Impact of Arsenic Contaminated Groundwater on Human Health in Affected Areas: A Case Study of Selected Villages, District Lahore

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CERTIFICATE

This is to certify that this thesis entitled: **"Impact of Arsenic Contaminated Groundwater on Human Health in Affected Areas: A Case Study of Selected Villages, District Lahore.".** submitted by Mariam Saif is accepted in its present form by the PIDE School of Public Policy, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in **Master of Philosophy in Environmental Economics**.

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Dedication

I dedicate this thesis to my father for his continued support and encouragement towards my studies

Acknowledgement

All praises to **Almighty ALLAH**, the omnipotent, the omniscient and the creator of the universe. Many thanks to Him who bestowed us the perfect code of life through His beloved prophet, **Hazrat Muhammad (S.A.W)**.

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Mariam Saif

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LIST OF ABBREVIATIONS

As- cons	Arsenic Concentration
MOWR	Ministry of Water Resource
WHO	World Health Organization
PCRWR	Principle Council of Research in Water Resources
NRCS	Natural Resource Conservation Service
DWSS	Drinking Water Supply Scheme
INR	International Normalized Ratio

ABSTRACT

The current study evaluates the health impact of arsenic contaminated groundwater in particular villages of district Lahore. The Ravi dissolves wastewater through nearby chemical industries. Ground water samples of 525 houses from the villages of Khud-Pur, Gopirai and Arazi have been tested to quantify the amount of arsenic by the Department of Environmental Science of Quaid-i-Azam University. Arsenic contamination level of water has exceeded beyond the standard WHO limit (50ug/l) in drinking water. The information about socioeconomic variables and diseases due to presence of arsenic in drinking water (Skin problem, skeletal bone, teeth discoloration) is directly collected from 225 families through well-structured questionnaire. Average family size is about 6 which generates 1335 observation for our analysis. Total sample is divided into three categories based on arsenic concentration in the drinking water i.e. high (≥300≤1000ppb), medium (<300≥50ppb) and low (<50ppb). In order to explore the determinants of frequency of disease, age, education, household size, water source and quality and arsenic concentration are considered as explanatory variables. In our sample each family member faces maximum one or zero disease, implying that dependent variable is in binary form. Therefore, Logit model is employed. Our empirical results revealed that, age, water source, water quality and arsenic concentration are significantly contributing to increase the probability of disease while household size has negative impact on the probability. The study also explored the determinant of health cost due to arsenic concentration. The results demonstrate that averting expenditures, no of visits to doctor, loss of working days and arsenic concentration have significant and positive effect on the health cost while water quality is found to have negatively impact on health cost. Government need to intervene by supplying clean drinking water to the residents of the study areas.

Keyword: arsenic concentration, environmental pollution, diseases health cost, drinking water

Chapter I

INTRODUCTION

1.1 Background of the study

Arsenic is ever-present in drinking water, soils and aquatic environment. Arsenic contamination is a global issue for the agriculture and health of common public due to extremely lethal and unsafe water. Contaminated groundwater is becoming common and many regions across the world have arsenic contamination in water beyond the maximum value. Arsenic problems are quite similar across many countries of the world. This issue is found in many places regardless of geological and climatic backgrounds. Arsenic elements move naturally from one place to another place through weathering reactions in water and soil or by anthropogenic source and microbiological activity (Smedley, 1993).

In Pakistan, industrial sewage is openly released into nearby water deposits such as river, drains, ponds, streams and fields, where the farmers are cultivating the crops, without any water treatment (Khalid et al, 2018). Populations of various countries rely heavily on groundwater for drinking purposes but it contains elevated level of arsenic (Farooqi et al; 2016).

It is projected that in 50 countries, nearly 140 million people are drinking water comprising of arsenic elements. The drinking water of 70 nations has been affected by arsenic. Most of these countries are located in Southeast Asia which suggests that 150 million people are affected by the consumption of arsenic contaminated water. Studies have shown that continuous exposure to arsenic through drinking-water and food can be the basis of cancer and skin lacerations *(WHO, 2018).* A major and predominant route of arsenic into the human body is through drinking water. The current provisional guideline set by WHO for the value of arsenic in drinking water is 10µg/L which has been reduced from 50 µg/L in 1993 (Smedley, 1993).

In terms of quantity and quality both, water is progressively becoming a scarce resource. Due to ever increasing population and rapid urbanization and industrialization, surface and groundwater have become scarce and contaminated in many places. Over the last few years, excessive abuse of both ground and surface water resources has caused grave problems in water pollution. The literature reveals that almost 70 per cent of total surface water resources and increasing percentages of underground water are polluted by natural, toxic, organic and inorganic pollutants *(MOWR, 2000).*

The quality of groundwater is deteriorating due to crude discharge of industrial and urban sewage which contains chemical substances. Industrial processed water that remains untreated has become the deadliest threat for health problems in the surrounding areas. It is a direct cause of contagious diseases, many of which are facilitated by the environmental conditions in which people live. As the world gets densely populated and natural resources become ever more stressed, issue of contagious diseases has, and will, become increasingly significant. Due to large scale environmental changes in recent years, the relationship between ecological modification and the spread of infectious maladies has become more obvious as large-scale environmental variations have occurred (Sayal, et al., 2016).

Water contamination by arsenic is very serious in several countries of South Asian region. Out of the total 64 districts in Bangladesh, 59 contained water above the WHO prescribed level of arsenic concentration which is >10ug/L (Chakraborti, et al., 2009). In Ganga- Meghna- Brahmaputra 500 million people live at threat of exposure to arsenic (Sengupta et al. 2003).

Arsenic contamination is also becoming a serious problem in Punjab where approximately 36% of the population is exposed to arsenic level in drinking water higher than 10 ppb. The empirical findings reveal that 66% of 1200 samples tested contained arsenic above WHO limit, threatening over 60 million residents. It approximately that 60 million residents of Pakistan consume water polluted with arsenic higher than 50 micrograms per liter which is much higher than the maximum residues limits (MRLs), levels for passing acceptable levels worldwide (Guglielmi, 2017).

