his optimal level as he consumes his utility increases. Leisure is the ultimate choice of the consumer, as he needs time to take a rest and consume his earnings. Hence more the leisure and income more will be the utility. Utility has an inverse relationship with health if it is sickness. As households get disutility so there is negative relationship between utility and sickness (Harrington and Portney, 1987).

Health Production Function

Grossman, (1972) gave the concept of health production function in which he considered environmental quality (i.e. pollutant) as an input. He explained health production function as:

H= H (Q, M, A, K, S)

Were,

H = Health (measured by numbers of sick days)

Q = Environmental quality (quality of natural resources i.e. air, water, scenic beauty etc.)

M = Mitigated cost (cost to reduce illness)

A = Avertive cost (cost to avoid illness)

K = Health of capital stock

S = Stock of social capital (education and skills)

When we measure health in terms of sickness environmental quality, health of capital stock and stock of social capital have negative impact on sickness. While with increase in sickness will also increase avertive and mitigated costs.

3.1 Econometric Models

Probit Model

Probit model is used when a research question depends on binary dependent variable, because it is difficult to interpret binary dependent variable by using OLS (Sayal et al., 2016). The dependent variables of sickness and medical cost are treated as binary variables in this study, for which we will use probit model to estimate the probability of sickness by maximizing the following log-likelihood function:

$L = \sum (Y_i \ln F(x, \beta) + (1 - Y_i)(1 - \ln F(x, \beta))$

Where:

i. x = vector of independent variables

ii. βs= coefficients (Individual-level information such as age (in years), Education (in four stages: illiterate, primary, middle, high school), Monthly income (PKR), concentration of Mercury (mg/L))

iii. F (x, β) = cumulative probability function for probit model

iv. Yi= The dependent variable (1 = sickness exists to mercury, 0 =sickness does not exist)

v. i = number of houses holds

Marginal Willingness to Pay

The Marginal Willingness to Pay (MWTP) approach will be used to calculate the willingness of households to get better water services. For which following model will be adopted:

$MWTP = Wi \times WDL \times Pi\ (S / \Delta C) + M \times Pi\ (M / \Delta C)$

Where:

i. $Wi \times WDL \times Pi\ (S / \Delta C)$ = marginal income loss due to marginal mercury exposure (probability of sickness)

ii. $M \times Pi\ (M / \Delta C)$ = marginal change in medical cost due to marginal change in mercury exposure

3.2 Variables and Hypothesis Development

Dependent Variables

This analysis is trying to find the impact of pollutants on the health of residents of Kehal. Health is measured by sickness where disease is taken as a dependent variable.

Sickness

Diarrhea is an infectious disease that is generally caused by different infections and bacteria like Cryptosporidium parvum infection, E. coli and Salmonella. These bacteria usually enter the human body through drinking and eating of unhealthy and contaminated food (Holland, 1990). This study tends to find whether the number of diarrhea patients (sickness) increase with increase in count of infectious bacteria in drinking water.

Medical Cost

Medical cost is the cost that is incurred in order to cure sickness. It includes doctor fee, admit fee, travel cost and medicine cost. Medical cost is calculated as:

Medical Cost = medicine cost + (doctor fee + travel cost) no. of visits + (admit fee) no. of hospital admission per year

Independent Variables

Water pollutants have an adverse impact on human health. This study aims to find out that impact on health. This study uses three independent variables which are briefly explained as follows:

E. Coli

E. Coli is a pathogenic bacterium which is able to cause severe gastrointestinal diseases. This bacterium is present in fecal tract of human body which is usually not harmful. But when it enters the body through outer carriers like water it can cause severe health conditions (Paton and Paton 1998). E. coli is a cardinal variable that is measured in counts. It is expected that there is a positive impact of E. Coli on diarrhea patients.

Education

Education lead to a change in thinking patterns. As the level of education increases, its impact on health also increases. Public policies regarding education could have significant impact on public health (Cutler and Lleras-Muney, 2006). Current analysis takes education as an ordinal variable, ranking from zero to three. Were,

0 = illiterate
1 = primary education
2 = secondary education
3 = higher secondary education

Age

Age is considered as one of the main factors of exposure to bacterial diseases. Children are more exposed to water borne pathogens. About 140-160 million cases are recorded related to water borne diseases under the age of 5 years (Woodall, 2009). This study will find the impact of age on incident of sickness (diarrhea).

