Impact of Water and Sanitation on Child Health:

Evidence from Pakistan

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CERTIFICATE

This is to certify that this thesis entitled: **"Impact of Water and Sanitation on Child Health: Evidence from Pakistan".** submitted by Aleena Khan is accepted in its present form by the Department of Environmental Economics, 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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Dedicated to my beloved

Husband

Whose support for me *was what* sustained me thus far.

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For any errors, the responsibility, of course, is entirely mine.

Aleena Khan

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ABSTRACT

In Pakistan, approximately 16 million and 68 million people lack access to safe drinking water and adequate sanitation facilities, respectively. This study aimed to determine whether children under the age of five years without access to improved sources of drinking water and sanitation facilities are at higher risk of childhood stunting in Pakistan. The Pakistan Demographic and Health survey (PDHS 2013) data is used to examine the impact of water and sanitation on children's height-for-age Z score (HAZ), an indicator of child chronic under-nutrition. Children are classified as 'stunted' if their HAZ is below -2 SD, according to the criteria by the World Health Organization. The estimates from Propensity Score Matching (PSM) methods show that children who have access to safe drinking water have at least 0.30 SD higher HAZ compared to the ones who do not have this access. Similarly, improved sanitation facilities increase the HAZ by at least 0.25 SD. In addition, access to high and intermediate quality of water is associated with a 0.28 SD and 0.22 SD HAZ. On the other hand, high quality of sanitation facilities increases HAZ by 0.45 SD. The combine effect of improved water and sanitation facilities is also found to be significant thereby suggesting that better quality of water and sanitation are associated with higher HAZ- scores. The study also found suggestive evidence that the incidence of diarrhea is a potential channel for this effect.

Keywords: matching estimation; water; sanitation; child health

Chapter 1

INTRODUCTION

The relationship between childhood development and later life outcomes has been documented in a growing body of literature which indicates that children's early years of life are extremely important for shaping their adulthood capabilities (Barnett et al. 1998; Cunha et al. 2007; Campbell et al. 2014; Shonkoff et al. 2010). Recent studies have concluded that exposure to various factors such as acute malnutrition, infectious diseases, iodine deficiency, ionizing radiation, stress hormones, and air pollution early in life (both in-utero and during childhood) alternatively avert development potential in millions of young children. This in turn can have significant detrimental effects on children's school performance, cognitive abilities as well as on their productivity and earnings during adult life (Engle et al. 2007; Walker et al. 2007).

Several studies have attributed the factors identified above to various kinds of negative shocks. These include both natural disasters (e.g. famine, flood, earthquake etc.) as well as man-made shocks (e.g. pollution and violent conflicts). For instance, floods may not only destroy the crops to create food shortages that can lead to nutritional deficit in children but it can also result in disease outbreak. Likewise, exposure to a violent conflict (e.g. terrorism or war) can cause maternal depression during pregnancy thereby leading to the release of stress hormones which can affect the fetus health. Amongst the several indicators of child health, child height adjusted for age and gender is the most widely used measure of a child's long-run nutritional status because height unveils the cumulative effect of the previous outcomes (Case and Paxson 2008; Strauss and Thomas

1998). For this purpose, Z-score for each child's height-for-age is computed. The z-scores is calculated according to those of the international growth standers; it is the difference between child's actual height and the mean height of the child of same age and gender, this difference is further divided by the standard deviation of the given population.

Subsequently, children with a HAZ score below -2 standard deviations (SD) are considered stunted. The severely stunted children will have this score below -3 SD. Hence, these children face multiple growth trajectories the rest of their lives (Hoddinott et al. 2013). Stunted children are more likely to have lower IQ, poor school performances, lower productivity, and higher chances of heart diseases, diabetes, and strokes in adult life (Hoddinott et al.2013; Carba et al. 2009; Strauss and Thomas 1998).

The extent of the prevalence of stunting can be judged from the recent report of Lancet Maternal and Child Nutrition Series (2013) which estimate that globally 165 million children are stunted, out of which one third live in Africa and half reside in Central Asia. On the other hand, the prevalence of stunting in Pakistan is approximately 43 % out of which 23 % are severely stunted. Stunting amongst male and female population is recorded as 43.8% and 42% respectively (National Nutrition Survey Pakistan, 2011). An estimated 6.6 million children under the age of five in 2012 died in resource poor countries and nearly half of those deaths (i.e. 45%) are attributed to under-nutrition.

An important question that comes to mind is that what happens to HAZ scores in the absence of negative shocks such as the ones mentioned above. An even more important query would be regarding the relationship between malnutrition and stunting.

Can children be still stunted even when they are well-fed? The answer to both these questions, based on the previous empirical literature, is yes. In India, for instance, even the well-fed children are found to be stunted (Schmidt 2014). In pursuit of other potential causes for stunting, the researchers found a link between lack of access to safe drinking water and unimproved sanitation and children's health in several developing countries. Several studies have examined that children who live in an environment with good sanitation facilities, clean water and adequate hygiene grow better than children who do not have these facilities[1]. A recent Cochrane review (2013) found some evidence of a small but significant effect on stunting of certain water and sanitation interventions and explored that the cause of stunting is not just indeed the lack of nutritious food but also frequent illness due to poor hygiene, and lack of improved water and sanitation facilities (Spears et al. 2013; Dangour et al. 2013). Hence, the unavailability of improved water and adequate sanitation facilities has severe consequences on child health.

Consequently, there is a growing interest in how safe drinking water and adequate sanitation might support preventive strategies for reducing childhood stunting in high-burden settings which can further decreased the amount of infection related diseases (Cumming et al. 2016)[2].

The availability of drinkable water has improved over time. For example, over the period of 1990 to 2004, drinkable water has been made available to approximately 1.2 billion people worldwide (McKenzie et al. 2009; Hossain et al. 2016). Nonetheless, by

[1]According to the report of water and sanitation program (2013), Children living in different communities of Combodia where all household defecate outside on average are 0.44 to 0.77 standard deviation shorter than children living in household who do not defecate outside openly. This on average is equal to 2 to 3.6 cm shorter children under the age of five years.

[2]These are cholera and diarrheal diseases, which alone are responsible for some 1.8 million deaths every year (WHO 2008).

2015 an estimated 780 million individual have no regular safe drinking water supply (Brown et al. 2013).

Moreover, WHO Global Health (2012) estimates that 2.4 billion individuals across the globe are without adequate sanitation facility or are force to use inadequate communal toilets. Out of these 946 million individual have no choice to practices open defecation .i.e. into open bodies of water, forest, behind the bushes or in open field etc.

This has severe consequences for children's health. Every day, about 900 children less than five years of age die from diarrhoeal diseases caused by poor quality of water and sanitation, which is one of the leading cause of child mortality (WaterAid 2016; Trinies et al. 2016)This problem has been recognized efforts are being made, both by governments and non-governmental organizations (NGOs), to reduce stunting and child mortality. In 2012, for instance, the World Health Organization (WHO) set a global target to pledge the number of stunted children less than five years of age by 40 percent by 2025. Achieving this target would mean that approximately 70 million more children would be on their way to a strong and healthy adulthood.

