

# Sanitation Ladder and Undernutrition Among Under-Five Children in Pakistan

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## Research Article

**Keywords:** Inadequate sanitation, Improved sanitation, Under-five children, Stunting, Underweight

**Posted Date:** February 9th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-197816/v1>

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**Version of Record:** A version of this preprint was published at Environmental Science and Pollution Research on March 19th, 2021. See the published version at <https://doi.org/10.1007/s11356-021-13492-7>.

# Abstract

While the state of sanitation in Pakistan has improved in the last decade, a significant proportion of its population is still using inadequate sanitation or no toilet facility at all. Open defecation has decreased over the years; however, it has been replaced by poor quality sanitation in rural areas that might still cause diarrhoea and undernutrition. The research regarding inadequate sanitation in Pakistan, especially in terms of the sanitation ladder, remains limited. The present research thus fills this research gap by assessing the impact of different types of sanitation on the prevalence of stunting and underweight (moderate as well as severe) among under-five children in Pakistan using the nationally representative micro survey, Pakistan Demographic and Health Survey (2017-18). The sanitation ladder comprises of Piped to Sewer (highest level, base) followed by Flush to Septic Tank, Flush to Pit Latrine, Other Improved, Unimproved Sanitation, and Open Defecation. In order to estimate the adjusted and unadjusted odds ratios of the determinants, this research uses logistic regressions are used to estimate adjusted and unadjusted odds ratios of the determinants. We show that toilets connected to piped sewerage network are rare in the rural areas of Pakistan and a large segment of the rural population is still practicing open defecation. The logistic regressions show that piped sewerage network and flush to septic tanks are associated with lowest odds (both adjusted and unadjusted) of stunting and underweight among under-five children. In multivariate regressions, pit latrines are associated with even higher adjusted odds of severe and moderate and severe stunting as well as underweight among under-five children, showing that poor quality pit latrines may bring the source of faecal contamination to the doorstep of the households. Therefore, interventions targeting reduction in open defecation should promote good quality toilets for sustainable long-term improvements in child health.

## Introduction

Sanitation is defined as access to and use of services and facilities for the safe disposal of human waste (WHO, 2019). An improved sanitation system enables human excreta to be isolated from human contact, starting with toilets and containment, through conveyance, to treatment, and subsequent safe-end use or disposal. The importance of ensuring proper sanitation may be fathomed by its inclusion in the 2030 agenda for Sustainable Development Goals (SDGs), of which the sixth target aims to facilitate everyone in terms of sufficient and equitable water, sanitation, and hygiene. In pursuit of the goals set by the UN, the developing countries started investing in sanitation infrastructure; the eradication of open defecation has especially been in focus since the last decade. Open defecation is considered the poorest form of sanitation in which human excreta is left in the open causing several health hazards. Despite considerable efforts being made in favour of the agenda, the progress in providing universal access to safe sanitation remains meagre in most of the developing countries. Currently, only 3.4 billion people have access to safely managed sanitation, about 2.2 billion use basic sanitation, 673 million use open defecation, and the remaining either use limited or unimproved sanitation (WHO & UNICEF, 2017).

Inadequate water, sanitation, and hygiene are directly correlated with public health, having implications in the form of infectious diseases like diarrhoea and other problems such as malnutrition in terms of

stunting (Cumming & Cairncross, 2016). Approximately 500,000, 280,000, and 300,000 mortalities around the world are associated with poor water, sanitation, and hygiene, respectively (Prüss-Ustün et al., 2014). Additionally, frequent episodes of diarrhoeal infections also make children more vulnerable to malnutrition, 16 percent of the burden of which is associated with poor water, sanitation, and hygiene (Cumming & Cairncross, 2016; Prüss-Ustün et al., 2019). Poor sanitation has emerged as a widespread health concern among children in the developing countries, especially those under five years of age. Eradication of open defecation is therefore expected to improve health outcomes. The impact of reducing open defecation, however, depends on the technology of toilets that are used to replace open defecation. Most of the schemes aiming at reducing open defecation usually construct (or recommend) unlined pit latrines inside the dwellings to switch from open defecation, for example simple pit latrines were constructed under Swachh Bharat program for eradication of open defecation in India. Since a large proportion of rural households use shallow handpumps in developing countries, there is a risk of faecal-oral contamination from pit latrines to handpumps. Additionally, in the absence of proper sewerage systems the health risks are high.

Even though malnutrition is a worldwide concern, South Asia bears an unfair burden of the problem. It annually impacts nearly 165 million children under five years of age and causes 13 million mortalities around the world (Chowdhury et al., 2018; Müller & Krawinkel, 2005), 50 percent of which occur in South Asia alone (Black et al., 2013). In addition to that, the South Asian region hosts at least 29 percent of the underweight and 31.7 percent of the stunted children under 5 years of age around the world (Kumar et al., 2019; WHO et al., 2020).

In Pakistan, even though the sanitation facilities have improved by 20 percent points between 2013 to 2018, 30 percent of households still remain with either a shared, unimproved, or no toilet facility at all (NIPS, 2019). The neglected sanitation sector in Pakistan translates into adverse health-related outcomes. For instance, Pakistan has the second-highest proportion of stunted children, third-highest rate of diarrhoea, and the second-highest rate of mortality due to diarrhoea in Central Asia. These problems are likely to be correlated with Pakistan's overwhelming rate of inadequate sanitation of 19.5 percent, which is comparable to that of Bangladesh, a poverty-stricken country, and Afghanistan, a war-torn nation (WHO & UNICEF, 2017). Efforts have been made in the country through the grants and support of international organisations such as the World Bank, Asia Development Bank, and UNICEF; however, in most cases open defecation is replaced with simple low-quality and low-cost pit latrines constructed by the households themselves. It remains unclear whether eradication of open defecation is beneficial for health when the alternative is of poor quality. Therefore, in this research, we estimate the likelihood of stunting and underweight associated with a sanitation ladder among under-five children in Pakistan. The sanitation ladder comprises of Piped to Sewer (highest level, base) followed by Flush to Septic Tank, Flush to Pit Latrine, Other Improved, Unimproved Sanitation, and Open Defecation. This research uses the nationally representative household survey, Pakistan Demographic and Health Survey (2017-18), to conduct the analysis. Adjusted and unadjusted odds ratios are calculated to estimate the relationship of different sanitation types with stunting and underweight (severe and moderate and severe). The results of the logistic regressions show that piped sewerage network and flush to septic tanks are associated with

the lowest odds (both adjusted and unadjusted) of stunting and underweight among under-five children. In multivariate regressions, pit latrines are associated with even higher adjusted odds of severe and moderate and severe stunting and underweight among under-five children, showing that poor quality pit latrines may bring the source of faecal contamination to the doorstep of the households. Among other WASH variables, improved water does not have a significant relationship with stunting or underweight; however, the absence of handwashing facility is strongly correlated with higher stunting and underweight prevalence. In addition to that, water treatment is also associated with lower odds of stunting and underweight, except for severe underweight.

This study is henceforth divided into the following sections. The second section provides the literature review, the third section explains the data, the fourth section outlines the methodology, the fifth section provides the results, the sixth section discusses the results, and the final section concludes the paper.

## Literature Review

### *WASH and Undernutrition*

Malnutrition has emerged as a primary public health concern today. It may become the cause of childhood mortality or lead to some detrimental long-term morbidities, especially if a child is undernourished in the first 1000 days post conception. This period is crucial for an infant as the body is rapidly setting up the pre-requisites for brain development and future growth. Any interruption at this stage, such as that from undernutrition or malnutrition, thus leads to irreversible damage in the later years (Smith & Haddad, 2015). This may occur in the form of short adult stature, reduced lean body mass, below potential school performance, lower worker capacity and productivity, lower earnings, and reduced intellectual functioning. Additionally, malnourished children are also more vulnerable to problems such as being overweight upon growing up, and chronically suffering from associated diseases like diabetes, cancer, and cardiovascular disease (Aguayo et al., 2014; Black et al., 2013; Hodinott et al., 2008).

There are various nutritional, socioeconomic, demographic, and environmental, factors that contribute towards malnutrition. The primary nutritional factors associated with malnutrition comprise poor and exclusive breastfeeding, inadequate intake of complementary and diversified diet, and a lack of nutritional knowledge. Certain socioeconomic determinants such as the family income status, food security, and parent's education level also play an important role in determining the prevalence of malnutrition among children (Adhikari et al., 2017; Chowdhury et al., 2018; Guerrant et al., 2013; Sand et al., 2018). Maternal characteristics such as the level of mother's education and mother's body mass index has especially been highlighted throughout the literature as one of the most significant factors causing malnutrition among children under five years of age (Adekanmbi et al., 2013).