3.3. Village Profile

Kehal is a Union Council in Abbottabad District spread over an area of about 0.58 km2. It is a densely populated residential area with a population of 27,391 households (PBS, 2017). Coordinates and altitude of the area are:

Latitude: 34° 8′ 32.5″ N
Longitude: 73° 13′ 5.5″ E
Altitude: 1282 m

Following map is showing the location of Union Council Kehal, Abbottabad:

Fig.: 1 Satellite Map of Union Council Kehal (Source: Google Map 2018)

3.4 Sampling

Kehal is a densely populated area, and it is difficult to conduct the survey of whole population. Therefore, the sample was calculated by taking 25% of total population at 5% confidence interval which was 286 households. The technique for sampling which was used is random sampling. Out of 5000 households ,255 households were samples based on survey system .com

3.5 Time Horizon

The survey and water sampling were conducted from September 2023 to March 2024. To control the impact of exogenous variable monsoons the survey was conducted after July and August.

3.6 Data Collection and Data Analysis

A survey was conducted in order to support research questions regarding water impurities and their health impact on the residents of Kehal. Sampling was carried out in two ways:

i. Water samples were collected from household drinking water sources.

ii. The household survey, for relevant information, was carried out through a planned questionnaire.

The following pictures of survey site were taken, showing drinking water pipelines passing through sewerage.

Fig. 2 Water Pipelines Passing through Sewerage

3.7 Laboratory Tests

Water samples were tested in microbiological and instrumental labs in COMSATS University Islamabad Abbottabad Campus. Following is the brief explanation of laboratory tests for coliforms and metallic concentration in collected water samples:

Water samples were tested for coliforms in Microbiological Lab. By following the epidemiological process of preparation and pouring of media in petri dishes and solidifying them in laminar flow. The medium used to grow bacterial colonies was EMB Agar. After solidifying medium samples were poured in petri dished which were incubated for 48 hours in incubator. After 48 hours of incubation period the samples were ready for the study of microbial aspects.

Samples were tested for metals in the instrumental lab. AAS (Atomic Absorption Spectrometer) was used to detect metals, which uses lights of different wavelengths to detect concentration of different metals in water sample that was passing through cathode tubes. The 3 samples that were not good for microbial aspect were excluded for metal detection also and 255 samples were tested for metal concentration.

The laboratory data show the microbial and metallic concentration in collected water samples. While questionnaire data shows the incidence of diseases and their relationship with pollutants. Also, age, education, monthly expenditures, and cost of illness is estimated from questionnaires. STATA is used to estimate the relationship, and magnitude of sickness and pollutants. In the end MWTP is calculated and discussion is made based on these results.

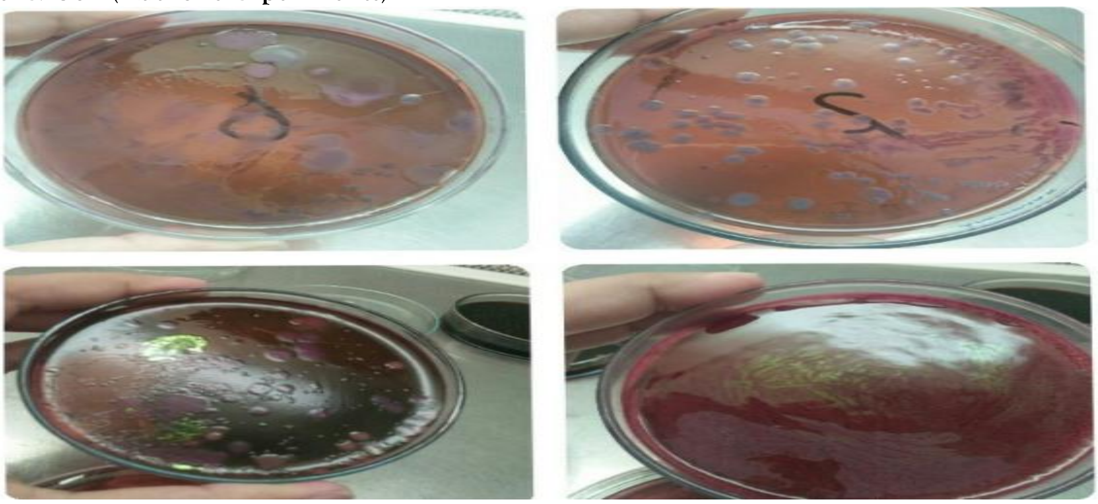
3.8 Laboratory Data Analysis

Water samples were tested for coliforms and heavy metals in Microbiological Lab and Instrumental Lab at COMSATS University Islamabad Abbottabad Campus. Following were the results for pollutants in collected water samples:

Coliforms

286 samples of water were tested for E Coli from which 31 samples had other colonies that were behind the scope of this topic while 255 samples were found to be good for further research. 68 samples were found clean having no coliforms while 187 samples were found to be contaminated with coliforms (E. Coli). The following collage is showing E.Coli in samples that were tested for coliform contamination in water samples.