1.1 Problem Statement

The prevalence of stunting in Pakistan is very high. According to Pakistan Demographic Health Survey (PDHS 2013), 45% children are stunted and 23% are severely stunted. This has generally been linked with nutritional deficit in children. Subsequently, the policy focus has mostly been on dealing with issues related to food insecurity. However, the situation of sanitation in the country is not encouraging either. In a statement last year, Geeta Rao Gupta - the deputy executive director at UNICEF – warned us that

"*There are 41 million people who do not have access to a toilet in Pakistan and as a result they are defecating in the open. And open defecation has significant health and nutritional consequences*".[3]

Moreover, 16 million people in Pakistan have no choice but to use poor quality of water (WaterAid Pakistan 2016). Despite these statements, however, there is no study available for Pakistan that has scientifically established the link between lack of access to safe drinking water and improved sanitation and stunting using a nationally representative dataset. Moreover, the few studies that have been previously conducted for Pakistan are geographically specific and, therefore, their results cannot be generalized for the entire country. Also, these studies are more focused on other health issues like diarrhea and mortality.

1.2 Objective of the Study

In the light of above discussion, the current study has the following two objectives:

- The prime objective of the study is to investigate the causal impact of access to improved drinking water and sanitation facilities on the incident of stunting among the Pakistani children aged five and below. We have also explored the share of each of these two factors, or the lack of them, in the incidence of stunting among children.
- To identify the channels through which safe drinking water and improved sanitation affect, if at all, the incidence of stunting in children.

[3] Dawn (2015). https://www.dawn.com/news/1168181

1.3 Significance of the study

As discussed in the problem statement, stunting has mostly been linked with lack of nutrition only and the policy discussions are more concentrated on dealing with food insecurity. Establishing a link between lack of access to safe drinking water as well as unimproved sanitation and stunting through a scientific study will stimulate the discussions on these factors and their public health implications. Approximately three million Pakistanis are infected by waterborne diseases and the children are the more vulnerable segment of society. Identifying how much roles do water quality and improved sanitation play in reducing these diseases, and thereby stunting, will help policy makers to formulate appropriate policies. These policies can have long term welfare consequences if they are able to reduce the incidence of stunting among children in Pakistan. On the other hand, this study has contributed to the literature on environment and public health in the context of Pakistan. To our knowledge, this is the first study on the relationship between water quality, improved sanitation, and stunting using nationally representative sample of children in Pakistan.

Chapter 2

LITERATURE REVIEW

The significance of safe drinking water and sanitation facilities in maintaining health has been accepted for centuries. In the 19^{th} and earlier 20^{th} century, ‘sanitary revolution’ played an exclusive role in reducing infectious diseases in industrialized countries (McKeown et al. 1962; Preston et al. 1978; Calman et al. 1998).The right to clean drinking water and basic sanitation facilities is not only an important socio-economic indicator of household but it’s also essential for health of its member. Safe drinking water has notable implication for development and survival of children and has direct impact on growth, well-being, and nourishment of children. (Fogden et al. 2009; Ashwani et al. 2014; Dugard et al. 2014).

Health of infants has been widely associated with Water and Sanitation Services (WWS) which has been endorsed and accepted in Public Health Literature (Jones 1923). To reduce child mortality rate, water and sanitation are regarded as the most important factors in policy making (Lancet editorial 2007).Children are more exposed to the health risk related to unimproved sources of water poor sanitization facilities. For example, their respiratory, digestive and immune system are still developing in early years of life (Ezeh et al. 2014). United Nations Water Cooperation (2013) estimate that globally, nearly 2.5 billion individual still lacks the sustainable sanitation facilities and almost 783 million populations i.e. 11% of the total population remains without the availability of clean and safe drinking water sources.

The combine effect of unimproved water and poor sanitation facilities is more pronounced against widespread diarrhea .Every year, around 760,000 children die of diarrhea which is the second leading cause among infants death across the globe (Gauri 2008; Osita et al. 2014; Ngure et al. 2014).These figures truly highlight the importance of providing safe drinking water to the infants.

Earlier studies demonstrated that more than the quality of drinking water, improved hygiene (ishing hands) and sanitation (availability of latrines) has better impact on the health of children, particularly their height (Case 2008; Currie 2012). For instance, Begum and Ahmad (2013) explore that the combined access to improved water and sanitation sources can decreased the incidence of diarrhea among children under age of five in Bangladesh.[4]

Safe and sustainable societies are showing more interest in how safe drinking water and adequate sanitation might help in preventive strategies and interventions for the prevalence of stunting in South Asia and in high burden regions (Cumming et al. 2016).

Stunting indicates and evaluates chronic malnutrition in children. Moreover, Stunting in particular is associated with long term health status of children because it reflects chronic under-nutrition, severe enough to cause long-lasting effects on intelligence quotient, poorer cognitive ability, lower school performance and future success and earning (Galloway et al. 2013). Stunting is not just a health issue for the affected countries but also for their economy.

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[4] In their study Begum and Ahmad (2013) used household data from demographic health survey of Bangladesh for year 1996/97 and 2007. Using propensity score matching (PSM) technique, the study found that the probability of childhood diarrhea incidence among those who have access to both water and sanitation is 31.5 per cent lower than of those without the combine use of water and sanitation in the 2007 survey. However, such observation are found absent 1996/97 data.

According to Lancet Maternal and Child Nutrition Series (2008), diarrhea incidences can be reduced by 30% and stunting by 2.4 % within 36 months of the child age if interventions regarding hygiene and sanitation are implemented by 99% coverage. Overall enhancement and improvement in sanitation and general hygiene linked with 0.6 – 0.65 increments in height-for-age z (HAZ) (Esrey 1996).

An improved water source is not the only factor for promoting increase in heights but better sanitation and hygiene practices are also essential (Cumming et al. 2016). Despite with worst sanitation, water sourcing and storage conditions, Peruvian children are only short by 0.9 cm than those children with ideal sanitation facilities (Checkley 2004).The same aspect is further estimated in Bangladesh (2013) where stunting prevalence under the age of 4 years who live in clean households had 22% lesser occurrences and 0.54 SD (standard deviations) higher HAZ than those lacking these facilities. Other studies in different countries have also provided evidence that improved growth in children can either be associated to improved water, better sanitation or both of them (Daniels 1991; Magnani 1993; Merchant 2003).

Various studies have been carried out to examine water and sanitation associate diseases for last two decades (Fewtrell et al. 2007). Prevalence of childhood stunting on global level has reduced substantially during MDG period (Svedberg and Peter, 2006). In 1990s, almost 40 % children are known to be stunted globally (Onis et al. 2012). This is now estimated to be dropped down to a quarter (black et al. 2013).The number of stunted children globally have been reduced by 100 million (Prendergast et al. 2014)

However, there are still 165 million children estimated to be stunted worldwide (Lancet 2013).Stunting is higher in South Asia and sub-Saharan Africa than elsewhere due to poor water and sanitation coverage (Black et al. 2013). On the other hand, according to recent report of Pakistan Demographic Health Survey (2013), over the last decade, nearly half of all children are stunted in Pakistan. That is, more than 45 % of children are stunted out of which 23 % are found severely stunted.