Contaminations are caused by natural, biological and human sources. The natural contaminants include salinity, iron, fluoride and arsenic which have lasting health impacts and become the cause of severe diseases. Sources of arsenic which it appeared in groundwater contamination through anthropogenic activities, such as industrial emission , urban and rural wastewater , biomass combustion, mining, fossil fuels burning, ores smelting, chemical wood preservatives, and arsenical pesticides that release high concentrations of arsenic to the environment (Zhang, et al., 2014) Arsenic contaminated drinking water and long-term use of fluoride in drinking water causes skin pigmentation sand skin cancer *(Thakur, et al, 2013)*. Investigations exposed the incidence of excessive arsenic in various cities of Punjab (Multan, Skeikhupura, Lahore, Kasur, Gujranwala and Bahawalpur) provinces. Arsenic concentration was found at a maximum value limit of 50ppb *(WHO, 2007; PCRWR, 2007).*

The economic activities of the arsenic affected households are declined due to various physical disabilities. The symptoms of chronic arsenic diseases include difficulty in walking, gripping, breathing difficulty, and weakness of limbs. Physical disabilities have resulted in a number of occupational disadvantages and it is observed that majority of the affected people are unskilled workers and daily wage earners. This implies that poor and uneducated people who have little or no excess to clean drinking water are suffering from arsenic contaminated water. Many of them cannot perform their normal physical activities and their earning has declined. Although the data is not available on the economic impact of chronic arsenic diseases at the household level but a number of qualitative analyses have shown decline of occupational activities. Moreover, expenditure on treatment further increases the economic burden. To meet treatment cost, poor households sell properties or borrow from money lenders at extremely high interest rates (Sarkar 2004, 2006a; APSU 2006).

Sources of arsenic exposure from the earth's crust have been proven as natural and they have been widely distributed through the environment in the air, water and land. It can move in the water supply via natural deposits in the earth's surface or from industrial and agricultural contamination as highly toxic in its inorganic form. (Nickson, et al., 1998).

1.2 Research gap

- There are the number of study on contamination groundwater with arsenic. Clinical studies are almost absent quantifying the arsenic induced health hazards to the people through drinking water (Berg, et al., 2001; Mukherjee, et al., 2006; Farooqi et al; 2016).
- The purpose for my study is to bridge the gap between health effects and their corresponding monetary damages due to the presence of arsenic in drinking water. The present study is attempting to fill this gap.

1.3 Research Question of the study

a. What people aware of the negative impacts of arsenic contamination in groundwater in study area?

b. What is cost borne by people due to consumption of contaminated water?

To address these research questions, following objectives have been formulated.

1.4 Objectives of the study

a. To explore the relationship of arsenic intensity with the health symptoms.

b. To quantify the health cost of locals due to contamination of groundwater with arsenic.

1.5 Organization of the Study

The organization of the study is as follows:

Chapter I covers the background information regarding arsenic concentration and its effects, the present situation in Punjab, research gap of the study, problem statement, research questions, objectives and hypotheses of the study. Chapter II reviews the literature related to the study and chapter III deals with the data description and research methodology which include the study area, source of data collection, data discussion and sampling technique. Chapter IV presents results of the study from the models of Logit and Ordinary Least Square for disease frequency due to varying arsenic concentration and health cost estimation due to arsenic contamination respectively. Chapter V deals with the conclusion and offers policy recommendations.

Chapter II

LITERATURE REVIEW

This chapter covers thematic literature review on the previous work done on arsenic contamination of groundwater. Due to which many issues like water contamination are discussed.

2.1 Arsenic concentration and public health issues

Shahid et al. (2018) studied areas of Punjab and Sindh province of Pakistan where high arsenic contamination in groundwater was found. Human health problems and possible future perspectives were discussed. The results showed that almost 47 million people residing in these area where more than 50 ug/l of wells contained arsenic concentrations greater than the WHO limit of arsenic in drinking water i.e. 10ug/l. Study results show that long term exposure to arsenic through drinking water caused hazardous effects on hair and blood of effected humans.

Ain et al. (2017) conducted a study in Rahim Yar Khan District of Punjab. The study focus was on arsenic and fluoride. A strong relationship between high arsenic and fluoride concentrations and associated health risks was discovered. Determined level of arsenic was found in areas close to agricultural lands and smelting areas, with a more frequent use of fertilizer in those areas. Study concluded that arsenic causes skin pigmentation, lung and bladder cancers while fluoride causes skeletal and dental poisoning and severe cases were recorded which resulted in the loss of mobility in human body.

Shankar et al. (2014) examined cross country data of the world including Australia, Bangladesh, China, Cambodia, Canada, Finland, India, Pakistan, Japan, USA, Vietnam etc. The study states that natural and anthropogenic sources lead to hostile effects on human health and ecosystem. High arsenic concentrations have known to play a significant role in aesthetic problems. Under optimum experimental conditions, arsenic was found to be oxidized by these bacteria, contributing to almost complete arsenic removal (up to 95%). Result of this paper states that arsenic contaminated drinking water causes environmental deterioration along with health diseases by causing skin problem, black spot on body, cuts on hand and feet. Study concludes that government mange waste water of industrial and agriculture activities that discharge to arsenic pollution.

Farooqi et al. (2007) worked on arsenic contamination water in Kalalanwala village, Punjab province, where small anthropogenic chemicals were mixed in surface groundwater. 147 groundwater samples were collected from the area which was known for arsenic related problems. Out of these, 91 percent samples exceeded the WHO standard (10 ug/L) for arsenic and 75 percent exceeded the WHO standard (50 ug/L) for fluoride. High concentration of arsenic were found from shallow well water in four villages from western and eastern that part of the study area, with high concentartion as 2400ug/L in Kalalanwala and Kot Asad Ullah, 883ug/L in Shamkey Bhatian, 672 ug/L in Manga Mandi and Waran Piran Wala. These four villages are located nearest area, where brick kilns are concentrated that released the smoke around the surrounding areas. Housing peoples are directly affected and damage the health status. Conclusion of this paper identifies high concentration of arsenic and fluoride and also identifies sulfur and other anthropogenic pollutants that effect human health through drinking water.

Thakur et al. (2015) calculated the economic costs levied by arsenic health problems, which were previously estimated by Roy (2008) and Khan (2007) in their respective works which were set around the economic cost imposed on households because of arsenic contaminated water. These studies revealed that low income households incurred the highest number of sick days and suggested that children and women are more susceptible to diseases caused by long term arsenic exposure.

Khattak et al. (2016) surveyed three districts of Mardan, Peshawar and Mingora in Khyber Pakhtunkhwa province for drinking water. Objective of the study was to analyze the impacts of arsenic contamination on human health, the data for which was collected from four rivers that contribute to a drainage system that ultimately discharges into the Kabul River. About 30 drinking water samples of the human hair and nails were collected from various parts of Peshawar district. All drinking water samples were below WHO limit of 10 ug/L.