Fig: 3 E. Coli (Author's Experiments)



According to the World Health Organization pathogenic microorganisms should not be present in drinking water. E Coli is a type of coliform which provide definite evidence of fecal contamination in water and can cause illness (potentially diarrhea). According to WHO (2017) water standards E Coli must not be detectable in 100 ml of water. Infections due to E Coli are not common but the symptoms may be severe that can cause hemolytic uremic syndrome (which lead to renal failure) and even death (World Health Organization2017).

The above table shows that led concentration in collected water samples is safe for drinking, while nickel, mercury and arsenic are above thresh hold values suggested by WHO. These metals have worse impacts on human health which are discussed in previous chapters.

Table 3 Descriptive Statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Sickness	255	.721	.449	0	1
Medical Cost	255	851.0	978.0	0	6200
E . Coli	255	303.298	274.87	0	1000
Edu	255	1.921	.8838	0	3
Age	255	36.729	11.637	19	87

Table shows the summary statistics of dependent and independent variables. The dependent variable of sickness is a dummy variable having binary values i.e. 0 and 1. It has average value of 0.722 that means sickness is more inclined toward dummy value 1, which explains that there is more sickness in the community. The second dependent variable is Medical Cost. The mean value of the Medical Cost is 851 PKR. The mean count of pollutant is 303.298. Average education is 1.921, which shows that respondents have an average education in secondary school. The average age of representatives of households is 36.729 years with a minimum of 19 years and maximum of 87 years.

Table 4 Dose Response Function

Sickness	Coefficient	Standard Error	z	Probability	dy/dx	Standard error
E. Coli	0.00392	0.0006	.59	0.00	0.001	0.0001
Edu	-0.6500	0.1450	-4.48	0.00	-0.167	0.037
Age	-0.0230	0. 0101	-2.27	0.023	-0.006	0.003
Constant	1.8094	0. 5824	3.11	0.002	---	---

The above table shows that E . Coli has a significant and positive relationship with sickness. 1 count increase in E. Coli will increase sickness by 0.39 patients. Education has a significant and negative relationship with sickness. With an increase in education by 1 standard sickness will decrease by 65 patients. While age also has significant and negative relationship with sickness if age of the population is increased by 1-year sickness will decrease by 2.3 patients. The probability of sickness can be reduced by 0.1% for one unit decrease in E. Coli count in drinking water, whereas probability of sickness will decrease by 3.7% and 0.3% with one standard increase in education and one-year increase in age respectively.

Table 5 Probability of Medical Cost

Medical Cost	Coefficients	Standard Error	z	Probability	dy/dx	Standard Error
E. Coli	.0035	0.0006	6.06	0.000	0.00084	0.00012
Edu	-0.674	0.15	-4.60	0.000	-0.164	0.0360
Age	-0.023	0.0101	-2.23	0.026	-0.006	0.0025
Constants	2.04	0.586	3.48	0.000	---	---

Pollutant (E. Coli) has a significant positive impact on medical cost. 1 count increase in E. Coli causes 0.35 PKR increase in medical cost. Education has a significant inverse relationship with medical cost. Medical expenses can be reduced by 67.12 PKR if education is increased by one standard. Age has a significant and negative impact on medical costs. Medical cost on disease will decrease by 2.3% with one-year increase in age. The probability of medical cost increases by 0.083% with an increase in one count of E. Coli. With one standard increase in education the probability of medical cost will decrease by16.68%. With a one-year increase in age the chances of incurring medical costs will decrease by 0.25%.