Stunting amongst male and female population is recorded as 43.8% and 42 % respectively. In a nutshell, investing in improving the quality of drinkable water will not only reduce the mortality rate of children but will also improve the social, economic and health related benefits of the country. This would in turn improve general health of children particularly their heights. If such measures are not ensured, children growth will be grossly affected from parasitic infection (WHO 2013).

It has been reported by many policy-makers that the decrease in open defecation has resulted into marked but irregular increase in health. However, better results regarding public health can only be accrued when entire community come forward and adopt improved sanitation behavior, excreta is well disposed and taken care of and area is entirely defecation free.[5] (Sanan and Moulik.2007).

According to World Bank (2012) report, every day about 1,800 under the age of five die due to waterborne diseases and nearly 2.4 billion people do not have access to adequate toilets facilities, where 1 billion people do not have access to any sanitation at all.

The situation in Pakistan is alarming in this regard due to poor sanitation coverage including toilets and latrines. Nearly 41 million people do not have improved toilets

[5] These results are based on the conclusion of a study in three villages of Himachal Pradesh by an organization called knowledge links, their study concluded that incident of diarrhea are still high (26 percent) in households having 95 percent of toilet usage and the same incidents are decreased to 7 percent in villagers using 100 percent of toilet facilities.

facilities (i.e. functional and safe toilets), forcing individuals to defecate in open, thereby, decreasing health conditions (World Health Organization, 2013).

There have been several researches carried out to relate association between improved growth and access to safe drinking water and improved sanitation facilities through various statistical methods (Esrey et al.1991; Spears et al 2013; Ngure et al. 2014). According to a recent Cochrane analysis (2013) five experimental (intervention) studies has been identified which prove the effects of water, sanitation and hygiene on under nutrition.

The interventions on childhood stunting which have been analyzed are: Solar disinfection for household water treatment (Du Perez et al., 2010, 2011), Chlorination of water (Luby et al. 2006, Arnold et al.2007), flocculent-disinfectant (Reller et al. 2003, Luby et al. 2006; Barbara et al. 2009) and finally, hand ishing promotion through provision of soap (Meilicke et al.2008; Phillips et al. 2015). However, no interventions regarding sanitation and water supply are identified.

In a much larger study carried out in Sudan, it is revealed that those children who came from clean household and had better sanitation facilities had lesser chances of having stunting. Moreover, they had 17 % greater chances of reversing stunting as well. The relation between child growth and sanitation is a complex affair; require a greater degree of interaction between them. Fuentes (2006) addressed child mortality and water and sanitation facilities in a multi county project and used the data of Demographic and Health Surveys (DHS) conducted in Cameroon. Fuentes explored the biological linkages and his results highlighted some seemingly consistent findings; in rural areas, access to safe water is found to be a pre-requisite for infant survival, whereas in urban areas, improved sanitation facilities increase the chances of survival.

Surprisingly, in Egypt, sanitation is not a significant factor in increasing health conditions. However, some evidence is available which indicated that provision of modern toilet facilities helped in reducing the chances of childhood mortalities.

Not much research and pragmatic efforts have been carried out on effects on poor water and sanitation facilities on the development of child in early days (i.e. their sensorimotor, cognitive and socio emotional development).

Moreover, there are not many health and sanitation regulations that has been formulated to stop childhood mortalities in the first three years of life. Keeping in view the practical as well as theoretical evidence, it is imperative that water and sanitation regulations must be made in much broader detail in support of early childhood development (ECD).

Factor such as child health, nutrition, child growth and development are closely related to each other. All these factors are greatly influenced by a common denominator i.e. hygiene of the surrounding area in which a child is growing. It is important that we should broaden our horizon regarding childhood nutrition and development regulations and should not restrict it to mere calculation of number of toilets, hand ishing and water purification facilities in an area. Current evidence suggests that water and sanitation services can greatly improve childhood under nutrition conditions.

Realizing the potential efforts of contribution of water and sanitation services to eliminate global stunting target do not only require strong initiatives but also required modification in intervention of water and sanitation programs. While improving alone water and sanitation facilities cannot eliminate stunting; however, it does have the potential to speed up the process of eliminating stunting in long term.

Chapter 3

POTENTIAL CHANNELS

The mechanism to link poor water and sanitation to childhood stunting are not easy to relate as it involves multiple interlinked biological pathways and many broader but less direct approaches. Here we discuss three of the potential channels that have been identified in the literature so far.

3.1 Water and Sanitation and Diarrhea

If the children are living in an unhealthy environment, there will not be any significant improvement in childhood stunting even if we improve the diet. Exposure to poor sanitation and unimproved drinking water can lead to diarrheal diseases which in turn can lead to stunting.

It is becoming increasingly clear that if children are living in an unhealthy environment, there will not be any significant improvement in postnatal stunting even if the diet is improved. Children living in such unhealthy situation are subject to all sort of infectious disease. There is a high risk of children absorbing fecal bacteria through putting dirty fingers in their mouth and contaminating other household items which may lead to intestinal infections.

These infections have the potential to affect children's nutritional status by decreasing their appetite, reducing absorption capacity of healthy nutrients and also increasing nutrients losses. Alternatively, this led to the increase the risk of childhood stunting (Higgins et al. 2016)

A study of five countries found that repeated bouts of diarrheal disease as a result of poor sanitation conditions results in almost 24% stunting in children at the age of 2 years. (Checkley et al .2008).

Another recent study found that over the period of five years the average height of Cambodian children are increased with a decreased in practice of open defecation, which is still a common practice in Cambodia. Very similar results are obtained in an observational study in Peru where poor water quality and improper disposal of sewage contributed to decrease in height by 1.0cm shorter in children less than 2 years of age than those children in comparison group with improved facilities (Checkley et al.2004). This study further found that access to sources of water and sanitation facilities explained 40 percent of stunting while diarrhea only accounts for 16 percent. This leads us to the conclusion that reducing the incidence of diarrhea by improved water and toilet facilities can have a substantial impact on child height but may not completely eliminate stunting.

3.2 Water and Sanitation and Environmental Enteropathy

The idea that rather than inadequate dietary intake, surrounding conditions have more impact on stunting is originally floated by Solomans in 1993. However, studies still focus on dietary solution to reduce the incidence of under nutrition, none of which is able to end childhood stunting.

Another recent study further suggests that environmental enteropathy can even worsen nutritional growth even if the child does not have recurrent diarrhea symptoms. Children between the age of 6 months to 2 years of age, are highly exposed to multiple enteric pathogens when they crawl and put objects in their mouth (Ngure, 2014) Repeated ingestion of these pathogens can eventually cause harm and inflammation to the guts which result in poor absorption of nutrients, a condition commonly known as environmental enteropathy. Environmental enteropathy is one of the root cause of childhood under nutrition and a leading cause of stunting due to poor water and sanitation condition (Humphrey, 2009).