Water, sanitation, and hygiene (WASH) have lately been recognised as the most important determinants of undernutrition in addition to inadequate food intake. There exists an intricate relationship among malnutrition, intestinal parasitic infections, and sanitation. Inadequate sanitation makes individuals more vulnerable to malnutrition through intestinal parasitic infections. It promotes the presence of various

pathogens that are usually found in faeces and disseminated via a faecal-oral pathway that can cause malnutrition (Schaible & Kaufmann, 2007). Open defecation is prevalent among individuals in marginalised areas; a practice that strongly correlates with malnutrition and stunted growth in children. It is thus a strong predictor of stunting among children in India, a country where as many as 624 million people engage in open defecation (Dewey & Mayers, 2011). The provision of proper WASH facilities has the potential to alleviate child mortality by 14 percent to 31 percent (Adhikari et al., 2017). Such environmental factors are particularly important during the first two years after conception as the process of stunting is concentrated in this time period (Cumming & Cairncross, 2016).

Throughout the literature, water, sanitation, and hygiene (WASH) feature at different levels with varying degrees of association with undernutrition. While they appear as primary risk factors in some studies, they appear as secondary causes of stunting and malnutrition in others. For instance, different elements of WASH have been associated with the four components of the food and nutrition security framework: food 'availability' via water as a major agricultural production resource, food 'access' through family income separated from food by the cost of acquiring water and ensuring proper sanitation, food 'stability' with regard to the ability of treating a WASH-related infection or the associated inability to earn income, and food 'utilisation' through the impact of WASH-related intestinal diseases on the body's ability to consume nutrients (Cumming & Cairncross, 2016). Similarly, Ali (2019) and Ali and Shah (2020) studied the determinants of child stunting in Pakistan and showed that adequate food, care, health, and environment, as well as their interactions, are important determinants of childhood stunting. These studies especially highlight that environment (proxied by WASH access) is not only an important determinant of stunting alone, it also significantly moderates the relationship of other determinants with stunting.

Inadequate sanitation also leads to diarrhoea (Ali et al., 2021). From early childhood, diarrhoeal diseases are especially associated with the prevalence of undernutrition worldwide. The protein-energy malnourishment caused by diarrhoeal diseases transpires in the form of lower nutrient absorption, decreased food intake due to anorexia, enhanced metabolic requirements, and direct nutrient losses (Müller & Krawinkel, 2005). Such acute enteric infections, especially during early childhood, become the primary cause of mortality among children under 5 years of age, caused partly because of undernutrition (Guerrant et al., 2013).

### ***Other Determinants of Undernutrition***

Explaining the relationship between child's age and stunting, Khan et al., (2019) show that children are more likely to be stunted as they grow older. Similarly, Ishaque et al., (2020) conclude that older children have lower height-for-age Z-scores in Pakistan and they are more likely to be moderately or severely stunted than younger children. It is thus pertinent to ensure suitable and timely commencement of supplementary feeding programmes that adhere to the growing nutritional requirements of a child (Khan et al., 2019). On the contrary, with a comprehensive literary analysis comprising 28 papers focusing on malnutrition among children in Pakistan, Asim & Nawaz, (2018) determine that children less than two

years of age are at a higher risk of stunting, because of an insufficient dietary intake and thus poor health (Asim & Nawaz, 2018). Investigating the socioeconomic and demographic factors linked to underweight and severely underweight children in Bangladesh, one research asserts that children under 5 months of age are the least vulnerable to being underweight, as they are being breastfed and gaining all of the essential nutrients. The possibility of children being underweight, however, increases with age, with those between 24 to 35 months of age the most vulnerable. This may be because children of those ages begin consuming complementary food along with breast milk, which is more likely to be contaminated and promote infectious diseases among them (Chowdhury et al., 2018).

Mother age is an important determinant of malnourished children. Investigating the factors associated with underweight children in Northwest Ethiopia, one study observes that children of mothers over 35 years of age are less likely to be underweight. Its justification follows that younger women, being less experienced in caretaking, naturally engage in behaviours that are not entirely adequate and/or hygienic for infants (Ghosh-Jerath et al., 2017; Nigatu et al., 2018). Additionally, since adolescent mothers require a higher amount of the nutrients and energy that adhere to their growth and development, pregnancy during these years may slow down their own growth, which may in turn lead to the birth of an underweight infant (Nigatu et al., 2018).

The level of a mother's education is also recognised as one of the most important determinants of malnourishment among children. Since educated mothers are better aware about the dietary and health requirements of their children, they ensure adequate hygiene and sanitation facilities – the two components that have a well-established nexus with malnourishment. Children of mothers with no formal education are thus more vulnerable to acute malnourishment, a state of being underweight, than those of mothers with some formal education. Educated mothers additionally choose to rely on the available health services over traditional practices, ensuring better healthcare and thus proper physical and mental growth and development of their children (Chowdhury et al., 2018; Ishaque et al., 2020; Khan et al., 2019).

## Data

The National Institute of Population Studies (NIPS), along with Ministry of National Health Services, Regulations, and Coordination, implemented the 2017-18 Pakistan Demographic and Health Survey (PDHS). PDHS 2017-18 used stratified sampling laid out in two stages. In the initial stage, a probability proportional to the primary sampling unit (PSU) size was established, through which the PSUs were selected. This was followed by a second stage where a specified number of households (28) were selected randomly from the clusters through equal probability systematic sampling procedure. To collect the representative data, the eight regions of Pakistan (Punjab, Sindh, Baluchistan, Khyber Pakhtunkhwa, Gilgit Baltistan, Islamabad Capital Territory, Gilgit Baltistan, and Federally Administered Tribal Areas) were divided into two areas each, namely urban and rural; hence a total of 16 sampling strata were created. PDHS 2017-18 included 12,338 households from Pakistan in their sample set, from which the survey ascertained a 96 percent response rate (11,869 households). Complete information for anthropometric

measures is available for a total of 3,622 children. In multivariate regression analysis, 2,483 valid observations remained for stunting and 2,560 for the analysis of underweight children.

## Dependent Variables

Moderate and severe stunting and underweight are defined as height-for-age and weight-for-age Z-scores less than minus two standard deviations from the median of the reference population, respectively. Severe undernutrition refers to a Z-score less than minus three standard deviation from the median of the reference population. Height-for-age is thus used as a measure for linear growth and cumulative growth deficits and weight-for-age as a composite index for weight-for-height and height-for-age, representing both types of undernutrition – acute and chronic.

## Explanatory Variables

The following set of WASH-related variables are included in the analysis; if water was treated before drinking, Yes = 1; if distance to the water source is less than 30 minutes from the house, Yes = 1; Drinking water facility: Piped water (reference), Tube well/bore, other improved and unimproved water; handwashing facility with soap (reference), handwashing facility without soap or water, handwashing facility with water and no facility; and sanitation ladder: Piped to Sewer (highest level, reference) Flush to Septic Tank, Flush to Pit Latrine, Other Improved (flush to somewhere else, pit latrine without slab, bucket toilet, hanging toilet), other improved sanitation (flush to don't know where, ventilated improved pit latrine, pit latrine with slab, composting toilet), and Open Defecation.

Other variables included in the regression analysis include household is situated in a rural area, Yes = 1; household belong to the bottom 40% of the wealth distribution (B40), Yes = 1; Yes = 1, Gender of the child, Male =1, child was born by Caesarean Delivery, Yes = 1; Birth was in a medical/health facility, Yes = 1; Birth was assisted by a trained professional, Yes = 1; Child had postnatal check within 2 months of birth, Yes = 1; Child had four or more prenatal checks, Yes = 1 and child had diarrhea in last two weeks, Yes = 1. The variable of under-five years old children consists of the number of children who are under the age of five that live in each household. The variable is divided into the following categories: <6 Months, 6-11 Months, 12-23 Months, 24-35 Months, 36-47 Months, and 48-59 months (reference). For the characteristics of the mother, we divide mother age into seven categories, ranging from 15 to 49, divided on increments of four. Education level of mother is categorized into no education, primary, middle, secondary, and higher education. Mother's empowerment is measure as the decision-making power of mothers with reference to their health. The mothers are asked about their role in making decisions pertaining to their healthcare, providing them with the following options: you, your husband, both jointly, or someone else. If a health decision is made either by women alone or jointly by her and her husband, mother empowerment variable equals 1.