The Terai region contains about 47% of the total population, where 90% people use contaminated water as their major drinking water source. Nepal recognized arsenic contamination of groundwater as a major public health issue. 15,000 tube wells were tested for arsenic out of which 23% of the samples exceeded World Health Organization's limit value of 10 ug/L and 5% samples crossed Nepal interim Arsenic Guideline of 50ug/L. The research was conducted in four districts of Nepal where 5215 individuals were exposed to arsenic contaminated water with concentration level more than 50ppb as observed by NRCS and DWSS. The data of the symptomatic patients was collected from the areas which confirmed the presence of high arsenic concentration by analyzing two major diseases of hair and nail which were found in the residents of these areas (Shrestha et al. 2003).

Sthiannopkao et al. (2008) worked on arsenic concentration and other trace elements in groundwater in six villages of Kandal province, Cambodia. Here the groundwater contamination is high for drinking water usage, especially in the rural areas. A small scale survey of drinking water quality of hand pumped tube wells in Combodia revealed for the first time arsenic concentration levels greater than 1000 μgL^{-1} in 2000. These results were much higher than the maximum contaminant level guidelines of the World Health Organization (10 μgL^{-1}). The Kandal province showed particularly high arsenic levels with average concentration of 233 μgL^{-1}. Hence it can be concluded that the Kandal Province populace is overexposed to Ba, Mn, Pb and Se from groundwater along with arsenic. The coming years pose serious health effects on the local population.

Studies show that arsenic contamination of groundwater has become a globally grim affair (India, Bangladesh, Taiwan Cambodia, china, Nepal) but the population of Uttar Pradesh, Bihar and west Bengal are particularly suffering greatly due to usage of arsenic contaminated drinking water. Arsenic has been entering into groundwater through natural weathering process of the arsenic infused rocks and minerals and by flow of effluents of various petroleum refining, fertilizer, pesticides and other chemicals industries. They lead to cause various kinds of dangerous ailments of skin, hyperkeratosis of palms and soles, warts, leukemia, acute renal failure and cancer rhino pharyngitis (cold infection). Effect of consumption of arsenic contaminated groundwater was studied. The human chromosomes aberration also provided results for the study of arsenic contaminated groundwater. Sample was collected from the respondents based on the information about their habits like smoking, tobacco chewing and chronic diseases. This study indicates that individual who consumed water with high arsenic concentration suffered from keratosis, pigmentation and chromosomal abnormalities due to arsenic range from 0.01 to 0.37 ppm (Singh et al. 2013).

In west Bengal first arsenic affected patient was detected in 1993. People were exposed to arsenic when they extracted water from underground aquifers through domestic and irrigation wells (SOES, 2007). The anthropogenic source of water contamination through arsenic is mainly due to the misuse of groundwater. Groundwater is a fundamental part of the changing agricultural practices of this region. It includes activities like incremental cropping frequency, increased land use, and the switch to low water consuming agricultural practices as traditional sources, for example, surface water from rivers and old canals (Sarkar et al. 2009).

McArthur (2018) worked on arsenic in groundwater. The guideline values for arsenic concentration in drinking water were given as 10 g/L by the World Health Organization since 1993 (WHO, 2017). Prior to that, it was set at 50 ug/L. The reason for decreased concentration of arsenic as standard level in drinking water was that it poses a risk to human health. Punjab province in northern Pakistan, reported 34 districts out of which 18 have arsenic polluted groundwater, with 40 percent of wells yielding groundwater with arsenic levels >10 ug/L and 9 districts with arsenic levels >50 ug/L. Human activity were added arsenic to groundwater. Many potential arsenic sources include the dusty discharges deposited from the smoke-plumes of brick-kilns, arsenic releases from soils by use of phosphate fertilizer that promotes oxidation of gangue sulphides in mine-waste, resulting in increased oxidation and weathering rate as compared to naturally occurring in situ, and poor disposal practices at factories that manufacture arsenic pesticides.

2.2 Health cost due to arsenic contamination of groundwater

Chowdhury et al. (2015) estimated health cost due to arsenic contaminated drinking water in Assam, India. The population was found to be affected through arsenic contaminated water. Primary survey was conducted in 355 households in 2013.

It was found that 1µgl increase in arsenic concentration results in the increase of 4 INR per household in health cost annually. The econometric model applied in the study is the three stage least square (3SLS) procedure. The results of the study suggest that these health cost and welfare gain vary considerably across different arsenic concentration levels and across districts. The study concludes with remarks about policy suggestions for safe drinking water.

Bibi et al. (2014) Estimate the health cost due to arsenic contamination of groundwater from three different age groups (children, adult and old age) residing in Lahore. Pakistan to gain insight into arsenic exposure to human via drinking water. Concentration of arsenic were significantly ($p< 0.05$) different among sites, while non-significant trends were observed among different age classes. The mean concentration of arsenic were higher in nails samples (0.74 ug/l), urine samples (0.82 ug/l) and hair samples (0.74) base on all sites. Maximum mean concentration in biological sample from all exposed site were shown by nail samples and blood samples followed by urine and hair sample. The econometric model applied in the study one-way ANOVA revealed that there were no significant variations between age groups.

2.3 Conclusion of literature

Arsenic contamination water is a serious problem and it's naturally present in soil and groundwater. The especially impact on the skin that coverage to high levels of arsenic in drinking water. Most of developing countries (Pakistan, India and Bangladesh) are still the worst affected areas in the world. Arsenic contaminated groundwater used for drinking water, agriculture, household food preparation, livestock, etc.

The anthropogenic sources covers of arsenic contamination pollute the groundwater quality, that water not useful for the humans. Arsenic contaminated caused environmental deterioration along with health diseases by causing skin lesions and pigmentation, black spot on body, cuts on hand and feet. The use of contaminated water creates different type of disease like diarrhea, waterborne disease, stomach problem and skin problem is leading cause of death. The health costs borne by people can be classified into different categories: averting measures, expenditure on hospital treatment, social costs in terms of number of working hours lost and stress on income. Also, in many developing countries including India, the permissible limit is (50ug/l). It is concluded that long terms exposure to arsenic above permissible limit leads to skin problem, skin cancer, teeth discoloration and skeletal bone problem.

Chapter III

DATA DESCRIPTION AND RESEARCH METHODOLOGY

3.1 Study Area

Lahore is the 2nd largest city of Pakistan where water quality is very poor due to high arsenic contamination. This study area of my research comprises of three villages on the banks of River Ravi. These are Khud-Pur, Arazi and Gopirai. The areas are part of the district, Lahore. These villages are plagued by arsenic. To some extent, these elements are naturally present in the underground water, however, the excess concentration of arsenic is due to dumping of industrial and chemical waste of the nearest factories fall in the Ravi River. Arsenic is not homogeneously distributed here; rather it is present in heterogeneous distribution. Arsenic poisoning is the biggest environmental disaster and public health issue in recent times in Lahore.