Exposure to fecal microbe's contamination, lacking basic sanitation facilities and hygiene cause environmental Enthropathy, which resulting in small intestines damage and inflammation. It may occur in those children who do not have toilet facilities and defecate in open or have poor sanitation facilities such children are exposed to microorganism's such as bacteria, fungi, viruses and pathogens causing intestinal diseases (Campbell, Humphery, 2009).

Moreover observational research has proved that more than anything, cleanliness at home and surroundings is more important. If water is used after attending ishroom, proper infrastructure for sanitation and measureable indicators for environmental enteropathy are being considered. Only then the desirable results like standardized child height and weight can be attained (Lin et al, 2013).It is evident from recent research that environmental enteropathy have a direct bearing with poor growth and may seriously affect the efficiency of nutritional regulations and interventions.

3.3 Soil-Transmitted Helminths

Inadequate sanitation could also lead to soil-transmitted helminth infections which are linked to childhood under nutrition. These helminthes are intestinal worms infecting humans and are transmitted through unhygienic soil. These infections are highly present among the poor communities particularly in the remote and rural areas, with high prevalence among children of preschool. Children living in poor sanitary conditions and near the area of open defecation are at higher risk of these helminthes. For instance Hookworms eggs are passed in the stool of infected child, normally transmitted with close contact of skin to contaminated soil or feces and by walking barefoot.

Roundworm (Ascaris lumbricoides), whipworm (Trichuris trichiura) and hookworms (Necator americanus and Ancylostoma duodenale) are the four main species that harm people. More commonly, pregnant women are affected by the consequences of helminth infections i.e. such women are at major risk of nutritional deficiencies and, in general, both mother and fetus could be affected. In particular, with growth faltering in children eventually lead to stunting (Pruss-Ustun et al.2008; Strunz et al. 2014). Apart from that, during pregnancy, hookworm infections may cause malabsorption of nutrients and other maternal anemia which can lead to stunting (Black, 2013)

Chapter 4

DATA AND EMPRICIAL METHODOLOGY

4.1 Data and Variables

We exploit the data from Pakistan Demographic and Health Survey (PDHS 2013) to enquire the impact of lack of access to improved drinking water sources and sanitation facilities on childhood health. This survey is the latest in the same series of three surveys previously conducted in Pakistan since 1990. It is a national cluster sample survey which include wide range of information on health and socio–demographic characteristics such as housing condition, characteristics of household members, childhood mortality, birth histories, childhood illness, domestic violence, household infrastructures, sex, education, and nutritional status of women and children, child feeding practices, maternal and child health, fertility practices, awareness regarding HIV/AIDS and information about other diseases.

The PDHS (2013) successfully interviewed 14,000 household which include 7056 households from rural areas and 6944 households from urban areas. The data also covers information of 3,070 children aged 5 years and below. This information on complete birth histories as well as anthropometric measures of these children is provided in the survey. In this study these children are the primary analytical unit.

Children's health status is measured using the height-for-age z (HAZ) scores. These are adjusted for age and gender. Information on water sources and sanitation facilities are also provided at the household level. These are multiple response questions. As discussed in the methodology later, need two groups (treated vs. control); household with improved water and sanitation facilities are in the treated group whereas those with unimproved facilities are in control group. Consequently, we categorize these responses in two groups. We first classify them into "improved" and "unimproved" facilities using the criterion adopted by the UNICEF Joint Monitoring Program (JMP).

This classification is mentioned in table 4.1.Four categories have been made regarding water sources and sanitation facilities. They are, improved water and improved sanitation facilities, improved water and un-improved sanitation facilities, un-improved water and improved sanitation facilities and lastly, un-improved water with un-improved sanitation facilities. The main reason for making such categories is to examine whether combine effect of both un-improved water and sanitation has any effect on childhood stunting or otherwise.

Table 4.1 Classification based on UNICEF JMP

Variable	Improved Sources	Unimproved Sources
Source of Drinking Water	Piped into dwelling/yard/plot Public taps or standpipes Boreholes or tube wells Protected dug well Protected spring and rainwater Bottle water Filtration plant	Unprotected dug well Unprotected spring Tanker Truck or Cart with drum Surface water
Sanitation Facilities	Pour-flush system to piped sewer system Pour –flush to septic tank Pour –flush to pit latrine Ventilated improved pit latrine (VIP) Pit latrine with slab.	Pit or tank latrine Pit latrine without slab or open pit Bucket Hanging toilet or latrine No facilities bush or field.

Note: bottled water is considered improved only when the household use another improved source for cooking and personal hygiene.

However, for our study to guarantee the comparability of water and sanitation variables across Pakistan at a given point of time, we will construct three categories dividing both water sources and access to toilet facility on the bases of presumed quality type. Generally the DHS does not give information about the quality type of the water and sanitation facilities. Nonetheless, better water and sanitation technology is always assumed to be associated with improved sources of water and hygiene conditions

Table 4.2 Classification based on Quality Type

Variables	Poor quality	Intermediate Quality	High Quality
Water Sources	Surface water i.e. Rivers, lakes and standing water	Below surface water i.e. springs, boreholes standpipes, wells and dug wells (not part of public pipe system)	Direct access to piped water, direct water bought from vendors
Sanitation Facilities	No access to toilet facilities	Access to basic or improved toilet i.e. Pour-flush system to piped sewer system, Pour–flush to septic tank, Pour –flush to pit latrine, Ventilated improved pit latrine (VIP), Pit latrine with slab.	Access to flush toilet

In the above table, we divided water sources into three categories of different presumed quality type. Household with access to surface water are placed/put into poor quality type; household with access to below surface water are placed into intermediate quality type; and household with direct access to piped water and those who buy water directly from vendors are placed into high quality type. In some cases it might be possible that water from intermediate quality type may be less polluted than water from vendors or from public piped system. The main reason behind the given categorization is the basic assumption that, on average better, technology leads to high water quality.

We also divided the toilet facilities into three categories of different presumed quality type by following the above logic for water sources. Households are placed into the poor quality type if they have no access to toilet facilities at all; households with access to improved or basic toilet facilities are placed into intermediate quality type; and households with access to flush toilet facilities are put into high quality type.

In addition to these we have also add other relevant control variable such as age and sex of the child, number of children in the family, mother and father education status (no education, primary, secondary), residence type (rural/urban), household wealth index (poor, middle, rich), mother working status (working, not working).

4.2Matching Techniques

The method of matching has been increasingly used in the evaluating literature to correct the problem of self-selection. The aim of the PSM is to match children who have access to improved services (treated group) as compared to those children who have no access to improved services (comparisons group). Rosenbaum and Rubin (1983) noted that the more coherent way of performing the comparison between two groups is to estimate the propensity scores and to point out the probability of being in the treatment group.

4.3 Propensity score Method

The Propensity score is defined as "the probability of assignment to a particular treatment conditional on a vector of observed covariates "(Rosenbaum and Rubin, 1983). The idea behind using matching method is to construct a comparison group which resembles as much as possible to the treated group with respect to their observed characteristics that affect both their outcome and decision of the participants across time.