## Methodology

Logistic regression method is used to estimate the coefficient of the following econometric model:

$$\begin{aligned}
 \text{logit}(Y_0) &= \ln \left( \frac{P}{1-P} \right) \\
 &= \beta_0 + \beta_1 \text{Gender of Child}_i + \beta_2 \text{Child Age}_i + \beta_3 \text{Had Diarrhea Recently}_i \\
 &+ \beta_4 \text{Mother's Age}_i + \beta_5 \text{Mother Education}_i + \beta_6 \text{Mother is Empowered}_i \\
 &+ \beta_7 \text{Mother's Access to Media}_i + \beta_8 \text{Caesarean Delivery}_i \\
 &+ \beta_9 \text{Birth in a medical facility}_i \\
 &+ \beta_{10} \text{Birth Assisted by a Trained Professional}_i + \beta_{11} \text{Post Natal checkup}_i \\
 &+ \beta_{12} \text{Prenatal checkup}_i + \beta_{13} \text{Distance to Water Source}_i \\
 &+ \beta_{14} \text{Water Treatment}_i + \beta_{15} \text{Drinking Water Source}_i \\
 &+ \beta_{16} \text{Sanitation Ladder}_i + \beta_{17} \text{Handwashing}_i \\
 &+ \beta_{18} \text{Number of Under - five children}_i + \beta_{19} \text{Rural}_i + \beta_{14} \text{Region}_i \\
 &+ \beta_{20} B40_i + \epsilon_t - - - - (1)
 \end{aligned}$$

Where,  $Y_0$  represents stunting and underweight and rest of the variables are explained in the data section above. The estimations were carried out in Stata version 14.1. Regressions are tested for multicollinearity using Variance Inflation Factors. All regressions had VIF scores less than 10 indicating the absence of multicollinearity in the model.

## Results

### *Descriptive Statistics*

Before presenting the regression results, we present the prevalence of moderate and severe stunting (HAZ <-2SD) and severe stunting (HAZ <-3SD) in Figure 1. Figure 1 shows that, in Pakistan, about 37% children under five years of age are moderately or severely stunted. The prevalence of stunting in rural areas is about nine percentage points higher than that in urban areas (40% vs 31%, Chi-Sq = 38.8, p-value = 0.00). Similarly, poor households bear a significantly higher burden of stunting than the rich households in Pakistan. In the bottom two wealth quintiles (bottom 40% of the wealth distribution), the prevalence of stunting in under five children is about twice as high as the top 60% of the wealth distribution (50% vs 28%, Chi-Sq = 188, p-value = 0.00). Figure 1 also presents the prevalence of severe stunting (HAZ <-3SD) in under-five children in Pakistan. About 17% under-five children are severely stunted. Rural-urban and poor-rich disparities are also present in the prevalence of severe stunting. In rural areas, prevalence of severe stunting in children under-five is seven percentage points higher than the children in urban areas (19% vs 12%, Chi-Sq = 50.3, p-value = 0.00). Similarly, bottom 40% of the wealth distribution bear more

than 2.5 times the burden of severe stunting than the top 60% of the wealth distribution (27% vs 10%, Chi-Sq = 196, p-value = 0.00).

The prevalence of underweight children in Pakistan is presented in Figure 2. About 23% of the children under-five are moderately or severely underweight (WAZ <-2SD) in Pakistan. Rural-urban disparity is also prevalent in the distribution of underweight children. In rural areas, the percentage of underweight children is about five percentage points more than that of urban areas (24% vs 19%, Chi-Sq = 25.9, p-value = 0.00). Similarly, the prevalence of moderate to severe underweight in bottom 40% of the wealth distribution is more than twice as high as those in top 60% of the wealth distribution (34% vs 14%, Chi-Sq = 196, p-value = 0.00). Figure 2 also shows that about 8% of the under-five children in Pakistan are severely underweight (WAZ <-3SD). Like the case of moderate and severe underweight, rural-urban disparity exists in the prevalence of severely underweight children where the percentage of severely underweight children in rural areas is about three percentage points higher than those in urban areas (9% vs 6%, Chi-Sq = 11.7, p-value = 0.00). Moreover, the bottom 40% of the wealth distribution bears about four times a higher burden of severely underweight children than the top 60% of the wealth distribution (14% vs 3%, Chi-Sq = 137, p-value = 0.00).

In Pakistan, about 78% of the households have access to improved sanitation including piped to sewer, flush to septic tanks, flush to pit latrine and other improved (Figure 3). Within the improved category, about 26% of the households have access to toilet connected to piped sewerage network, 30% use flush toilet connected to septic tanks, and 18% use flush toilets connected to pit latrines. About 14% of the households practice open defecation in Pakistan and about 8% use other types of unimproved types of sanitation such as pit latrines without slab, bucket latrine, and hanging toilet. The access to improved toilet types is significantly higher in urban areas than that in rural areas. About 95% of the households use improved sanitation in urban areas as compared to 70% in rural areas (Chi-Sq = 901, p-value = 0.00). In rural areas, only 9% of the households have access to piped sewerage network whereas 63% of the households in urban areas use toilet system connected to piped sewerage network (Chi-Sq = 1.8e+03, p-value = 0.00).

Sanitation access also varies significantly by wealth. About 97% of the households in top 60% of the wealth distribution use improved sanitation whereas, only 54% of the bottom 40% households use improved sanitation (Chi-Sq = 2.3e+03, p-value = 0.00). Out of those who use improved sanitation in poor households, only 6% have toilets connected to piped sewerage network while septic tanks and pit latrines dominate the improved sanitation category.

Open defecation is predominantly prevalent in rural areas and among poor households. About 32% of the households in bottom 40% of the wealth distribution practice open defecation as compared to 0% in richer wealth quintiles. Similarly, 20% of the households in rural areas practice open defecation as compared to 1% in urban areas.

Descriptive statistics of the variables used in this analysis are presented in Table 1. About 52% of the sample of children are male. Children between the ages of 12 and 23 months dominate the sample (27%)

followed by 24-35 months (20%) and under six months (16%). About 23% children had diarrhoea recently. About 54% of the mothers are aged between 25 and 34 years. Mothers in the age groups 15-24 and 35-49 years correspond to 23% of the sample each. About 70% of the households have less than three under five children living in the house. About 47% of the mothers have access to media. About 18% of the children were born with caesarean delivery method and 66% were born in a medical facility. About 26% of the children had post-natal check-ups after 2 months of birth and 49% of the mothers had at least four prenatal check-ups. About 44% of the mothers were empowered to take their own health decisions jointly or alone. Under WASH variables, 90% of the households have drinking water source within 30 minutes from the dwelling and about 10% of the households apply any type of treatment method to water before drinking. About 38% of the households use piped water for drinking and 40% use ground water through bore system. About 14% use unimproved water for drinking. Only 9.6% households apply any type of treatment method to water before drinking. To cover household's hygiene behaviour, types of handwashing facilities are used as one of the determinants of undernutrition. About 63% of the households have access to handwashing facility with water and soap, 24% have handwashing facility with water, and 10% have handwashing facility without soap or water.

#### Table 1: Descriptive Statistics

| <b>Variables</b>                | <b>Percent</b> |
|---------------------------------|----------------|
| Stunting                        |                |
| Moderate and Severe (HAZ <-2SD) | 37.6           |
| Severe (HAZ <-3SD)              | 17.2           |
| Underweight                     |                |
| Moderate and Severe (WAZ <-2SD) | 22.7           |
| Severe (WAZ <-3SD)              | 8.2            |
| Male child                      | 51.9           |
| Child Age                       |                |
| <6 Months                       | 16.0           |
| 6-11 Months                     | 14.0           |
| 12-23 Months                    | 26.6           |
| 24-35 Months                    | 19.8           |
| 36-47 Months                    | 13.5           |
| 48-59 Months                    | 10.1           |
| Child had diarrhea recently     | 22.7           |
| Source of Drinking Water        |                |
| Unimproved                      | 14.3           |
| Piped Water                     | 37.7           |
| Tube Wel/Bore                   | 40.2           |
| Other Improved                  | 7.8            |
| Toilet Type                     |                |
| Piped to Sewer                  | 26.1           |
| Flush to Septic Tank            | 30.5           |
| Flush to Pit Latrine            | 18.2           |
| Other Improved                  | 3.78           |
| Unimproved Sanitation           | 7.5            |
| Open Defecation                 | 13.9           |
| Handwashing Facility            |                |

|   |      |
|---|------|
| No Facility                                 | 2.7  |
| Handwashing facility without soap or water  | 10.3 |
| Handwashing facility with water             | 23.7 |
| handwashing facility with soap and water    | 63.4 |
| Rural                                       | 54.6 |
| Bottom 40%                                  | 42.7 |
| Water source at less than 30 min            | 89.8 |
| Any water treatment for drinking            | 9.6  |
| Mother has Access to TV, Radio or Newspaper | 47.0 |
| Mother's Age                                |      |
| 15-24 Years                                 | 23.2 |
| 25-34                                       | 54.1 |
| 35-49                                       | 22.7 |
| Mother is empowered                         | 43.8 |
| Caesarean Delivery                          | 18.0 |
| Birth at Medical Facility                   | 65.5 |
| Assisted Birth                              | 91.3 |
| Post Natal Check within 2 Months            | 25.9 |
| At least 4 Prenatal Visits                  | 48.6 |
| Number of Under 5 Children in the House     |      |
| <3  | 69.5 |
| 3-4   | 23.5 |
| 5+  | 7.1  |

Source: Authors based on PDHS 2017-18 data.