The study covers three affected areas with varying levels of arsenic concentration. The population of the villages under concentration differs from each other. The total population of Khud-Pur is 2226, Gopirai is 5507 and Arazi is 741. The residents of these areas are suffering from Arsenic poisoning since decades, as the symptoms of arsenic related diseases appear late in time (Farooqi et al., (2007)

The purpose of this study is to explore the impact arsenic concentration in drinking water on frequency of health symptoms and health cost in three villages of district Lahore. People's use arsenic contaminated groundwater for cooking, bathing and washing their mouth after eating and cleaning of utensils that cause teeth discoloration problem.

3.2 Source of Data Collection

To achieve the objectives of this study questionnaire based primary data are collected from the households of the three villages i.e. Khud-Pur, Gopirai and Arazi. A total sample size was 225 household 75 from each household was taken from the residents of these village about the type of diseases which have occurred due to arsenic contaminated groundwater along with the expenditure on health, working days loss, averting measure to avoid the negative impact of arsenic contamination of groundwater in the district Lahore.

3.3 Data Discussion

The survey involved simple random sampling procedure. The choice of groups is made according to three varying levels of high arsenic concentration is (≥300≤1000ppb), medium (<300≥50ppb) and low (<50ppb). These criteria is applied in all three groups because arsenic concentration in groundwater varies from one household to another due to its heterogeneous nature. Water is extracted in these villages through wells and hand-pumps.

The Department of Environmental Sciences, Quaid-e-Azam University, have collected the samples of arsenic contaminated groundwater by surveying different groups from Punjab. The Department of Environmental Sciences has already done water testing of 526 samples taken from all villages along the Ravi River. From this large scale data, we have selected three groups namely Khud-Pur, Arazi and Gopirai from district Lahore as our focal areas of research because these groups have moderate to high arsenic concentration as compared to all the other villages of Punjab. Thus, three villages with high, medium and low arsenic concentration are selected respectively.

The study has attempted to obtain individual, as well as household level information from these villages. For the first objective, personal information such as age, gender, household size, education, water quality and source of water used for drinking and arsenic concentration level in the ground water have been taken as explanatory variables. Arsenic concentration variable is taken from water samples previously tested by Quid e Azam University at the household level. For the second objective, specific questions regarding disease occurrence (skin diseases, skeletal bone problems and teeth discoloration) and health cost is considered. The health cost is further divided into two components (i.e. direct and indirect cost). In direct cost; doctor fee (per visit), travel cost (return), medicinal expense, lab test or any other expense which directly relates to treatment is considered. Indirect cost includes income based on working days lost, opportunity cost of attending the patient with symptoms and income of the respondents is taken into consideration. Arsenic concentration, water source and quality are also taken as independent factors affecting the health cost of the respondents. For this purpose data is divided into three groups as follow;

- Group I consists of respondents which has high level of arsenic concentration in their ground water and in this group concentration level is more than or equal to 300ppb but less than 1000ppb i.e.≥300≤1000ppb.
- Group II consists of respondents which has medium level of arsenic concentration more than 50 ppb but less than 300 ppb, i.e. <300≥50 ppb. It is assumed that due to high arsenic concentration the frequency of disease and its associated health cost would be high.
- Group III consists of respondents which has low arsenic concentration i.e. <50ppb. This can be considered as base group assuming that due to

low arsenic concentration, the frequency of disease and health cost of the respondents will be low as compared to the other two groups.

3.4 Sampling Design

A sample size of 225 (n=225) households containing 1335 family members is taken from the study area. It is observed that there are 392 individuals who are drinking water with high concentration of arsenic (.≥300≤1000ppb), 589 are drinking water with medium level of arsenic concentration (<300≥50) and 354 individual are drinking water with low or no concentration of arsenic in the study area. Since, arsenic is not homogeneously distributed in groundwater rather it is heterogeneously distributed, implying that study area cannot be divided in terms of concentration of arsenic. One household may have high level of concentration of arsenic in the groundwater but next door household could have zero concentration of arsenic. That is why study divided the total sample intro three groups with respect to the presence of arsenic concentration. Majority of the respondents are associated with farming or works on daily wages as laborers. The respondents of all three groups have similar socio-economic and demographic characters along with nearly same level of education and awareness. The only difference is arsenic concentration level that differs among three groups which provides an ideal situation for comparison.

A descriptive analysis of different variables included in the model is reported in Table 1.

Table 1: Descriptive Analysis of Variables Used in the Model by applying t-statistic

Variables	Mean Values		
	Group1(a)	Group2(b)	Group3(c)
Age	26.097^{abc}	26.215	26.103
Gender	0.57^{abc}	0.56	0.49
Education	4.613^{abc}	4.644	4.689
HHS	(6.995)^{abc}	(7.034)^{bc}	(7.313)
Water quality	(2.397)^{abc}	(2.134)	(2.167)
Water source dummy	(0.704)^{abc}	(0.546)^{bc}	(0.507)
Frequency of Symptoms	(0.313)^{abc}	(0.280)^{bc}	(0.254)
Income per month	(5877.418)^{abc}	(7313.636)^{bc}	(6566.685)
Working days loss	(1.163)^{abc}	(1.05)^{bc}	(0.817)
Averting measures	(0.780)^{abc}	(0.609)^{bc}	(0.345)
Total travel cost	(26.899)^{abc}	(20.142)^{bc}	(16.816)
Number of visits	(0.645)^{abc}	(0.486)^{bc}	(0.398)
Arsenic_ concentration (μg/L)	(247.042)^{abc}	(143.688)^{bc}	(138.80)

All the variables are collected through questionnaire which was conducted from the villages of Khud-Pur, Gopirai and Arazi respectively.

The t-statistic is applied to investigate the statistical significance across three groups based on the presence of arsenic. Here, it is calculated to reveal the difference in mean values of the three groups (1 , 2 and 3) in data. These groups are included in the statistical models applied on the data. A brief description of the variables and their reason for inclusion in the data is discussed in the following section.

3.5 Variable Description

Age

With the increase in age, the resistance against different diseases decreases, therefore, it is important to investigate the impact of age on prevalence of disease due to drinking water contaminated with arsenic. Hence, it is empirically need to investigate whether arsenic contaminated water has more severe affect in the old age. The positive and significant impact indicates that old age people are vulnerable to arsenic presence in the drinking water. It is observed during the interviews process that old people are commonly facing diseases like skeletal bone problems in the study area, implying that age could be potential explanatory variable in our model. Literature also reveals that different kind of disease increase in old age because of decline in body resistance (Farooqi et al, 2016).