To avoid the selection biases affecting our analysis we have controlled several covariates including household and child characteristics that may correlate with both child health and water and sanitation facilities. Though this paper, treatment status is describes as, household with access to improved water source and sanitation facilities

4.4 Estimating the Impact Using Propensity Score Matching

Based on the above discussion, we estimate the impact of water sources and sanitation facilities using various variants of the following equation:

$$HAZ_{ij} = \beta_0 + \beta_1 Treatment_j + \gamma X + \varepsilon_{ij} \qquad (1)$$

Where HAZ is height-for-age Z score (indicator for stunting) for child i living in household j; X is a matrix of additional control variables. The variable $Treatment_j$ takes several forms.

We first examine the impact of water sources on HAZ. The $Treatment_j$ variable in this case takes the value 1 if water sources in the household are improved; 0 otherwise (see Table 4.0). Next, we have changed the treatment to investigate the impact of sanitation facilities. The variable $Treatment_j$ takes the value 1 if the household has improved sanitation facilities; 0 otherwise. Next, we have explored the combine effect of improved water and sanitation facilities. Hence, the variable $Treatment_j$ take the value 1 if household has both improved water sources and sanitation facilities; 0 otherwise.

The three different quality types is also classified into two categorize (see table 4.1) First, we have included the intermediate quality with the poor quality to put it into unimproved facilities (comparison group). Then, we have combined it with the high quality (treated group). For exploration of the channel we use the same equation but have replace the dependent variable with, say diarrhea, to explore the potential channels.

Lastly, we have run separate regressions to examine the impact of different quality types on HAZ using the following equation:-

$$HAZ_{ij} = \alpha + \beta_1 High\ Qaulity_j + \beta_2 Int.Quality_j + \beta_3 Poor\ Quality_j + \gamma X + \varepsilon_{ij} \quad (2)$$

Here $Int.Quality_j$ shows the intermediate quality of the facilities that household j possesses.

4.5Average Treatment on the Treated (ATT)

ATT shows the difference in mean outcomes of the prevalence of stunting among children under age of five in treatment group to non-beneficiaries (*control group)*. Using results computed from propensity score probit regression. The treatment in our case refers to household with access to improved water source and sanitation facilities and is a binary variable. For example treatment =1, if household have access to improved water and sanitation facilities, 0 otherwise. The ATT captures the effect of treatment on child health.

$$ATT = E(Y1|p(X), D = 1) - E(Y0|p(X), D = 0) = E\big(Y1 - Y0\big|p(X)\big) \quad (3)$$

However using equation (1) estimation of propensity score is not enough to determine the ATT estimates. This is because the probability of observing two units, one from treated and other from control with exactly same value of propensity score value is in principle zero, since p(x) is a continuous variable.

To correct this issue various matching methods have been proposed in PMS, we do not discuss the technical specification of all methods rather we have discussed 4 most widely matching methods.

The different types of matches have different advantages. For example to check the robustness of our results, for each analysis we have run four different PSM techniques. The simplest technique is one-to-one technique commonly known as nearest neighbor technique which pairs each treated case with control case with closest propensity scores.

Radius matching is another technique which uses variant of calipers. To avoid the risk of poor matches by nearest neighbor, radius matches specifies the caliper band, by imposing a restriction that allow tolerance level for the maximum scores of propensity .Hence, the quality of matching rises and bad matches are avoided.

Kernel and Local Linear Regression (LLR) is a non-parametric matching estimator, which uses average of all the control cases to find out match for a treated case. In these methods, more weightage is placed on those cases whose propensity score is closer to that of treated case. These methods offers advantage in the form of reduced variances because more information is used but may potentially use bad matches.

The final method, stratification matching works by dividing the common support of the propensity score into set of strata and estimate their effect in each PS sets of intervals (stratum) by taking the mean difference in the outcome of interest between the treated and control observation. In this method, five nearest control matches are taken to create match for the treated case. These methods again have a disadvantage of reduced variations for poorer matches on average (Caiendo and Kopeining, 2005).

Chapter 5

RESULTS AND DISCUSSION

The following chapter discusses in detail the results obtained from the econometric technique spelled out in detail in the last chapter. As mentioned in the objectives of the study, we aim to calculate and discuss the impact of improved water and sanitation facilities on the incidence of stunting in children under the age of five in Pakistan.

5.1 HAZ and Regression Analysis

We begin our analysis by first regressing the indicator for child health, the height –for-Age-Z-Score (HAZ), on the treatment variables separately. These results are reported in Table 5.1. Model 1 in the table shows the importance of improved water sources on HAZ without controlling for other child and household characteristics. The coefficient of the treatment variable is positive and statistically significant suggesting that improved water is associated with higher HAZ. More specifically, children living in households with improved water facilities have higher HAZ by 0.38 standard deviation (SD) compared to children living in households with unimproved facilities.

However, since Model 1 does not control for other characteristics, the coefficient value for this treatment effect could be biased. In order to deal with this potential bias, we control for various child, parental and household characteristics in Model 2. We can observe that the coefficient is still positive and statically significant However, its magnitude has decreased by 0.17 SD in Model 2. This indicates that Model 1 overestimated the effect of improved water sources. Moreover, the value of R-square confirms that Model 2 is a better fit.

Table 5.1: Regression Results for Improved Water and Sanitation Facilities

	Water Sources		Sanitation Facilities	
Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**
Treatment_w	0.385***	0.17 83*		
	(0.105)	(0.103)		
Treatment_s			0.511***	0.239***
			(0.074)	(0.077)
ChildAge (months)		-0.292***		-0.291***
		(0.023)		(0.023)
Gender of Child		0.078		0.078
		(0.065)		(0.065)
Mother's Age		0.016***		0.015***
		(0.758)		(0.005)
Mother's Education		0.593***		0.576***
		(0.075)		(0.076)
Mother's Employment		-0.129		-0.080
		(0.082)		(0.082)
Fathers Education		0.268***		0.255***
		(0.074)		(0.747)
Household Size		-0.025 ***		-0.026***
		(0.006)		(0.006)
Residence		0.143**		0.101
(Urban/Rural)		(0.069)		(0.0712)
Adj R-squared	0.004	0.097	0.014	0.099
Observations	3,070	3,070	3,070	3,070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Model 2 and 4 controls for the following variables: child's age and sex, mother's age, education and employment status, father education, household size, and urban and rural residence.

We repeat similar exercise for better sanitation facilities in Model 3 and 4 in Table 5.1. Model 3 do not control for child, parental, and household characteristics. The coefficient for treatment variables in this case is also positive and statistically significant. In Model 4, where we control for various characteristics, this coefficient decreases in magnitude even though it still remains positive and statistically significant. It suggests a positive relationship between improved sanitation facilities and HAZ. That is, improved sanitation facilities increase HAZ by 0.239 SD for children who have access to these facilities compared to those who do not have this access. Hence, Model 2 and 4 confirm the importance of clean drinking water and improved sanitation for child health.

