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Impact of Water, Sanitation and Hygiene Poverty on Child Health in Pakistan: Evidence from Micro Data

Abre-Rehmat Qurat-ul-Ann[1], Syed Badar-ul-Husnain Rizvi[2], Maryam Bibi[3]

[1] Assistant Professor, Department of Economics, University of Gujrat, Pakistan. Email: abre.rehmat@uog.edu.pk
[2] Assistant Professor, Department of Economics, University of Gujrat, Pakistan.
[3] M. Phil. Scholar, Department of Economics, University of Gujrat, Pakistan.

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ABSTRACT

Attainment of SDGs by Pakistan and emphasis on hygiene and sanitation during and after COVID-19 pandemic signifies importance of current study which analyses the effect of conditions of water, sanitation and hygiene facilities at household level on child health. This study uses household data from PSLM Survey 2018-2019. Results of zero-inflated poisson regression reveal that a one-unit increase in household water poverty significantly increases expected log outcome of the number of children with diarrhoea. One-unit increase in sanitation poverty increases expected log of number of children with diarrhoea significantly by 1.462. A one-unit increase in household multidimensional hygiene poverty of the household insignificantly increases the expected log of number of children under age five with diarrhoea. Rural households have more children affected from diarrhoea when household is multidimensional water, sanitation and hygiene poor compared to urban households. There is a significantly high impact on child health in Balochistan and Sindh if water, sanitation, and hygiene poverty increases by one unit with households in KP as reference group. Household characteristics like type of wall, floor, and roof significantly determine the expected change in the log number of children suffering from diarrhoea in a water-poor, sanitation poor and hygiene poor household in Pakistan. The study recommends targeted and stern policy formulation along with the effective implementation of existing policies to attain the associated sustainable development goals.

Corresponding Author's Email: abre.rehmat@uog.edu.pk

1. Introduction

One of the main concerns of developing countries are uncontaminated drinking water, better sanitation, and hygiene amenities owing to their close connection with issues like high mortality and morbidity rates. Most prioritized global agenda is to provide clean water, improved sanitation, and hygiene facilities to the people. Children are more likely to be affected from contaminated water, poor sanitation, and unhygienic practices out of which children under age five are more vulnerable, as mortality is quite high in this group (WHO, 2019; Zahid, 2018). To attain SDG 6 of access to water and sanitation for all and their sustainability in their management, hygiene practices are indispensable to maintain health and prevent the spread of diseases (Giné Garriga & Pérez Foguet, 2018; WHO, 2021). Slow progress to attain SDG targets signify the increased efforts of less developed economies towards achievement of the goals by 2030. Less developed countries are experiencing problems in provision of uncontaminated drinking water, better sanitation and hygiene facilities for rural population making them more susceptible to health shocks. 71 percent of the population has accessibility of prime hygiene facility worldwide currently, which is expected to increase to 78 percent by 2030 (Giné Garriga & Pérez Foguet, 2018; WHO, 2021).

Percentage of children in total population is high for South Asia, as there are 616 million children under 18 out of 1.86 billion encompassing Afghanistan, Bangladesh, India, Pakistan, Maldives, Bhutan, Nepal, and Sri Lanka. About 325 million children are poor in at least one of the following dimensions i.e. education, health, housing, nutrition, water, and sanitation. South Asian region also accounts for more than 60 percent of the global burden of open defecation (UNICEF, 2020). Poor sanitation facilities account for high mortality rates in developing countries like sub-Saharan Africa and Asia compared to other countries. Poor sanitation and unhygienic practices led to 775,000 premature child deaths (1.4 percent of world mortality rate) (Fuente, Allaire, Jeuland, & Whittington, 2020).

1.1. Significance of the study

Pakistan, as a developing economy is deprived of protected drinking water, better sanitation and hygiene facilities. Water-borne diseases originate from contaminated drinking water, poor sanitation and hygiene facilities, where children as the most suffered group of all (Zahid, 2018). Only 36 percent inhabitants had access to clean and safe drinking water resources in Pakistan. Improved sanitation facilities are available to 58 percent of the residents. Clean water provision, improved sanitation and hygiene facilities still post a great challenge for Pakistan. There is a definite sanitation inequality in rural-urban areas; as open defecation is not reported more than one percent in urban areas compared to 19 percent in rural areas. More than 42 percent households in rural Punjab, 60 percent in rural KP and 82 percent in rural Sindh and Baluchistan are facing shortage of access to adequate drainage system (UNICEF, 2020).

COVID-19 pandemic also highlighted the prominence of water, sanitation and hygiene when the cheapest and easiest way to prevent the virus had been 'washing hands with soap' (UNICEF, 2020). This study helps in upgrading infrastructure of water, sanitation and hygiene facilities to target improvement in health of general public and especially the vulnerable group of young children. Despite the efforts like National Water Policy 2009 and National Sanitation Policy 2006, the situation of clean drinking water provision and improved sanitation facilities is alarming in Pakistan. The results of this study will support the implementation and expansion of ongoing projects from international organizations and government with more target specific approach. The objective of our study is to estimate the effect of household water, sanitation and hygiene conditions in Pakistan on child health at household level and provide a base for policymakers to devise appropriate public health policies. Section 2 covers literature review, Section 3 encompasses research methodology and section 4 presents estimated results. Section 5 concludes the study with suitable policy recommendations.