## ***Unadjusted Odds Ratio Analysis***

Our first set of estimations present unadjusted odds ratio for the relationship between sanitation types and undernutrition (stunting and underweight). Table 2 shows that relative to toilets connected to piped sewerage system, the children who practice open defecation are about 1.9 times more likely to be moderately or severely stunting [OR = 2.88\*\*\*, CI = 2.29 – 3.63]. Similarly, children who use unimproved

sanitation are about 1.8 times more likely to be stunted [OR = 2.77\*\*\*, CI = 2.13 – 3.62]. Odds of moderate to severe stunting for those who use flush to septic tanks are same as those who use piped sewerage system implying that septic tanks are as safe as toilets connected to piped sewerage system in terms of the relationship with stunting [OR = 1.05, CI = 0.86 – 1.28]. Similar relationships are observed in case of severe stunting where odds of severe stunting are highest for children who practice open defecation [OR = 3.72\*\*\*, CI = 2.82 – 4.91] followed by Other Improved [OR = 3.33\*\*\*, CI = 2.39 – 4.65], Unimproved sanitation [OR = 3.11\*\*\*, CI = 2.27 – 4.26] and Flush to Pit latrine [OR = 1.84\*\*\*, CI = 1.43 – 2.37]. Odds of Flush to Septic Tanks are statistically insignificant [OR = 0.94, CI = 0.71 – 1.24] showing that the correlation between septic tanks and severe stunting are the same as for piped to sewerage and severe stunting.

Table 2: Sanitation Ladder and Stunting (Unadjusted Odds Ratios of Logistic Regressions)

| Independent Variables                | Moderate and Severe Stunting<br>(HAZ <-2SD) |                          | Severe Stunting<br>(HAZ <-3SD) |                          |
|--------------------------------------|---|--------------------------|--------------------------------|--------------------------|
|                                      | Odds Ratio                                  | 95% Confidence Intervals | Odds Ratio                     | 95% Confidence Intervals |
| Type of toilet (Ref: Piped to Sewer) |   |                          |                                |                          |
| Flush to Septic Tank                 | 1.05  | 0.86 - 1.28              | 0.94                           | 0.71 - 1.24              |
| Flush to Pit Latrine                 | 1.64***                                     | 1.36 - 1.98              | 1.84***                        | 1.43 - 2.37              |
| Other Improved                       | 2.47***                                     | 1.86 - 3.29              | 3.33***                        | 2.39 - 4.65              |
| Unimproved Sanitation                | 2.77***                                     | 2.13 - 3.62              | 3.11***                        | 2.27 - 4.26              |
| Open Defecation                      | 2.88***                                     | 2.29 - 3.63              | 3.72***                        | 2.82 - 4.91              |
| Constant                             | 0.41***                                     | 0.36 - 0.47              | 0.14***                        | 0.11 - 0.17              |
| Observations                         | 3,997                                       |                          | 3,997                          |                          |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively

Unadjusted Odds ratios for the relationship between sanitation ladder and prevalence of underweight (moderate and severe, and severe) are presented in Table 3. Like the case of stunting, the odds of moderate and severe stunting are the highest for open defecation [OR = 3.23\*\*\*, CI = 2.52 – 4.16] relative to pipe to sewerage network, followed by Unimproved [OR = 2.64\*\*\*, CI = 1.98 – 3.52], Other Improved [OR = 2.17\*\*\*, CI = 1.58 – 2.98], and Flush to Pit latrine [OR = 1.85\*\*\*, CI = 1.49 – 2.31]. Similarly, the correlation between open defecation and severe stunting is about four times higher than piped sewer system [OR = 4.97\*\*\*, CI = 3.41 – 7.25]. The odds of open defecation are followed by Unimproved

Sanitation [OR = 3.14\*\*\*, CI = 2.01 – 4.89], Other Improved [OR = 2.30\*\*\*, CI = 1.39 – 3.81], and Flush to Pit latrine [OR = 2.26\*\*\*, CI = 1.57 – 3.25]. Odds of being moderate and severe underweight and severe underweight for children using Flush to Septic Tanks are statistically insignificant [Moderate and Severe Underweight: OR = 0.86, CI = 0.67 – 1.09, Severe Underweight: OR = 0.94, CI = 0.62 – 1.44] i.e., the odds are not different from the children using piped sewerage system.

Table 3: Sanitation Ladder and Underweight (Unadjusted Odds Ratios of Logistic Regressions)

| Independent Variables                | Moderate and Severe Underweight<br>(WAZ <-2SD) |                          | Severe Underweight<br>(WAZ <-3SD) |                          |
|--------------------------------------|--|--------------------------|-----------------------------------|--------------------------|
|                                      | Odds Ratio                                     | 95% Confidence Intervals | Odds Ratio                        | 95% Confidence Intervals |
| Type of toilet (Ref: Piped to Sewer) |  |                          |                                   |                          |
| Flush to Septic Tank                 | 0.86   | 0.67 - 1.09              | 0.94                              | 0.62 - 1.44              |
| Flush to Pit Latrine                 | 1.85***  | 1.49 - 2.31              | 2.26***                           | 1.57 - 3.25              |
| Other Improved                       | 2.17***  | 1.58 - 2.98              | 2.30***                           | 1.39 - 3.81              |
| Unimproved Sanitation                | 2.64***  | 1.98 - 3.52              | 3.14***                           | 2.01 - 4.89              |
| Open Defecation                      | 3.23***  | 2.52 - 4.16              | 4.97***                           | 3.41 - 7.25              |
| Constant                             | 0.19***  | 0.16 - 0.23              | 0.05***                           | 0.04 - 0.07              |
| Observations                         | 4,119  |                          | 4,119                             |                          |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively

## ***Multivariate Regression Analysis: Adjusted Odds Ratios***

The unadjusted odds ratios presented in the previous section are informative, however, there are several confounding variables that may affect the choice of sanitation or undernutrition status. To retrieve the estimates adjusted for the confounding variables, this research estimates the multivariate regressions for moderate and severe, and severe stunting (Table 4), moderate and severe, and severe underweight (Table 5). The first regression in Table 4 shows that after controlling for the child related, mother related, household-related, and region-specific variables, the magnitude of the odds ratios have reduced significantly. The most striking result is that flush to pit latrines is associated with highest odds (AOR = 1.84\*\*, CI = 1.19 – 3.01) of moderate and severe stunting (HAZ <-2SD), even higher than open defecation (AOR = 1.81\*\*, CI= 1.08 – 3.04). the probability of stunting is about 60% higher for those children who use unimproved sanitation (AOR = 1.60\*, CI= 0.99-2.57) than those who use piped sewerage network. Similarly, odds of stunting are 21% higher for those who use other types of improved sanitation (AOR =

1.21\*\*, CI= 0.87 – 2.04) than those who use piped sewerage network. The odds of stunting are not statistically different for children using toilet connected to piped sewerage network and those using flush to septic tank.

Similarly, for severe stunting, flush to pit latrine and unimproved sanitation have higher odds than open defecation (flush to pit latrine AOR = 1.52\*\*, CI= 1.06 – 2.19, unimproved sanitation AOR = 1.88\*\*, CI= 1.21 – 2.90). Children in the households that practice open defecation are about 74% more likely to be severely stunted than those who have access to piped sewerage network (AOR = 1.74\*\*, CI= 1.13 – 2.68). Additionally, households that use other types of improved toilet facilities are 52% more likely to be severely stunted than households that use piped sewerage system (AOR =1.52\*\*, CI= 1.06 – 2.19). The odds of severe stunting are not statistically different for those who use piped sewerage system and those who use flush to septic tanks.