Table 5.2: Test of Means for Treatment and Control Groups (Water Sources)

Variables	Unimproved Waters sources	Improved Water Sources	Difference
HAZ	-2.116	-1.731	-0.385***
	(0.117)	(0.0353	(0.1054)
Child Age (Years)	2.073	2.075	-0.001
	(0.073)’	(0.027)	(0.078)
Gender of Child	1.513	1.490	0.023
	(0.026)	(0.009)	(0.027)
Mother’s Age	30.112	29.303	0.808***
	(0.356)	(0.116)	(0.341)
Mother’s Education	0 .177	0.440	-0.262***
	(0.020)	(0 .009)	(0.026)
Mother’s Employment	0.180	0.212	-0.031
	(0.020)	(0.007)	(0.022)
Fathers Education	0 .494	0.675	-0.180***
	(0.026)	(0.009)	(0.026)
Household Size	9.204	9.302	-0.097
	(0 .206)	(0.100)	(0.282)
Residence (Urban/Rural)	0.2841	0.453	-0.169***
	(0.023)	(0.009)	(0.027)
Observations	366	2,704	

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5.3: Test of Means for Treatment and Control Groups (Sanitation Facilities)

Variables	Unimproved sanitation facilities	Improved sanitation facilities	Difference
HAZ	-2.136	-1.624	-0.511***
	(0.062)	(0.040)	(0.742)
Child Age (Years)	2.099	2.064	0.034
	(0.046)	(0.030)	(0.055)
Gender of Child	1.489	1.494	-0.005
	(0.016)	(0.010)	(0.019)
Mother’s Age	29.415	29.393	0.808**
	(0.356)	(0.116)	(0.341)
Mother’s Education	0.203	0.496	-0.290***
	(0.013)	(0.010)	(0.018)
Mother’s Employment	0.337	0.153	0.184***
	(0.015)	(0.007)	(0.015)
Fathers Education	0.504	0 .717	-0.213***
	(0.016)	(0.009)	(0.018)
Household Size	9.062	9.388	-0.325
	(0.137)	(0.116)	(0.200)
Residence (Urban/Rural)	0.201	0.532	-0.330***
	(0.013)	(0.010)	(0.018)
Observations	918	2152	

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The descriptive statistics for the two groups in case of both treatments are reported in Tables 5.2 and 5.3. These tables provide important information about socio-economic and demographic characteristics of the child, parents and household. These also show the status of access to water and sanitation facilities for 3,070 children under the age of five. As per our data set, the average age of children is similar in both the treated and control groups and, on average, the household heads of the treated groups are slightly more educated than their counterpart in control group.

Table 5.2 shows the covariate means in treated (column 1) and control groups (column 2) respectively, while column 3 tests whether the difference in means are statistically significant or otherwise. The HAZ score is 0.385 SD lower in children using unimproved sources of drinking water than those who do have access to improved sources. To put this in context, the chances of stunting in children living in household with access to improved sources of water are lower compared to children in the control group. Hence, the incidence of stunting is significantly higher in the control group.

Similarly, Table 5.3 summarizes results for improved (column 2) and unimproved (column 1) sanitation facilities. Column 3 of the same table tests for the difference in means and their statistical significance. The lack of access to improved sanitation is more pronounced than access to improved water sources. Table 5.3 reports that the prevalence of stunting is higher in children belonging to household using unimproved sources of sanitation as indicated by the HAZ score. The average HAZ score for children using unimproved sanitation facilities is -2.13 SD. Whereas, the HAZ score for children that have access to improved sanitation facilities is -1.624 SD. As a result, the average stunting is 51% higher in children exposed to unimproved sources of sanitation.

5.2 HAZ and Propensity Score Matching

It can be noted from Tables 5.1, 5.2 and 5.3 that, apart from the fact that treated households have more access to improved sources of water and sanitation facilities, these two groups also differ on certain dimensions. This means that treated households are enjoying relatively high social and economic status, as compared to control households. In addition to these observed characteristics, households in the two groups could also be different based on unobservable characteristics. If this is indeed the case, then it is also possible that the reason for the difference between children health may not necessarily be due to treatment effect. It is quite possible that these observable and unobservable characteristics are correlated with the treatment assignment and therefore difference in children's health could be wrongly assignment to the treatment. We thus use Probit regression model to first confirm if the treatment assignment is indeed correlated with the observable covariates. In the next step, the propensity scores are calculated. After the assigning of the propensity scores to every individual, different matching method are used to compare the two groups and calculate the Average Treatment Effect on the Treated (ATT). Estimating ATT using propensity score matching helps solve the problem of biasness.

In the first step of matching, propensity scores are estimated so that it satisfies the balancing property. This program generated 11 blocks of observations in case of improved water sources and 7 blocks in case of improved sanitation facilities, ensuring that mean propensity scores is not different in each block of treatment and control group. The balancing property is satisfied, which show balance of covariates in each block of treated and control group. The program also identified the region of common support to estimate the ATT of the two groups, ensuring that the combinations of observed characteristics are similar between the two groups. Thus, any treated observation with a score that lies outside the maximum and minimum value of common support of control group will be dropped. As extrapolation is not an option, the use of common support not only improves the quality of matching but also checks precision of the ATT estimation (Caliendo and Kopeinig 2008). The region of common support determined in the case of water is [0.718, 0.985]. Within the region of common support, the estimated propensity score of the treatment group ranged from a minimum value of 0.720 to a maximum of 0.968, and the propensity scores of the control group ranged between 0.718 and 0.985. Whereas in case of sanitation, the range of common support is [0.296, 0.958] between treatment and control group. Within the region of common support, the estimated propensity score of the treatment group ranged from a minimum of 0.296 to a maximum of 0.954; the propensity scores of the control group ranged between 0.296 and 0.958. The above values are the common area of the estimated propensity scores of treatment and control groups in both water and sanitation. After the balancing and common support property is satisfied, we now move to match the two groups.

Table 5.4 shows the child, parental, and households' characteristics that could potentially affect the treatment assignment. The findings suggest that probability of being in the improved household facilities is not affected by child age and sex, mother age and household size but it is affected by parental education and their employment status and area of residence. The results suggest that more educated mothers are more likely to use improved water and sanitation facilities compared to households headed by illiterate mothers. Rah et al (2015) found in India that household access to piped water in itself is not linked with stunting but when accompanied by mother knowledge of personal hygiene practice, childhood stunting is decreased. Interestingly though, mother employment is negatively associated with access to better sanitation facilities. It could be because these mothers might have to a blue collared job which could be an indicator for their lower socioeconomic status and could, therefore, be linked with unimproved sanitation facilities. Moreover, results shows that people living in urban area have more probability to be in treated group. This means that those households are using better water and sanitation facilities.

Table 5.4: Treatment Assignments (Probit Estimation for Propensity Score)

Variables	improved water sources	improved sanitation facilities
Child Age (months)	0.017	0.0009
	(0.022)	(0.018)
Gender of Child	-0.041	0.002
	(0.060)	(0.050)
Mother's Age	-0.006	0.008**
	(0.004)	(0.004)
Mother's Education	0.542***	0.481***
	(0.075)	(0.059)
Mother's Employment	0.279***	-0.473***
	(0.078)	(0.060)
Fathers Education	0.223***	0.276***
	(0.0656)	(0.055)
Household Size	0.006	0.006
	(0.006)	(0.005)
Residence (Urban/Rural)	0.246***	0.693***
	(0.066)	(0.055)
Observations	3,070	3,070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Caliper= 0.2, for all matching methods.