Gender

Gender is taken in the form of dummy variable i.e. (1=male, 0=female). It is considered as an important explanatory variable because questionnaire based survey has revealed that skin and teeth problems are more prevalent in females as compared to males. Bibi et al., (2014)

Education

Education refers to the years of schooling received by the respondents. Therefore, education of respondent have negative impact on the prevalence of diseases.

Family Size

Number of total family members has been considered as an explanatory variable because it is expected to affect the dependent variable. As family size increases it can affect in two ways to the probability of prevalence of diseases. If numbers of children are higher in the family that can help to bring drinking water from other sources then family size is expected to affect probability of diseases negatively. However, if number of elders is dominant in the family and they are not economically active then no one will go out bring water and also they don't sufficient resources to shift towards cleaner sources of water, implying that large family size may lead to higher probability of diseases.

Water Source and Quality

Water source is taken as a dummy variable i.e. (0=own groundwater, 1=other sources/averting measures) whereas water quality is taken as count variable in the form of decreasing water quality i.e. (1=good, 2=average and 3=poor).

Frequency of symptoms

These include skin problems, skeletal bone issues and teeth discoloration. Since, 99% respondent of sample faced either only one of these disease or none. Therefore, it is decided to define this variable in the form of dummy variable i.e. 0=absence of disease, 1=prevalence of disease.

Income

Income is taken in Rs per month. It relates to the quality of medication because it indicates affordability or excess to better medical facilities and a body of literature attempt to investigate income impact of different diseases. Among them includes, (Thakur et al. 2015; Roy, 2008 and Khan, 2007)

Health Cost

It is taken in two groups i.e. direct and indirect cost. Direct cost includes doctor fee, travel cost, medicinal expenses and lab tests whereas indirect costs include economic loss of working days and opportunity cost of the attendant with the patient. It is taken in Rs. This variable has been included after literature revealed its direct role in economic well-being of households (Chowdhury et al. 2015)

Arsenic Concentration

Arsenic concentration is taken in µg/L. Since it varies in all three groups, it is a key variable for determination of frequency symptoms and affiliated health cost (McArthur, 2018;Sthiannopkao,et al.,2008)

3.6 Econometric Methodology

To explore the impact of different explanatory variables on the probability of symptoms faced by individuals due to presence of arsenic in groundwater being used for drinking, Logit model was applied because symptoms were non-negative binary variable. When different symptoms were summed up then it was observed that dependent variable was in the form of "1" and "0", implying that each individual was facing maximum one symptom during the last six month or facing no symptoms. If the individual was facing disease then the dependent variable is 1, otherwise zero. In order to handle such data there are special econometrics techniques called the logistic regression model which has been applied in this study.

3.6.1 Model I

The first part of the study show the frequency of diseases among the population of the study area. It has already been established (from the literature review) that high concentration of arsenic is found in the water of the areas, thus, the study aims to find if a relation exists between As concentration and disease occurrence in the respective area.

Since the occurrence if disease is taken in binary form i.e. 1 and 0, the study applies Logistic regression model on such type of data. For this purpose, disease symptoms have been taken as the dependent variable while common diseases in that area along with other demographic and social factors have been taken as independent variables, which are mathematically expressed as follows:

$$(\,\boldsymbol{count\ symptoms}) = \boldsymbol{\beta_0} + \boldsymbol{\beta_1 age_i} + \boldsymbol{\beta_2 edu_i} + \boldsymbol{\beta_3\, hhs_i} + \boldsymbol{\beta_4\, wq_i} + \boldsymbol{\beta_5\, wsd_i} + \boldsymbol{\beta_6 AS_{Conc_i}} + \boldsymbol{\beta_7 dg1_i} + \boldsymbol{\beta_8 dg2_i} + \boldsymbol{\varepsilon} \qquad (1)$$

Where,

Symptoms, if faced, then 1, otherwise= 0:

D_1: Skin Problem (yes =1, no = 0)

D_2: Skeletal Bone (yes =1, no = 0)

D_3: Teeth discoloration (yes =1, no = 0)

Age: Age of respondent (in Years)

Edu: Education of Respondent (Years of schooling)

HHS: Household Size (total family members in numbers)

WQ: Water quality (is giving three categories 1=good, 2=average, 3=poor)

WSD: Water source dummy (groundwater from own=0, otherwise=1)

As_cons: Arsenic concentration

dg1: Dummy for group1 (if arsenic is ≥300 then =1, otherwise=0)

dg2: Dummy for group 2 (if arsenic ≥50<300 then =1, otherwise=0)

The expected signs of the coefficients of the dependent as well as independent variables have been gathered in Table II. These signs have been seen in literature on arsenic related diseases like the work of (Bibi , et al., 2014) (Sayal, et al., 2016). These will be a good indicator of the results of this study which will prove whether this study provides same results as previous studies done on similar problems in other areas.

Table II: Expected Signs for Logit Model

Variables	Variables explanation	Expected sign	Reference
Frequency of symptoms	Skin problem + skeletal bone + teeth discoloration	Positive (+)	
Age	Age of respondent (in years)	Positive (+)	
Education	Education of respondent (schooling of years)	Negative (-)	(Sayal, et al., 2016) (Bibi , et al., 2014)
HHS	Household size (Total family members)	Positive (+)	
WQ	Water quality	Positive (+)	
WSD	Water source dummy	Positive (+)	
As-concentration	Arsenic concentration	Positive (+)	
dg1	Dummy for group 1	Negative (+)	Additional variables for specific study purpose
dg2	Dummy for group 2	Positive (+)	

3.6.2 Model 2

There are various factors that directly or indirectly affect the health of people. In Pakistan, average spending on healthcare is 33% by public institutions and most of the spending in Pakistan is private spending (Malik et al., (2015). Briefly, almost all the aspects of human life are related to man's health, thus, by increasing health cost, poverty will also be substantially increased. Since health cost consists of various tangible and intangible factors, we cannot measure all of them, but some of the factors have a significant share in health cost estimation. To explore the determinant of health cost faced by individuals due to presence of arsenic concentration in the drinking water, we have applied Ordinary Least Square (OLS) method. In this regression, health cost (in rupees) is taken as the dependent variable and variables affecting health cost are taken as explanatory variables which can mathematically be represented as,

$$HC = \beta_0 + \beta_1 Age_i + \beta_2 Edu_i + \beta_3 Wq_i + \beta_4 WSd_i + \beta_5 f\_sptm + \beta_6 AVRT_i + \beta_7 As\_cons_i + \beta_8 I_i + \beta_9 WDL_i + \beta_{10} T_i + \beta_{11} NV_i + \varepsilon \quad (2)$$

Where,

HC: Health cost face in the last 6 months *****

D: Predicted value of health symptoms from equation 1

Age: Age of respondent (in Years)

Edu: Education of respondent (Years of schooling)

I: Per month income of respondent (In rupees)

WQ: Water quality (is giving three categories 1=good, 2=average, 3=poor)

WSD: Water source dummy (groundwater from own=0, otherwise=1)

AVRT: Cost incurred on adopting averting measures

WDL: Working days loss

Time: Total Time spent to visit for treatment from beginning to return (in hours)

No visit: Number of visits to doctor in a month

***Health cost** **(Rs-last six months)**	Doctor Fee, Medicinal expenditures, Lab test expenditures, Travelling expenses.