Table 4: Sanitation Ladder and Stunting: Adjusted Odds Ratios of Logistic Regressions

| Dependent Variables                       | Moderate and Severe Stunting (HAZ <-2SD) |                          | Severe Stunting (HAZ <-3SD) |                          |
|---|--|--------------------------|-----------------------------|--------------------------|
|   | Adj Odds Ratio                           | 95% Confidence Intervals | Adj Odds Ratio              | 95% Confidence Intervals |
| Sanitation Facility (Ref: Piped to Sewer) |  |                          |                             |                          |
| Open Defecation                           | 1.81**                                   | 1.08 – 3.04              | 1.74**                      | 1.13 - 2.68              |
| Unimproved Sanitation                     | 1.60*                                    | 0.99 - 2.57              | 1.88***                     | 1.21 - 2.90              |
| Flush to Septic Tank                      | 1.08                                     | 0.72 - 1.62              | 1.29                        | 0.78 - 2.12              |
| Flush to Pit Latrine                      | 1.84**                                   | 1.19 – 3.01              | 2.01***                     | 1.41 - 2.86              |
| Other Improved                            | 1.21**                                   | 0.87 - 2.04              | 1.52**                      | 1.06 - 2.19              |
| Constant                                  | 0.49                                     | 0.18 - 1.31              | 0.28***                     | 0.12 - 0.67              |
| Observations                              | 2,483                                    |                          | 2,483                       |                          |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively. The control variables include Gender of Child, Child Age (Ref: 48-59 months), Child Had Diarrhea Recently, Mother age (Ref: 15-24 Years), Mother Education (Ref: No Education), Mother is empowered to make own health decisions (jointly or alone), At least once per week reads newspaper, listens to radio daily, or watches TV (Yes =1), Caesarean Delivery (Yes = 1), Birth in a medical/health facility (Yes = 1), Birth assisted by trained professional (Yes = 1), Baby postnatal check within 2 months (Yes = 1), Mother had 4 or more prenatal checks (Yes = 1), Distance to water source (≤ 30 minutes =1), Any treatment to make water safe (Yes =1),

Drinking Water Source (Ref: Piped water), Handwashing Facility (Ref: Handwashing facility with soap and water), Number of Under-five Children at home (Ref: <3=1), Urban-Rural Residence (Rural = 1), Region (Ref: Punjab), and Bottom 40% of the wealth distribution = 1.

Similar to the relationship between the sanitation ladder and moderate and severe stunting, the odds of moderate and severe underweight (WAZ <-2SD) are the highest for children living the households that use flush to pit latrine (AOR = 1.70\*\*\*, CI= 1.18 – 2.46), followed by those who practice open defecation (AOR = 1.63\*\*, CI= 1.12 – 2.39) and those who use unimproved sanitation (AOR = 1.51\*, CI= 0.96 – 2.32) or other improved sanitation (AOR = 1.45\*\*, CI= 1.01 – 2.09). The odds of moderate and severe underweight for flush to septic tanks are statistically indifferent from those who use toilet connected to piped sewerage network. The odds of severe underweight (WAZ < -3SD) are the highest for those who practice open defecation (AOR = 1.89\*, CI = 0.98 – 3.66), followed by flush to pit latrine (AOR = 1.86\*\*, CI= 1.04 – 3.31), other improved sanitation (AOR = 1.80\*, CI= 0.99 – 3.28), and unimproved sanitation (AOR = 1.59\*, CI= 1.01 – 3.17).

Table 5: Sanitation Ladder and Underweight: Adjusted Odds Ratios of Logistic Regressions

| Dependent Variables                       | Moderate and Severe Underweight<br>(WAZ <-2SD) |                          | Severe Underweight<br>(WAZ <-3SD) |                          |
|---|--|--------------------------|-----------------------------------|--------------------------|
|   | Adj Odds Ratio                                 | 95% Confidence Intervals | Adj Odds Ratio                    | 95% Confidence Intervals |
| Sanitation Facility (Ref: Piped to Sewer) |  |                          |                                   |                          |
| Open Defecation                           | 1.63**   | 1.12 - 2.39              | 1.89*                             | 0.98 - 3.66              |
| Unimproved Sanitation                     | 1.51*  | 0.96 - 2.32              | 1.59*                             | 1.01 - 3.17              |
| Flush to Septic Tank                      | 1.06   | 0.63 - 1.77              | 0.95                              | 0.42 - 2.12              |
| Flush to Pit Latrine                      | 1.70***  | 1.18 - 2.46              | 1.86**                            | 1.04 - 3.31              |
| Other Improved                            | 1.45**   | 1.01 - 2.09              | 1.80*                             | 0.99 - 3.28              |
| Constant                                  | 0.21***  | 0.10 - 0.45              | 0.04***                           | 0.01 - 0.12              |
| Observations                              | 2,560  |                          | 2,560                             |                          |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively. The control variables include Gender of Child, Child Age (Ref: 48-59 months), Child Had Diarrhea Recently, Mother age (Ref: 15-24 Years), Mother Education (Ref: No Education), Mother is empowered to make own health decisions

(jointly or alone), At least once per week reads newspaper, listens to radio daily, or watches TV (Yes =1), Caesarean Delivery (Yes = 1), Birth in a medical/health facility (Yes = 1), Birth assisted by trained professional (Yes = 1), Baby postnatal check within 2 months (Yes = 1), Mother had 4 or more prenatal checks (Yes = 1), Distance to water source ( $\leq 30$  minutes =1), Any treatment to make water safe (Yes =1), Drinking Water Source (Ref: Piped water), Handwashing Facility (Ref: Handwashing facility with soap and water), Number of Under-five Children at home (Ref:  $<3=1$ ), Urban-Rural Residence (Rural = 1), Region (Ref: Punjab), and Bottom 40% of the wealth distribution = 1.

## Discussion

The stunting rate in Pakistan is among the highest in South Asia. The rural rate of stunting is higher than that of the urban areas, most probably because of high likelihood of ingestion of faecal bacteria in high quantities from human and animal waste (Asim & Nawaz, 2018; Kandala et al., 2011). Practices such as mouthing dirty fingers and household objects cause intestinal infections, which negatively affect the nutritional status of a child. Poor households also bear a significantly higher risk than rich ones most probably because poor households generally have inadequate access to clear water, sanitation, food, and health care services (Ali, 2018; Ali & Shah, 2020). Similarly, underweight children are in significantly higher proportions in rural areas and among poor households, showing that poor socioeconomic conditions contribute towards undernutrition (Chowdhury et al., 2018). High percentages of open defecation in rural areas and among poor households could be one of the reasons why stunting and underweight prevalence are higher in these areas. High rates of unimproved sanitation and low-quality improved sanitation are also likely to be correlated with stunting and underweight. The unadjusted odds ratios for the relationship between types of sanitation and stunting in Table 2 show that the piped to sewerage network and septic tanks are relatively safer forms of sanitation in Pakistan as they are associated with the lowest odds of stunting, both severe and moderate and severe. Children living in the households that practice open defecation are at the highest risk of stunting than other types of sanitation, especially in case of severe stunting. The effect of open defecation is followed by unimproved sanitation in terms of high odds of severe and moderate and severe stunting. Similar findings are reported in Table 3 for severe and moderate and severe underweight. The results show that there is a sort of sanitation ladder that exists in Pakistan as far as the relationship of sanitation with undernutrition is concerned. The lowest step of this ladder is open defecation, followed by unimproved sanitation (flush to somewhere else, pit latrine without slab, bucket toilet, hanging toilet), other improved sanitation (flush to do not know where, ventilated improved pit latrine, pit latrine with slab, composting toilet), flush to pit latrines, and the final ladder can be either flush to septic tanks or piped to sewerage network. The results change slightly when adjusted odds ratios are calculated after accounting for the potential confounding factors. The most striking finding is that pit latrines have higher odds ratios than open defecation for severe stunting, moderate and severe stunting and underweight. It means that even after accounting for confounding factors, pit latrines are at least as harmful for child nutritional status as open defecation. In Pakistan, 15% of rural households use the combination of handpumps/motorized pumps and pit latrines and could be the cause of faecal-oral contamination. It is possible that pit latrines are contaminating the ground water

which is pumped and used for drinking without treatment, as 96% of the households in rural areas do not treat water before drinking. Similar findings are reported in (Mansuri et al., 2018). Therefore, our results show that eradication of open defecation alone is not sufficient because if the sanitation technology that replaces open defecation is not safe, as it is the case with pit latrines, the interventions will bring the source of faecal-oral contamination inside the house, leading to even more health problems than in the case of open defecation.

## Conclusion

In this paper we studied the correlations of sanitation types with undernutrition status in Pakistan using micro data from Pakistan Demographic and Health Survey. Open defecation in Pakistan has been declining over the years, however, typically an open defecation reduction program in Pakistan consists of a comprehensive behaviour change campaign which aims to educate the residents of the target area about potential health risks associated with practicing open defecation and motivates the households to construct toilets from their own budget. The households choose the toilet type based on their affordability. Poor households in rural areas generally opt for unlined pit latrines which can contaminate ground water and cause health risks. The multivariate logistic regression analysis in this study shows that pit latrines might be at least as unsafe as open defecation for child nutrition. Piped to sewer and flush to septic tanks are the safest forms of toilets followed by other types of improved toilets and unimproved toilets. Our results show that programs for the eradication of open defecation should recommend construction of safe toilets and subsidies should be provided to those who cannot afford to construct safe toilets.