The results in Table 5.4 show that matching is required to establish a causal impact of treatments on HAZ. As mentioned before, the impact is estimated using different matching techniques (nearest-neighbor, radius, kernel and stratification matching) and subsequently a regression-based technique as a robustness check. The results from four types of matching techniques are given in Table 5.5. This table shows the average treatment effect on the treated for HAZ. The ATT shows the difference in mean outcomes of the prevalence of stunting among children under age of five in treatment group to comparison group (*control group***)**.

Table 5.5: ATT for Improved Water Sources and Improved Sanitation Facilities

Matching Technique	**ATT for Improved water sources**	**ATT for improved Sanitation facilities**
Nearest Neighbor	0.297*	0.262**
	(0.172)	(0.126)
Radius matching	0.415**	0.378***
	(0.128	(0.080)
Kernel Matching	0.347***	0.250**
	(0.135)	(0.098)
Stratification	0.145	0.265**
Matching	(0.152)	(0.107)
Observations	3,070	3070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Caliper= 0.2, for all matching methods.

The ATT value of 0.297 for the Nearest Neighbor matching method in column 1 indicates that the Height-for-Age Z score (HAZ) is 0.297 SD higher for children who have access to improved water sources compared to those who lack these improved facilities. The results are also statistically significant in case of radius and kernel matching. However, the ATT estimate of stratification matching does not found significant difference between treatment and control group in terms of prevalence of childhood stunting. Moreover, the results of ATT for all other matching method in column 2, confirm that the Height-for-Age-Z score (HAZ) is at least 0.25 SD higher for children who have improved sanitation facilities compared to those who lack these improved facilities. These ATT estimates are robust and consistent across different matching techniques. These results confirm that improved sources of water and sanitation facilities play an important role in improving the long term health of children.

We have so far examined the impact of these two treatments separately. We now explore the combined effect of improved water and sanitation facilities on HAZ. The probit estimates for the treatment assignment are provided in Table 5.6. Since certain characteristics affect the treatment assignment, we need to do matching for investigating the causal effect on HAZ. These results are shown in Table 5.7.

Table 5.6: Treatment Assignment for Combined Impact (Probit Estimation)

Variables	Improved water and sanitation
Child Age (months)	0.010
	(0.018)
Gender of Child	0.002
	(0.049)
Mother's Age	0.004
	(0.004)
Mother's Education	0.571***
	(0.056)
Mother's Employment	-0.309***
	(0.060)
Fathers Education	0.287***
	(0.054)
Household Size	0.004
	(0.004)
Residence (Urban/Rural)	0.610***
	(0.052)
Observations	3,070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5.7: ATT for the Combined Impact of Water and Sanitation Sources

Matching Technique	ATT for Improved water sources
Nearest Neighbor	0.214**
	(0.100)
Radius matching	0.383***
	(0.078)
Kernel Matching	0.244**
	(0.089)
Stratification Matching	0.213**
	(0.094)
Observations	3,070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Caliper= 0.2, for all matching methods.

The ATT value for the Nearest Neighbor matching method signifies that the Height-for-Age Z score (HAZ) is 0.214 SD higher for children who have access to both improved water sources and sanitation facilities simultaneously compared to those who lack to these improved facilities. The results are also statistically significant in the rest of the matching methods as well confirming the robustness of these results.

Our obtained results are consistent with previous studies and analysis addressing this question. A study by Fink et al. (2011) using Demographic Health Survey (DHS) datasets for 70 low and middle income countries estimated the odd of lower risk of mild or severe stunting (OR = 0.92, 95% CI 0.89-0.94) in children using improved sources of water and sanitation facilities. Another study on the National Demographic and Health Survey of the Northern regions of Brazil found similar results. The study recorded the prevalence of severe stunting as approximately 14.8% for children who came from household who do not have adequate toilet facilities or a proper sewer system (Planejamento 2008). A study by Merchant et al (2003) found that children who came from clean household and better toilet facilities have lesser chances of stunting and a 17 percent greater chance of reverse stunting. Another study in Indonesia found that lower maternal education in rural area is associated with 43.4 percent higher stunting in children (Torlesse et al. 2016). Numerous studies have also been conducted for calculating the incidence of stunting at a country level. Esrey (1996) in a multi country analysis found small but positive benefits on child height (HAZ score) when both improved sanitation and optimal water is available. Another country wise analysis of low and middle income countries by Bredenkamp et al. (2014) shows that low and middle-income countries have a higher incidence of stunting.

5.3 HAZ and Quality of Water and Sanitation Facilities

As mentioned before in Chapter 4 (Table 4.2), categorization of three presumed Quality type of water and sanitation i.e. Poor Quality, Intermediate and High Quality is given. Table 5.8 shows the association of three types of drinking water sources and toilet facilities and HAZ. Models 1 and 3 present results for the cases where controls are not included in the models. On the other hand, Models 2 and 4 show results after controlling for confounding variables. The magnitudes of the association between various quality types and HAZ decreased after the child, parental and household characteristics are controlled for. Nonetheless, the signs and significance of the impact remain the same. The results in Model 2 imply that high and intermediate water quality increase HAZ by 0.28 SD and 0.22 SD respectively. Not surprisingly, poor quality decreases HAZ by -2.190 SD. Hence, children living in household with access to poor quality of drinking water have higher risk of childhood stunting, because these children are more likely to be exposed to pathogens in contaminated water which, according to categorization of poor water quality, include surface water, rivers, lakes and standing water.

Table: 5.8 HAZ and Quality Types of Water and Sanitation

	Water Quality		Sanitation Quality	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
High	0.702***	0.284*	0.796***	0.453***
	(0.155)	(0.151)	(0.084)	(0.093)
Intermediate	0.475***	0.227*	-0.310**	-0.392***
	(0.133)	(0.129)	(0.148)	(0.147)
Poor	-2.254***	-2.190***	-2.340***	-2.244***
	(0.127)	(0.235)	(0.075)	(0.215)
Controls	No	Yes	No	Yes
Adj. R Squared	0.006	0.097	0.042	0.112
Observation	3070	3070	3070	3070

Note: Robust standard errors are in parenthesis. *** and ** show significance at 1% and 5% levels respectively. Models 2 and 4 control for child age and sex, mother's age, education and employment status, father's education, and household size and urban and rural residence.

The point estimates for sanitation is considerably high; the results of model 4 including all the control variables are also displayed in Table 5.8. These findings suggest that a child in household with access to high quality of toilets increases HAZ by 0.45 SD. However, in case of intermediate and poor quality of sanitation, HAZ decreases by 0.39 SD and 2.24 SD respectively. In particular, given that children living in household with access to intermediate and poor quality of sanitation have more stunted children, based on the categorization of sanitation quality in Chapter 4 (Table 4.2), households with access to flush to septic tank, flush to pit latrine, pit latrine with slab, and ventilated improved pit latrine are more vulnerable in terms of child health. These toilet facilities can be only considered improved if no toilet facility is available (open defecation) but these facilities do not ensure proper hygienic disposal of human excreta from human contact. If these are not properly managed, they can contribute to child illness. Moreover, the coefficient on intermediate quality falls (moving from column 3 to column 4) but do not lose statistical significance, suggesting that the association is indeed due to intermediate quality categorizing mention before.