Table 6 Estimation of Marginal Willingness to Pay

Indicators	Estimated values
Average wage rate	631 PKR
Average workday lost	23 days/ year
Average Medical cost	3404 PKR
P (S/ΔC)	0.001

The value of marginal willingness to pay is calculated by placing computed values of wage loss and medical cost in the equation of MWTP. We get:

$$MWTP = 631 * 23 * 0.001 + 3404 * 0.001$$
$$= 17.92 \text{ PKR}$$

With respect to marginal effects, marginal willingness to pay per household per trimester is Rs 17.92. By multiplying this cost by 4 we will get an annual willingness to pay, i.e. 17.92*4 = 71.68. Therefore, marginal willingness to pay per household per year is 71.68 PKR which is very less with respect to incident of disease. It is the apathy of the residents of the area that they enslaved themselves to drink unhealthy and unsafe water rather than taking avertive measures to drink healthy and safe water.

3.9 Economic Cost

As avertive cost is negligible in the area under study therefore total avertive cost and opportunity cost of avertive measures is considered to be zero. Economic cost is measured by the following formula:

Total Economic Cost = total medical cost + total opportunity cost

Total Economic Cost = 868,120 + 41,208
= 909,328 PKR

The residents of kehal incurring Total Economic Cost, of E. Coli contamination in drinking water, is Rs 909,328 per year.

3.10 Total Welfare Loss

Total welfare loss is calculated as:

Table 7 Total Welfare Loss

Population at Risk	Affected Population	Total Sick Days	Loss of Earnings (WDL)	Medical Expenditures	Welfare Loss
Total population	P (S/ΔC) * Total Population	Affected Population* Average Workdays Lost	Wage Rate * Total Sick Days	Average Medical Cost* Affected People	Loss of Earnings + Medical Expenditures
27,391	27	621	391,851	91,908	483,759

Welfare loss is calculated in the above table by adding loss of earnings and medical expenditures. Total welfare loss of the community is 483,759.

5. Conclusion and Policy Implications

It is obvious through literature and the current study that E. Coli and heavy metals have not only worse health impacts but also burdened the residents economically. Water borne pathogens have several pathways through natural and manly managed water resources. Household and industrial wastes contaminate drinking water. Both public health and the environment are likely to get harmed due to heavy metal, detergent and sewerage water contamination. In most of the developing countries people are using untreated and contaminated water for drinking and cleaning purposes, which can cause acute and chronic diseases. Common water borne diseases which people are prone to, are Gastrointestinal diseases, typhoid fever, cholera, hepatitis A, hepatitis E etc. (WHO, 2018).

The present study analyzed the impact of pollutants, education and age on sickness and cost of sickness. Pollutant (E.Coli) has a significant positive impact on dependent variables sickness and medical cost, as pollutant increases in drinking water sickness and medical cost will also increase by 0.00392 units and 0.0035 units respectively. Education has a significant but negative relationship with sickness and medical cost. With an increase in one standard of education, sickness and medical cost reduces by 71.5 patients and 66.8 PKR respectively.

The results support the theoretical framework. Sickness and medical cost have a positive relationship with concentration of pollutants in drinking water source. While education and age have a negative relationship with sickness and medical cost. The marginal price a household is willing to pay to avoid sickness is 71.68 PKR per year. Where the economic cost is 909,328 PKR per year. Total welfare loss of the community is 483,759 PKR. It is recommended that the government install water purification plants in the affected area in order to reduce medical cost of the residents. Also, the government should pay attention toward infrastructure development in Kehal and water pipelines should be separated from sewerage lines. Households do not use avertive measures in the area. They should filter and boil the water before drinking.

It is not only bacterial contamination, but also metallic concentration is higher than thresh hold values suggested by WHO water guidelines 2017. Concentration of arsenic and mercury in drinking water if far higher than thresh hold values. Arsenic causes dermal lesions, skin cancer, bladder and lung cancers and peripheral vascular disease, peripheral neuropathy, cardiovascular system risks in children and diabetes. While mercury is responsible for causing acute oral poisoning results primarily in hemorrhagic gastritis and colitis the ultimate damage is to the kidney and benign tumors. Further study can be made in order to find the impact of these metals on health of residents and collective economic cost, rising due to drinking metal contaminated water, can be estimated.

The present study analyzed the impact of pollutant (E. Coli), education and age on sickness and cost of sickness. The results showed that E. Coli has a significant positive relationship with sickness. While education and age have a significant negative relationship with sickness. Although the residents of Kehal are not willing to pay enough in order to avert the pollutants, it is also noticed that people are not using avertive measures in order to avoid diseases. But still, they are bearing collective welfare loss in the form of medical cost. The government should step in to provide safe and clean drinking water so the community can save welfare loss which can be used on education and other development projects. Further studies can also be made in order to quantify health hazards of heavy metals which are found in collected drinking water samples.

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