## Declarations

- ***Ethics approval and consent to participate***

This study uses Demographic and Health Survey which provides anonymous unit level data. Authors obtained permission from DHS to use their data for this study.

- ***Consent for publication***

Not applicable

- ***Availability of data and materials***

The datasets generated and/or analysed during the current study are available in the Demographic and Health Survey repository, [https://dhsprogram.com/data/dataset/Pakistan\\_Standard-DHS\\_2017.cfm?flag=0](https://dhsprogram.com/data/dataset/Pakistan_Standard-DHS_2017.cfm?flag=0)

- ***Competing interests***

The authors declare that they have no competing interests

- **Funding**

No funding was received for this research.

- **Authors' contributions**

All three authors jointly came up with the concept of the study. AK and KF prepared the first draft of this research including literature review and data analysis. MA revised the manuscript, improved the data analysis and writeup.

- **Acknowledgements**

Authors are grateful to the DHS office for provision of data and faculty members of the department of economics at School of Social Sciences and Humanities, National University of Sciences and Technology, Islamabad during the presentation of this paper in October 2020.

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## **Appendix**

TableA 1: Determinants of Stunting: Adjusted Odds Ratios (Full Model)

| Dependent Variables  | Moderate and Severe Stunting (HAZ <-2SD) |                          | Severe Stunting (HAZ <-3SD) |                          |
|--|--|--------------------------|-----------------------------|--------------------------|
| Independent Variables  | Adj Odds Ratio                           | 95% Confidence Intervals | Adj Odds Ratio              | 95% Confidence Intervals |
| Gender of Child (Male = 1)   | 1.19*                                    | 1.00 - 1.43              | 1.35***                     | 1.08 - 1.70              |
| Child Age (Ref: 48-59 months)  |  |                          |                             |                          |
| <6 Months  | 0.25***                                  | 0.16 - 0.37              | 0.24***                     | 0.14 - 0.40              |
| 6-11 Months  | 0.26***                                  | 0.18 - 0.39              | 0.21***                     | 0.12 - 0.36              |
| 12-23 Months   | 0.65**                                   | 0.47 - 0.91              | 0.55***                     | 0.37 - 0.83              |
| 24-35 Months   | 1.24                                     | 0.89 - 1.72              | 1.13                        | 0.77 - 1.68              |
| 36-47 Months   | 1.44**                                   | 1.01 - 2.04              | 1.22                        | 0.80 - 1.84              |
| Had Diarrhea Recently  | 1.23*                                    | 0.99 - 1.53              | 1.37**                      | 1.05 - 1.79              |
| Mother age (Ref: 15-24 Years)  |  |                          |                             |                          |
| 25-34  | 0.97                                     | 0.77 - 1.23              | 0.73**                      | 0.55 - 0.98              |
| 35-49  | 0.77*                                    | 0.58 - 1.02              | 0.60***                     | 0.42 - 0.85              |
| Mother Education (Ref: No Education)   |  |                          |                             |                          |
| At most Primary  | 0.99                                     | 0.65 - 1.50              | 0.84                        | 0.48 - 1.46              |
| Secondary and above  | 0.63***                                  | 0.49 - 0.80              | 0.68**                      | 0.50 - 0.94              |
| Mother is empowered to make own health decisions (jointly or alone)                    | 0.74***                                  | 0.61 - 0.90              | 0.86                        | 0.67 - 1.11              |
| At least once per week reads newspaper, listens to radio daily, or watches TV (Yes =1) | 1.13                                     | 0.91 - 1.39              | 1.22                        | 0.93 - 1.60              |
| Caesarean Delivery (Yes = 1)   | 0.82                                     | 0.62 - 1.08              | 0.78                        | 0.52 - 1.16              |
| Birth in a medical/health facility (Yes = 1)   | 0.95                                     | 0.75 - 1.21              | 0.81                        | 0.61 - 1.09              |
| Birth assisted by trained professional (Yes = 1)                                       | 1.00                                     | 0.70 - 1.44              | 0.95                        | 0.62 - 1.45              |
| Baby postnatal check within 2 months (Yes = 1)   | 0.91                                     | 0.72 - 1.13              | 1.06                        | 0.79 - 1.41              |
| Had 4 or more prenatal checks (Yes = 1)  | 0.84                                     | 0.68 - 1.04              | 0.78*                       | 0.60 - 1.03              |
| Distance to water source ( $\leq$ 30 minutes =1)                                       | 0.86                                     | 0.62 - 1.18              | 0.78                        | 0.54 - 1.12              |
| Any treatment to make water safe (Yes =1)  | 0.64**                                   | 0.45 - 0.91              | 0.62**                      | 0.38 - 1.00              |

|  |         |             |         |             |
|--|---------|-------------|---------|-------------|
| Drinking Water Source (Ref: Piped water)                             |         |             |         |             |
| Unimproved   | 0.93    | 0.69 - 1.26 | 1.15    | 0.80 - 1.67 |
| Tube Well/Bore   | 1.01    | 0.81 - 1.26 | 1.17    | 0.88 - 1.56 |
| Other Improved   | 0.82    | 0.57 - 1.18 | 0.93    | 0.59 - 1.47 |
| Sanitation Facility (Ref: Piped to Sewer)                            |         |             |         |             |
| Open Defecation  | 1.81**  | 1.08 - 3.04 | 1.74**  | 1.13 - 2.68 |
| Unimproved Sanitation  | 1.60*   | 0.99 - 2.57 | 1.88*** | 1.21 - 2.90 |
| Flush to Septic Tank   | 1.08    | 0.72 - 1.62 | 1.29    | 0.78 - 2.12 |
| Flush to Pit Latrine   | 1.84**  | 1.19 - 3.01 | 2.01*** | 1.41 - 2.86 |
| Other Improved   | 1.21**  | 0.87 - 2.04 | 1.52**  | 1.06 - 2.19 |
| Handwashing Facility (Ref: Handwashing facility with soap and water) |         |             |         |             |
| No Facility  | 1.39    | 0.86 - 2.27 | 1.73*   | 0.99 - 3.01 |
| Handwashing facility without soap or water                           | 1.20    | 0.90 - 1.61 | 1.45**  | 1.03 - 2.04 |
| Handwashing facility with water                                      | 0.88    | 0.68 - 1.14 | 1.15    | 0.84 - 1.56 |
| Number of Under-five Children at home (Ref: <3=1)                    |         |             |         |             |
| 3-4  | 1.48*** | 1.18 - 1.84 | 1.28*   | 0.97 - 1.70 |
| 5+   | 0.85    | 0.58 - 1.24 | 0.92    | 0.58 - 1.48 |
| Urban-Rural Residence (Rural = 1)                                    | 0.90    | 0.72 - 1.12 | 0.88    | 0.66 - 1.16 |
| Region (Ref: Punjab)   |         |             |         |             |
| KPK  | 0.89    | 0.66 - 1.20 | 1.06    | 0.71 - 1.57 |
| Sindh  | 1.87*** | 1.40 - 2.49 | 2.23*** | 1.56 - 3.19 |
| FATA   | 1.26    | 0.88 - 1.82 | 1.99*** | 1.29 - 3.06 |
| Balochistan  | 1.27    | 0.92 - 1.77 | 1.85*** | 1.24 - 2.75 |
| Islamabad  | 0.85    | 0.53 - 1.38 | 0.55    | 0.24 - 1.25 |
| Bottom 40%   | 1.43*** | 1.10 - 1.86 | 1.79*** | 1.27 - 2.50 |
| Constant   | 0.49    | 0.18 - 1.31 | 0.28*** | 0.12 - 0.67 |
| Observations   | 2,483   |             | 2,483   |             |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively

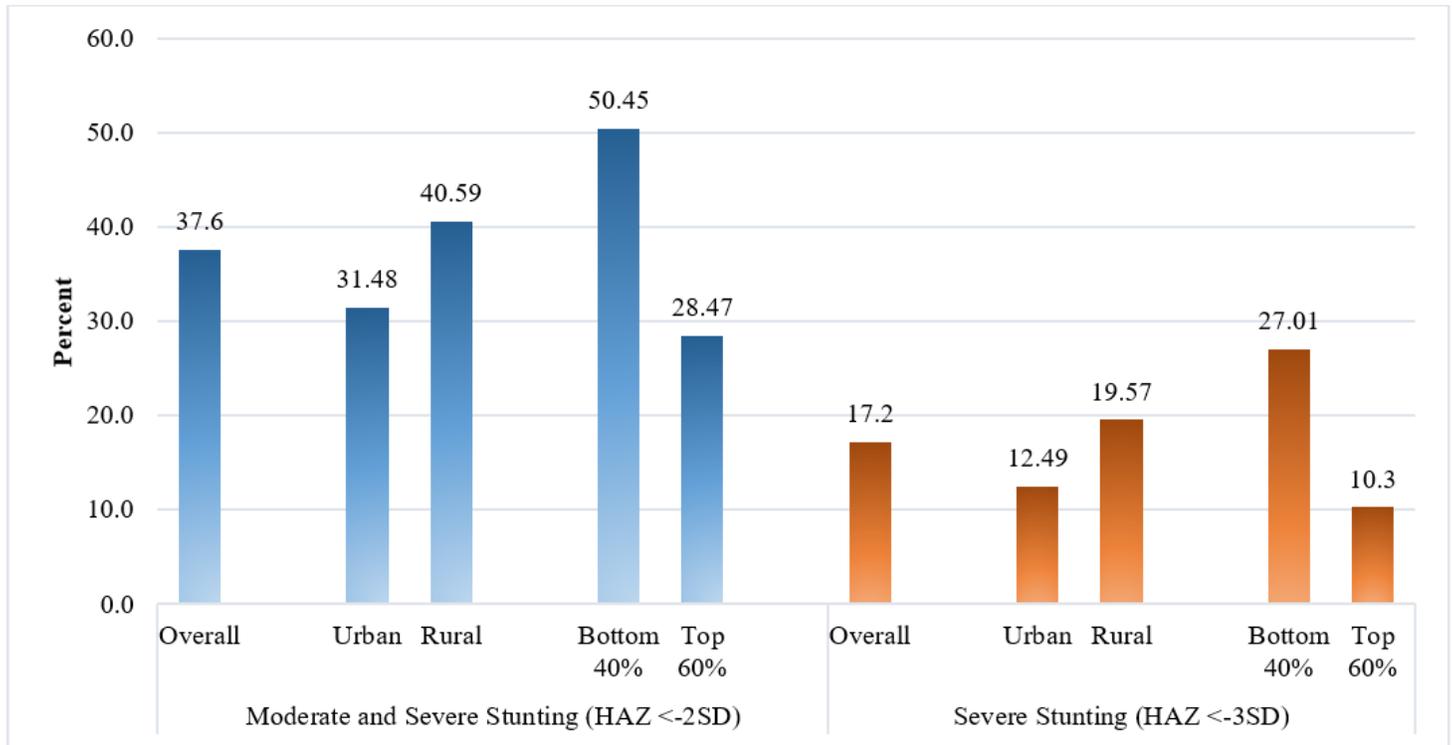
TableA 2: Determinants of Underweight: Adjusted Odds Ratios (Full Model)

| Dependent Variables   | Moderate and Severe Underweight<br>(WAZ <-2SD) |                                | Severe Underweight<br>(WAZ <-3SD) |                                |
|---|--|--------------------------------|-----------------------------------|--------------------------------|
| Independent Variables   | Adj<br>Odds<br>Ratio                           | 95%<br>Confidence<br>Intervals | Adj<br>Odds<br>Ratio              | 95%<br>Confidence<br>Intervals |
| Gender of Child (Male = 1)  | 1.18   | 0.96 - 1.44                    | 1.16                              | 0.86 - 1.56                    |
| Child Age (Ref: 48-59 months)   |  |                                |                                   |                                |
| <6 Months   | 0.57***  | 0.37 - 0.87                    | 0.83                              | 0.45 - 1.55                    |
| 6-11 Months   | 0.51***  | 0.33 - 0.79                    | 0.85                              | 0.46 - 1.57                    |
| 12-23 Months  | 0.53***  | 0.36 - 0.77                    | 0.59*                             | 0.33 - 1.05                    |
| 24-35 Months  | 1.04   | 0.72 - 1.51                    | 1.10                              | 0.63 - 1.90                    |
| 36-47 Months  | 1.04   | 0.70 - 1.55                    | 1.04                              | 0.57 - 1.90                    |
| Had Diarrhea Recently   | 1.45***  | 1.14 - 1.85                    | 1.16                              | 0.82 - 1.65                    |
| Mother age (Ref: 15-24 Years)   |  |                                |                                   |                                |
| 25-34   | 0.96   | 0.74 - 1.25                    | 0.75                              | 0.52 - 1.07                    |
| 35-49   | 0.77   | 0.56 - 1.06                    | 0.53***                           | 0.34 - 0.84                    |
| Mother Education (Ref: No Education)  |  |                                |                                   |                                |
| At most Primary   | 0.89   | 0.54 - 1.45                    | 0.95                              | 0.44 - 2.08                    |
| Secondary and above   | 0.71**   | 0.54 - 0.94                    | 0.84                              | 0.55 - 1.29                    |
| Mother is empowered to make own health decisions (jointly or alone)                     | 0.88   | 0.70 - 1.11                    | 1.01                              | 0.73 - 1.40                    |
| At least once per week reads newspaper, listens to radio daily , or watches TV (Yes =1) | 0.98   | 0.77 - 1.25                    | 0.91                              | 0.64 - 1.30                    |
| Caesarean Delivery (Yes = 1)  | 0.65**   | 0.46 - 0.92                    | 0.55**                            | 0.31 - 0.97                    |
| Birth in a medical/health facility (Yes = 1)  | 0.74**   | 0.57 - 0.96                    | 0.86                              | 0.59 - 1.24                    |
| Birth assisted by trained professional (Yes = 1)  | 0.79   | 0.54 - 1.16                    | 1.02                              | 0.56 - 1.84                    |
| Baby postnatal check within 2 months (Yes = 1)  | 1.01   | 0.79 - 1.31                    | 1.22                              | 0.85 - 1.76                    |
| Had 4 or more prenatal checks (Yes = 1)   | 1.06   | 0.83 - 1.35                    | 0.85                              | 0.59 - 1.21                    |
| Distance to water source ( $\leq$ 30 minutes =1)  | 1.04   | 0.74 - 1.46                    | 0.96                              | 0.62 - 1.49                    |

|  |             |             |             |             |
|--|-------------|-------------|-------------|-------------|
| Any treatment to make water safe (Yes =1)                            | 0.70*       | 0.47 - 1.04 | 0.66        | 0.35 - 1.22 |
| Drinking Water Source (Ref: Piped water)                             |             |             |             |             |
| Unimproved   | 1.15        | 0.82 - 1.60 | 1.42        | 0.89 - 2.27 |
| Tube Well/Bore   | 0.98        | 0.76 - 1.27 | 1.08        | 0.73 - 1.59 |
| Other Improved   | 0.92        | 0.61 - 1.38 | 0.81        | 0.43 - 1.51 |
| Sanitation Facility (Ref: Piped to Sewer)                            |             |             |             |             |
| Open Defecation  | 1.63**      | 1.12 - 2.39 | 1.89*       | 0.98 - 3.66 |
| Unimproved Sanitation  | 1.51*       | 0.96 - 2.39 | 1.59*       | 1.01 - 3.17 |
| Flush to Septic Tank   | 1.06        | 0.63 - 1.77 | 0.95        | 0.42 - 2.12 |
| Flush to Pit Latrine   | 1.70***     | 1.18 - 2.46 | 1.86**      | 1.04 - 3.31 |
| Other Improved   | 1.45**      | 1.01 - 2.09 | 1.80*       | 0.99 - 3.28 |
| Handwashing Facility (Ref: Handwashing facility with soap and water) |             |             |             |             |
| No Facility  | 2.19***     | 1.32 - 3.63 | 1.44        | 0.71 - 2.92 |
| Handwashing facility without soap or water                           | 1.42**      | 1.04 - 1.93 | 1.48*       | 0.97 - 2.28 |
| Handwashing facility with water                                      | 1.25        | 0.94 - 1.65 | 1.23        | 0.82 - 1.86 |
| Number of Under-five Children at home (Ref: <3=1)                    |             |             |             |             |
| 3-4  | 1.28**      | 1.00 - 1.65 | 1.25        | 0.88 - 1.78 |
| 5+   | 1.08        | 0.72 - 1.61 | 0.99        | 0.56 - 1.75 |
| Urban-Rural Residence (Rural = 1)                                    |             |             |             |             |
| 0.89   | 0.69 - 1.15 | 0.73*       | 0.50 - 1.05 |             |
| Region (Ref: Punjab)   |             |             |             |             |
| KPK  | 1.06        | 0.74 - 1.52 | 0.97        | 0.53 - 1.76 |
| Sindh  | 3.92***     | 2.84 - 5.42 | 4.28***     | 2.65 - 6.93 |
| FATA   | 1.07        | 0.71 - 1.62 | 1.71*       | 0.94 - 3.10 |
| Balochistan  | 2.70***     | 1.90 - 3.83 | 3.44***     | 2.07 - 5.74 |
| Islamabad  | 1.02        | 0.55 - 1.89 | 0.78        | 0.23 - 2.64 |
| Bottom 40%   | 1.49***     | 1.11 - 2.01 | 1.88***     | 1.18 - 2.98 |
| Constant   | 0.21***     | 0.10 - 0.45 | 0.04***     | 0.01 - 0.12 |
| Observations   |             |             |             |             |
|  | 2,560       |             | 2,560       |             |