Similar results are found in other studies in case of poor and intermediate quality of sanitation. Torlesse et al (2016) found 10.5 % higher stunting among children who came from household with access to unimproved toilet facilities compared with improved facilities (4.3%). Whereas the same study found 8.9 % higher stunting in household that did not dispose of child faeces compared to those that did (3.9%) respectively. In another ecological analysis, Sperars et al (2013) found that a 10 % increase in open defecation account for 0.7 % of mild to severe stunting. Children in rural Lesotho, on average, have

0.27 SD higher HAZ than those who do not use improved sources of sanitation (Daniels et al 1991).

5.4 Channels

Although we find that unimproved water quality and sanitation facilities leads to higher incidence of stunting in children in Pakistan, it is yet to be determined what are the channels through which this effect works. The data in PDHS restricts us explore all channels empirically. Nonetheless, the data on diarrhea is available in PDHS and can be used to empirically examine this channel. Table 5.9 shows regression estimates of quality types of water and sanitation on the incidence of diarrhea in children in the past two week. Models 1 and 3 present results for the cases where controls are not included in the models. On the other hand, Models 2 and 4 show results after controlling for confounding variables.

The results of both high and intermediate quality of water sources do not show association with diarrheal incidence. However, positive and highly statistically significant relationship is found between poor water quality and diarrheal diseases among children under the age of five. Hence, children living in household with access to poor quality of drinking water have higher risk for diarrheal diseases which in turn could lead to stunting as mentioned before in chapter 3.

The results of model 4 including all the control variables are displayed in Table 5.9.

The estimates of high sanitation quality do not show any association with incidence of diarrhea. On the other hand, increasing the intermediate quality of sanitation decreases the incidence of diarrhea and this association is statistically significant. Moreover, the magnitudes of the association between poor quality of sanitation and diarrhea increased after the child, parental and household characteristics are controlled for. This shows higher incidence of diarrhea in children who have access to poor quality of sanitation compared to those who have improved facilities. These results provide suggestive evidence that poor water and sanitation facilities leads to stunting through the channel of incidence of diarrhea. These findings also supports the claim by Checkley et al (2008) that repeated bouts of diarrheal disease due to poor sanitation conditions results in almost 24% stunting in children at the age of 2 years.

Table 5.9: Diarrhea and Quality Types of Water and Sanitation

	Water Quality		**Sanitation Quality**	
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**
High	0.020	0.018	-0.016	-0.015
	(0.032)	(0.032)	(0.019)	(0.021)
Intermediate	0.027	0.024	-0.091***	-0 .078***
	(0.027)	(0.028)	(0.029)	(0.030)
Poor	0.194***	0.471***	0.235***	0.508***
	(0.026)	(0.054)	(0.017)	(0.049)
Controls	No	Yes	No	Yes
Adj. R Squared	0.0003	0.034	0.002	0.035
Observation	3070	3070	3070	3070

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
Models 2 and 4 control for child age and sex, mother's age, education and employment status, father's education, and household size and urban and rural residence.

Nonetheless, this may not be the only channel. There is also a possibility that these children may have also been exposed to a variety of negative environmental risks other than the unhealthy water sources and sanitation facilities inside the house. For example as mention earlier in Chapter 3, there is a high risk of exposure to environmental pathogen in early age. These pathogens have potential to affect children's nutritional status by decreasing their appetite, reducing absorption of healthy nutrients and also increase nutrients losses. Unfortunately, the unavailability of data on these factors in PDHS (2012-13) prevents us from empirically verification of the other channels.

Chapter 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

This paper employs propensity score matching to examine the impact of availability of improved water and sanitation facilities on stunting in children under the age of five in Pakistan. Children's health status is measured by the height-for-age Z score (HAZ) according to international growth standards. Children who have HAZ score below -2 standard deviations (SD) are considered as stunted. Moreover, households are classified into "improved" and "unimproved" groups; i.e. treatment status is defined as children living in household with access to improved water and sanitation facilities and otherwise. After analysing various characteristics, the estimates of regression coefficients for treatment variables indicates positive and significant results which prove that improved water and sanitation facilities is associated with higher HAZ.

To control for potential biases and to establish a causal relationship between water and sanitation facilities and children's health, we also used the propensity score matching (PSM) method. The ATT estimates of children who have access to both improved water sources and sanitation facilities are statistically significant in almost all the matching methods, thereby confirming the robustness of these results. This indicates that water and sanitation facilities play an important role in improving the health of children in the long run. Furthermore, children living in household with access to poor quality of drinking water and sanitation facilities are mostly confined to higher risk of childhood stunting.

Moreover, Diarrhea incidences of past two weeks are used to examine the channel through which unimproved water and sanitation quality lead to higher incidence of stunting in children in Pakistan. The association between poor quality drinking water sources and sanitation facilities is found to have a statistically significant and positive association with the incidence of diarrhea. Overall, the results show highly protective effects of improved water and sanitation facilities against childhood stunting. Hence, improved water and sanitation facilities can bring significant gains in tackling stunting in children less than five years of age. More importantly, the evaluation of the joint effect of water and sanitation quality on child growth further compliment the findings of the study done by Sedgh et al (2000). Access to improved water and sanitation will enable government to achieve the targets of MDGS four and seven in improving child health.

6.2 Policy Recommendation

In the line with research findings regarding the impact of improved water and sanitation facilities on child health, some important recommendations preferred are as under:

1. The nutrition specific interventions at present require a border framework other than better nutritional needs of young children. For example, it should also take into consideration the environmental factors such as water quality and sanitation facilities for the intervention to be effective in the fight against stunting.
2. Government should ensure the provision of at least intermediate quality of water facilities to those who cannot afford. It will significantly affect the physical growth of the children. Improving water quality alone cannot eliminate stunting;

however, it does have the potential to significantly reduce the process stunting in children.

3. Awareness programs should be introduced among the residents about good hygiene practices and the improvement program should aim to improve the disposal and toilet facilities. People should be educated on the aspects of improved hygiene (toilets in particular) at both households and community level in order to reduce stunting or chronic malnutrition. This can only be done by devising interventions to cater for these important aspects.
4. There is a dire need to have a research on interventions regarding integrated effects of water sources, sanitation facilities, and hygiene and devise a mechanism to reduce stunting in Pakistan
5. Government should also use electronic media as a source to enhance awareness about the potential risks of childhood stunting and role of water and sanitation as its contributing factors.

6.3 Limitation and Future Work

There are certain limitations in this study which should be considered the potential directions in which this research could be extended in the future. First, while we have examined the impact of water quality and sanitation facilities, we could not cover other hygenic practices such as treatment of drinking water (e.g. boiling the water etc.) and hand wash. These are important factors and should be explored in the future research. Second, data limitations allowed us to examine only one potential channel (i.e. Diarrhea). Other channels could not be empirically verified. This is another important avenue for future work regarding environment and health.

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