The expected signs for the variables used in the health cost estimation of arsenic contaminated groundwater have been presented in Table III. Chowdhury et al., (2015) has used the same variables for estimating the health cost due to aresnic contamination in India, so these signs have been taken as a road sign. These signs will provide a basis for the results of this study to carefully analyze the similarities or differences in the relationship between health cost and its affiliated variables.

Table III: Expected Signs for Variables in Health Cost Estimation

Variables	Description	Expected sign	Reference
Total cost	Health Cost (in rupees)		
Age	Age of respondent (no. of years)	Positive (+)	
Education	Education of respondent (years of schooling)	Negative (-)	
WQ	Water quality	Negative (-)	
WSD	Water source dummy	Negative (-)	
Frequency of symptoms	Skin problem + skeletal bone + teeth discoloration	Positive (+)	
Avrt	Averting expenditure	Positive (+)	Chowdhury et al., (2015)
As_ cons	Arsenic concentration	Positive (+)	
I	Income per month (in rupees)	Positive (+)	
WDL	Working days loss	Positive (+)	
T	Total travel cost	Positive (+)	
NV	Number of visits	Positive (+)	

Chapter IV

EMPIRICAL RESULTS AND DISCUSSION

4.1 Introduction

This chapter contains empirical results of econometric models which have been discussed in Chapter 3. Result and discussion section is divided into following two sections:

Section one is about the disease model where dependent variable is total number of diseases faced by the each family member. The diseases that are considered in the analysis are purely due to arsenic and among them are skin problem, skeletal bone problem and teeth discoloration. Since, 99% of the family members either did not get any of the above mentioned disease or faced these diseases, it implies that number of disease variable have only 0 and 1 value. Therefore, logistic regression approach has been employed.

Section two is about the health cost model and factors involved in it. The health cost contains both direct and indirect costs. Direct costs include travel cost, doctor fee, medicinal expenses and lab tests. While the indirect cost includes economic loss of working days due to illness, all these costs have been taken as separate variables. Since all the variables are in numerical form (i.e. in Rs unit), simple Ordinary Least Square (OLS) approach has been adopted for this estimation. The results of each model have been discussed in detail as below.

4.2 Econometric Analysis of Total Disease Frequency

4.2.1 Regression Analysis:

The Logit model is employed to investigate the impacts of independent variables on the dependent variable i.e. disease frequency (skin problem, skeletal bone and teeth discoloration). These diseases are caused mainly by the use of groundwater contaminated with arsenic. Logit Model has been applied for this data because it is appropriate when dependent variable is in the form of a dummy variable having 0 and 1. The independent variables which are used in this model are age, education, household size, water quality, water source in the form of dummy variable (own groundwater=0, other water sources=1), based on arsenic concentration we divided the total sample into three categories, with high concentration, medium concentration and low concentration as defined earlier. The comparison across groups has been made by adding dummy variable in model as explained in earlier in the methodology. The results of the model have been presented in Table IV as shown below:

Table IV: Logistic Model for Disease Frequency with Marginal and Standardized Coefficients

T- disease	Logistic model Coefficient	Marginal effect coefficient	Coefficient of standardized equation
Age	0.034*** (0.003)	0.006*** (0.000)	0.006*** (0 .000)
Education	0.012 (0.013)	0.002 (0.002)	0.001 (0.002)
Family size	- 0.066*** (0.023)	-0.012*** (0.004)	-0.009*** (0 .003)
Water quality	0.311** (0.142)	0.056** (0.025)	0.046** (0.024)
Water source dummy	0.0566 (0.184)	0.010 (0.033)	0 .006 (0.031)
Arsenic concentration	0.002*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Dummy-for-group1	0.606* (0.358)	0.117* (0.072)	0.057 (0.058)
Dummy-for-group2	0.668*** (0.283)	0.123*** (0.052)	0.067*** (0 .043)
Log likelihood	-665.57818		
LR $chi^2(8)$	252.41		
F(8, 1326)	35.73		
R-squared	0.17		

Note: ***, **, and * indicate the level of significance at 1%, 5% and 10% respectively.
Note: In addition, the value in parenthesis shows standard errors of the respective coefficients.

The empirical results of Logit regression model indicate that age of the household has significant and positive impact on the probability of diseases and coefficient is significant at 1% level. This implies that 1 year increase in age is expected to contribute in the probability of diseases by 0.034%. Family size shows a negative coefficient with significance level of 1%, implying that larger families have fewer tendencies to get infected by diseases. This is probably due to the fact that large family size includes more children providing free labor to adopt averting measures in the form of acquiring water from neighbors or from filtration plants. Empirical results reveal that increase in family size by 1 member leads to decline the probability of disease by 0.066%. The coefficient of water quality is significant with positive sign. Since water quality was taken in continuous number where 1 stands for good quality of water, 2 for average and 3 for poor quality, implying that increase in the number actually leads to decline in water quality. Empirical results are consistent with our expectation and demonstrate that decline in water quality leads to increase in the probability to face diseases. Decrease in water quality by 1 unit (from good to average or average to poor) leads to contribute in the probability by 5%. Presence of arsenic concentration in ground water is found to have positive and significant impact on probability of diseases which is according to our priori expectation. Empirical results demonstrate that 1µg/L increase in arsenic concentration in groundwater results in 0.000% increase in total diseases. Since the values for arsenic concentration in ground water in our study areas is well above the WHO standard (10µg/L) which support our empirical findings. The small coefficient is mainly because unit problem and coefficient significantly improved in the standardized regression model. The coefficient of dummy for group 1 and 2 are significant with positive sign, implying that group1 and 2 have high probability of prevalence of diseases compared to the base group which has lowest level of arsenic in their ground water. Empirical results demonstrate that group 1 and 2 has 0.606 and 0.668, respectively higher probability to face disease than the group has less 10 µg/L arsenic in ground water.