\*, \*\*, \*\*\* indicates significance at the 10%, 5%, and 1% level, respectively

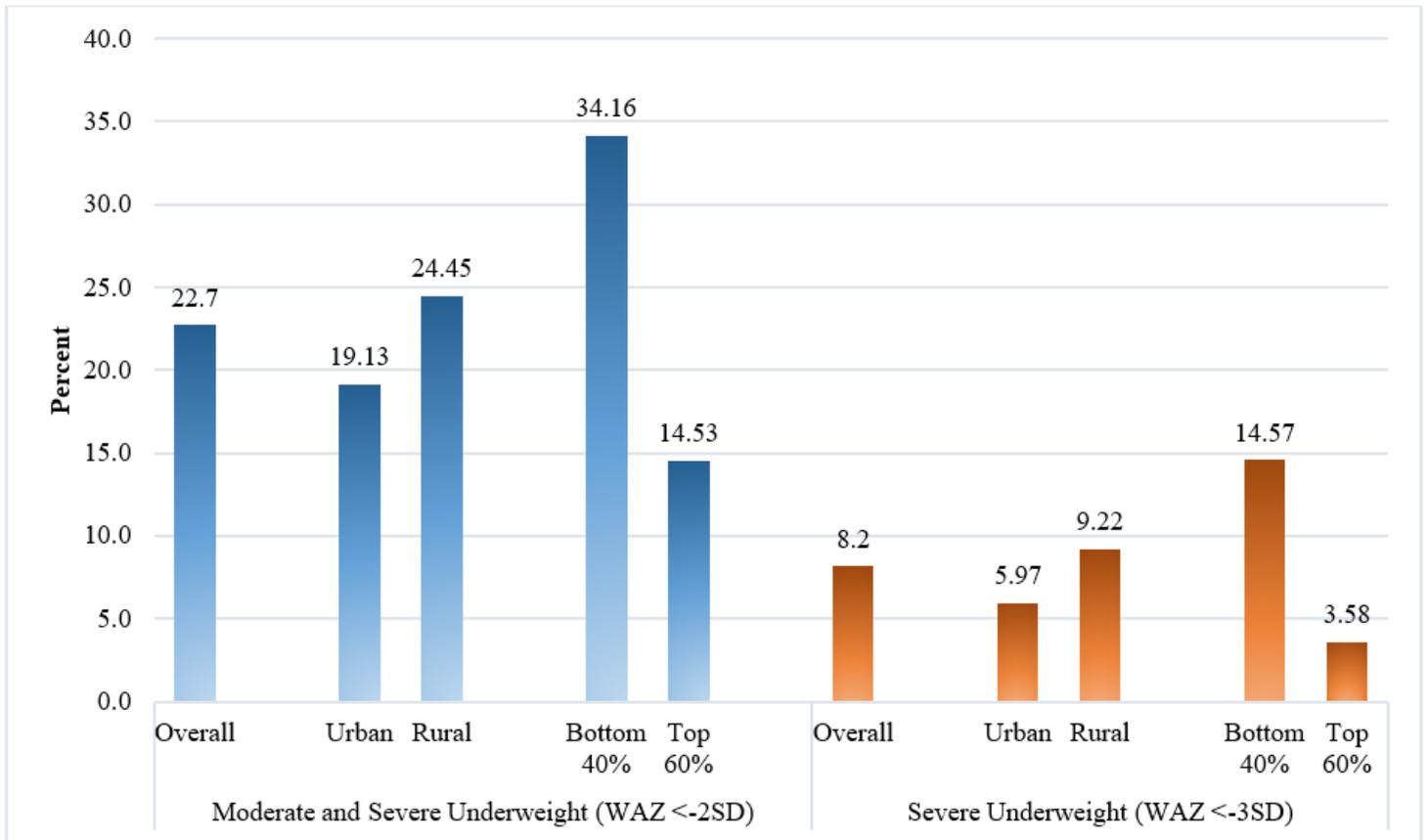
## Figures



Source: Authors based on PDHS 2017-18 data.

### Figure 1

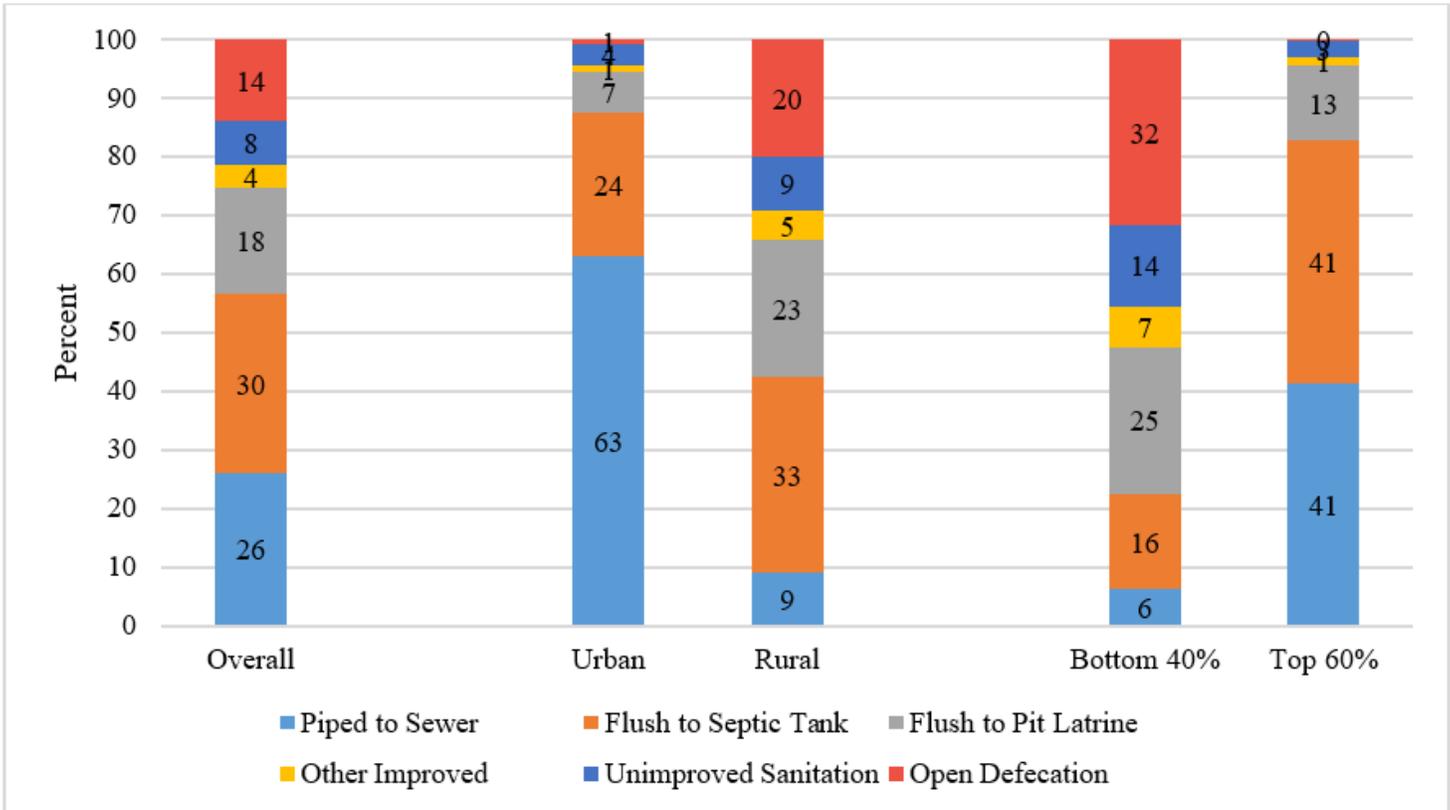
Prevalence of Stunting in Pakistan



Source: Authors based on PDHS 2017-18 data.

## Figure 2

Prevalence of Underweight in Pakistan



Source: Authors based on PDHS 2017-18 data.

**Figure 3**

Access to Sanitation