Other than these, education and water source show an insignificant positive relationship with the probability of diseases. Since the residents of these groups have limited resources at their disposal, the increase in education does not significantly increase their health care. Education of the family members does not significantly affect the disease likelihood if the water quality remains the same. Although, education contributes to improve exposure but due to limited alternative options it does not contribute and has insignificant and positive relationship with probability of diseases. Similarly, water source dummy also shows insignificant positive relation with probability of diseases. The results are insignificant because water source is associated with the adoption of averting measures and the exact time when each family has adopted averting measures is unknown, making it insignificant.

4.2.2 Marginal Effect

The marginal effect has been calculated in order to check which independent variable is more likely to marginally affect the dependent variable, i.e. total disease. This is due to the fact that variables are not in the same unit e.g. age is taken in years while household size is taken in number of family members. The results of the Marginal Effect model also indicate that age, household size, water quality and arsenic concentration are the main explanatory variables that are causing significant marginal change in the dependent variable. Age, water quality, dummy for group 1 and 2 and arsenic concentration have significant positive marginal effect while household size has a significant negative marginal effect on the total disease frequency.

Since all the explanatory variables have different units of measurement and coefficient cannot be compared in terms of magnitude. Therefore, we employed Standardized Regression Model for better understanding contribution of explanatory variables.

4.2.3 Standardized regression model

The standardized regression model removes the units from dependent and independent variables and makes them comparable by dividing them over the standard errors of the coefficients. In this way we can explain the variables per standard error for better comparison that which explanatory variable contributes more to explain the variation in the dependent variable. Since the units have been removed, the signs and numbers of the coefficients of independent variables indicate the direction and strength of the explanatory variables with the explained variable. As we can see from column IV of Table II, the coefficient of age is highest followed by arsenic, implying that arsenic is contributing highest in the probability of disease after age. This helps to conclude that age is more crucial factor for the disease due to arsenic and arsenic concentration in the ground water is second most serious threat to diseases in the study areas.

4.3 Econometric Analysis of Health Cost Estimation

In order to estimate the health cost due to arsenic related symptoms, Ordinary Least Square model was applied on the data. The dependent variable (health cost) is continuous in numerical form, OLS is the appropriate model for this type of data. The dependent variable in this model was health cost (Rs) while the explanatory variables were travel cost, doctor fee, medicinal expenditure, lab tests and economic loss of working days lost due to illness. All these variables were taken in Rs unit. Other explanatory variables include age (years), education (years of schooling), water source (dummy variable, 0=own groundwater, 1= other sources), income (Rs/month), frequency of symptoms (skin disease, skeletal bone problem and teeth discoloration) and arsenic concentration (µg/L). All explanatory variables have been selected after careful analysis of literature and have been discussed in Chapter III in detail. The results for the OLS model have been presented in Table V:

Table V: OLS Model for Health Cost Estimation

t-cost	**Coefficient.**	**Std. Err**	**t-value**	**P>|t|**
Age	0.576	0.704	0.82	0.413
Education	-3.759	2.450	-1.53	0.125
Water quality	73.579***	22.075	-3.62	0.000
Water source dummy	-33.968	32.047	-1.06	0.289
Frequency of symptoms	523.168***	41.472	12.61	0.000
Averting expenditure	0.156***	0.048	3.22	0.001
No. of visit	108.505***	16.703	6.50	0.000
Working days loss	26.907***	4.466	6.02	0.000
Income per month	0.001	0.001	1.22	0.221
Arsenic concentration	0.878***	0.071	12.23	0.000
_cons	55.407	45.494	1.19	0..234
Adjusted R^2	0.53			
Observation	1335			

Age shows positive relation with health cost. The people in old age suffer more from symptoms due to low immunity, lack of physical mobility and improper nourishment but they are also reluctant to visit doctor, 15.13% of the sample size is above the age of 50 years and they are causing more health cost than others in all families that is why the coefficient of Age is insignificant and positive relation with health. Moreover, due to financial constraints and negligible contribution in family income, young generation is reluctant to spend on their parents. This may explain the reason that why age has positive and significant impact on the probability of prevalence of disease but the contribution in cost is insignificant. Education indicates a negative but insignificant effect on health cost, implying that 1 year increase in education leads to nearly Rs 3.759 per month or Rs 44 decrease in health cost per year. The education is considered as proxy for awareness and increase in awareness makes people more conscious about their health, motivating them to spend more on health. This awareness also lead to adopt averting measures to control disease in advance before it appears. One example could be, buy water from other sources to avoid from drinking water polluted with arsenic. Water quality has a positive relation with health cost. Result show that 1 unit increase in water quality (from good to average or average to poor) increases the health cost of the residents by Rs 73.58 per month or Rs 883 annually. Water source had been taken as dummy variable explained above and results depicts negative but insignificant impact on total health cost, implying that respondents using water from other sources rather than home are facing less health cost. This also implies that those who are adopting averting measures are facing less health cost. If the respondents use their own groundwater, the chances of getting disease increase, which lead to increased health cost. However, if they adopt certain averting measures, such as sharing water from their neighbors, getting water from filtration plants or buying bottled water, the health cost affiliated with disease decreases. Since, it is unknown that for how long they are using averting measures and in the presence of this information the interaction of dummy and from the period they are using may help to measure the impact more appropriately. Frequency of symptoms (skin problem, skeletal bone disease, teeth discoloration) indicates that coefficient is highly significant positive relation with total health cost. This implies that 1 unit increase in diseases and increases the health cost by Rs 523.168 per month or Rs 6278.016 per year.

Since health cost is a function of averting measures adopted by the residents, Rs 1 increase in the cost of averting expenditures increases the heath cost by Rs 0.156. Number of doctor visits and loss of working days have highly significant positive relationship with health cost. By increasing 1 more visit to the doctor in a month, the health cost increases by Rs 108.505 while loss of 1 working day leads to a financial strain of Rs 26.907, which could otherwise have been a part of the patient's disposable income. Income of the respondent shows positive yet insignificant relation with total health cost. Increase in income is proportional to availability of better health care facilities. Thus increase in income leads to increase in health cost. Arsenic concentration has a highly significant positive relation with health cost. 1µg/L increase in arsenic increases the health cost by Rs 0.878. This proves that arsenic is the leading variable responsible for the increase in total health cost of the respondents.

Chapter V

CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusion

Arsenic contaminated groundwater is a serious problem in district Lahore due to dumping of industrial waste in the River Ravi. Arsenic is present in high concentrations at varying levels in many villages along the coast of Ravi. Due to arsenic contaminated groundwater people are affected from different types of diseases like, skin scraping, stomach problems, black spots on body, skeleton bone issues, teeth discoloration and cuts on hands. People have no knowledge about the adverse health impacts of arsenic in water. The arsenic contaminated ground water is used daily for the preparation of food, drinking, bathing and almost every purpose of life. According to WHO, Approximately 36% of the population is exposed to high arsenic level in drinking water which is beyond the acceptable limit (10 μgL^{-1})

This study proves the presence of skin problem, skeletal bone and teeth discoloration due to the arsenic contaminated ground water and the affiliated health cost which the patients have to bear due to these diseases. Three villages, namely Khud-Pur, Gopirai and Arazi had been selected for the study. The total sample is divided into three groups. Group1 consists of respondents varying levels of high arsenic concentration i.e. ($\geq$300$\leq$1000ppb), medium (<300$\geq$50ppb) and low (<50ppb). Primary data had been collected through questionnaire based survey with a total sample size of 225 (n=225). Sample is equally distributed by selecting 75 respondents from each of the three villages. Water samples from every household from these village had already been done by a team of researchers from Quaid-e-Azam University, Islamabad. The comparative results of the first two groups with the third base group will determine the increase in disease frequency and health cost in high arsenic concentration groups as compared to low arsenic concentration groups.

Majority of the respondents are facing frequency either 1 or zero, implying that one respondent is not facing more than one disease. Therefore, rather than poison regression, Logit model is applied on the data due to the count nature of the dependent variable i.e. in the form of 0 and 1. The explanatory variables for this regression were age, gender, education, household size, water source and quality and arsenic concentration. The results showed that age, water quality and arsenic concentration had significant positive effect at 1% significance on the total disease frequency while household size had significant negative effect on disease frequency. The dummy variables generated for Groups 1 and 2 reveal that Group 1 has significant positive effect on frequency of symptoms as compared to base group, indicating high arsenic concentration has a direct cause of increase in diseases.

For estimating total health cost, simple OLS model has been employed. For this purpose, total health cost has been taken as the dependent variable while the explanatory variables include age, education, water source and quality, income of the respondents, expenditure on averting measures, arsenic concentration, total diseases and direct and indirect costs (number of visits to the doctor, financial loss of working days due to illness). Results show that frequency of symptoms, averting expenditure, no of doctor visits, loss of working days and arsenic concentration have significant positive relation with total health cost while water quality has significant negative relation with health cost. About 13 percent of the households report skin diseases (in males, females and children) while skeletal bone disease is most frequent in old age and teeth discoloration was frequently reported in the females and children.

In conclusion, this study proves the existence dangerous levels of arsenic in groundwater of the villages along the coast of River Ravi. High arsenic concentration in water has led to a number of diseases like skin problems, skeletal bone disease and teeth discoloration in males, females and children of all age groups. The results revealed that arsenic concentration and decreasing water quality is the leading cause of symptoms in the study areas. The increases frequency of diseases also lead to elevated health costs that are borne by the residents. The lack of education coupled with scarce resources force the residents to live in these impoverished circumstances. People continue the use of arsenic contaminated ground water for their daily life activities while only some of them can afford to spend on adopting averting measures.

5.2 Policy Recommendations

Keeping in view the purpose and findings of the research, the following policy recommendations are offered:

- The residents to the study area are facing the problem of safe drinking water so the concerned authorities need to take immediate steps towards the up gradation of the existing filter plants and installation of new filter plants in the poor villages of district Lahore.
- Site visits and interviews with local residents have revealed that arsenic contamination was due to the inadequate treatment and sanitation, poor sewage and drainage system in the area.
- Reasons of the anthropogenic sources was the intermitted water supply, improper maintenance and the scattered layout of sewer lines and government drinking water supply lines. Government must layout the future water supply and sewer pipes on opposite sides of street to eliminate the chances of cross connection between them.

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Appendix 1:

Group_________

Serial No.______

Date: / /2019

Survey Questionnaire on

I am M Phil Research student department of Environmental Economics at Pakistan Institute of

Development Economics (PIDE) Islamabad. Mainly my focus is to **"Impacts of Arsenic Contaminated Groundwater on Human Health in Affected Areas: A Case Study of Selected Villages District Lahore".** This is the part of my M.Phil. Thesis and this information will be very helpful to me. I request you to kindly respond to the questionnaire.

I would like to assure you that the information given by you will be kept strictly confidential and will be used for research purpose only.

I am hopeful to receive your co-operation

Mariam Saif

Section I

1. What is your quality of groundwater?
    a. Good
    b. Average
    c. Poor

2. What is your source of drinking water?
    a. Groundwater from own home
    b. Ground water from neighbor
    c. Bottled water
    d. River water

e. Other sources

3. Since how many year you are using water from this source?
   a. 1 to 2 years
   b. 3 to 5 years
   c. 6 to 10 years
4. Are you using groundwater for drinking and preparing meal?
   a. Yes
   b. No
5. Are you using groundwater for taking shower and washing?
   a. Yes
   b. No
6. Have you ever heard about arsenic?
   a. Yes
   b. No.

7. If yes then when ____________________

8. And how_________________?

9. If not using groundwater from own home then why?
   a. Muddy water
   b. Water borne diseases
   c. Have no excess to ground water
   d. Other reasons
   e. Contaminated with arsenic

10. How do you know that your water is contaminated with arsenic?
    a. Some surveys in the past have been conducted in your area
    b. Neighbors informed you
    c. You did a lab test of your drinking water

Section II

Health cost in last six month

Family/Household information

Sr. No	**Age (Years)**	**Education (Years)**	Relation of respondent with family member	Skin problem	Skeletal bone	Teeth discoloration	**Medication Source** (Private hospital/Govt. hospital)	**Health Cost(Rupees)**									
				Yes/ No	Yes/ No	Yes/ No		**Doctor fee**	**No of Visits to Doctors**	Avt. Measures Yes=1, No=0	Avt. Expenditures (Rupees)	**Lab Test fee**	**Medical expenditures**	**T.Travaling Cost**	Wage rate/month	Working days loss
M1																
M2																
M3																
M4																
M5																
M6																
M7																
M8																
M9																
M10																

F1																
F2																
F3																
F4																
F5																
F6																
F7																
F8																
F9																
F10																

Yes=1, No=0

T. Traveling cost= Total Travelling Cost

Clini/privete medication =1, Govt medication=0