2. Literature Review and Research Gap

Diarrhoea is most common disease due to water, sanitation and hygiene poverty making it a leading cause of deaths among children under age five. Literature suggested that water, sanitation and hygiene poverty is more prevalent in Northern Africa, Western Asia and in Central and South Asia and is more common in developing countries with a significant impact on health, especially among children under age five (He et al., 2018; Headey & Palloni, 2019; Jeyakumar, Godbharle, & Giri, 2021; Komarulzaman, Smits, & de Jong, 2017; Shrestha, Six, Dahal, Marks, & Meierhofer, 2020; Yaya et al., 2018). Nanan, White, Azam, Afsar, and Hozhabri (2003) evaluated water, sanitation, and hygiene education intervention on diarrhoea in northern Pakistan. Results found 33 percent higher ratio of diarrhoea prevalence in children not living in villages with a water and sanitation intervention program. This ratio was 25 percent higher in girls than boys. G. Arif and Ibrahim (1998) evaluated diarrhea morbidity differentials among children in Pakistan. Socio-economic, demographic, and environmental factors were associated with diarrhea prevalence and duration.

Shah, Ara, Muhammad, Khan, and Tariq (2012) investigated water quality and potential health risk assessment in Northern Pakistan and found contaminated water as the main cause of diseases like diarrhoea, hepatitis, headache, abdominal pain, hypertension, liver and kidney in general population. Muhammad, Bangush, and Khan (2012) predicted diarrhea as one of the leading diseases due to unclean and contaminated drinking water. 2.5 million children in Northern Pakistan died each year due to unsafe drinking water. A. Arif and Naheed (2012) evaluated socioeconomic determinants of diarrhoea morbidity in Pakistan using PSLM (2004-2005) and found direct role of economic factors and mother's unhygienic practices in diarrhoea prevalence. Imran, Zahir, Khan, Pasha, and Anjum (2014) estimated effect of household environment on diarrhea incidence among newborn children using Pakistan DHS (2006-2007). Incidence of diarrhea has a significant negative relationship with environmental factors and water source. Households sharing toilet facilities showed a negative impact on diarrhea prevalence. Results suggested that government should build improved public toilet facilities, filtration plants, hand pumps, and tube wells, along with public awareness through media to reduce diarrhea prevalence.

Nadeem, Cheo, and Shaoan (2018) estimated multidimensional water poverty and its effects on subjective well-being for households in ten villages of Faisalabad. Household wastage and environmental variations are found as serious threats to water, sanitation, and hygiene of households. Zahid (2018) analyzed effect of clean water and sanitation on water-borne diseases for Pakistan along with the socio-economic, demographic, and environmental factors. Multivariate logistic regression results showed that post neo-natal deaths had a significant proportion in morbidity caused by diarrhea at the provincial level. High diarrhea incidence in Sindh and KP was due to poor water quality and household conditions. Literature review suggested that evidence on the impact of clean water availability, improved sanitation and hygiene facilities on child health is very limited in Pakistan. Some studies are available but those are outdated and some are only covering regions and do not encompass a national analysis. In addition, this study aims to expand the analysis based on the provincial differences.

3. Research Methodology

3.1. Data Source

The data for this study is obtained from PSLM (Pakistan Social living and Standards Measurement) 2018-2019 survey covering information on 24,809 households where 21,160 households have children under age five.

3.2. Variable Description

To gauge the condition of child health due to water, sanitation and hygiene poverty in Pakistan, the study used three indices of water, sanitation, and, hygiene poverty (Giné Garriga & Pérez Foguet, 2013). Water Poverty Index (WPI) refers to percentage of households deprived of water resources, access, use and capacity. Sanitation Poverty Index (SPI) refers to percentage of households deprived of sanitation facilities. Hygiene Poverty Index (HPI) submits a household as hygiene-poor when it has no handwashing facilities available in and around the premises and it uses water from unprotected sources such as pond, spring, open well, canal, river, tanker and stream. Child health is measured with number of children under age five reported with diarrhea symptoms in the household in the last fifteen days before the survey was conducted. Floor equals 1 if material used is mud/sand, dung or other specific material and 0 otherwise. Roof is assigned 1 if wood, bamboo, and other materials[1] used. Wall is assigned 1 if material used is mud-brick, wood, plywood/cardboard, stones. Four province dummies are used with KP as a reference category. Region is 1 if child was in urban area.

3.3. Model Specification

Several studies examined the effect of water, sanitation and hygiene on child health (diarrhea) (Fink, Günther, & Hill, 2011; Günther & Fink, 2010; Headey & Palloni, 2019; Luby et al., 2018). To evaluate the effect of water, sanitation, and hygiene poverty on child health, the following functional forms are specified (equation 1-3);

$$\widehat{NCD_i} = \lambda_i = exp(\alpha_o + \alpha_1 WPI_i + \alpha_2 Roof_i + \alpha_3 Floor_i + \alpha_4 Wall_i + \alpha_5 P_i + \alpha_6 S_i + \alpha_7 B_i + \alpha_8 R_i + \mu_i) \quad (1)$$

$$\widehat{NCD_i} = \lambda_i = exp(\beta_o + \beta_1 SPI_i + \beta_2 Roof_i + \beta_3 Floor_i + \beta_4 Wall_i + \beta_5 P_i + \beta_6 S_i + \beta_7 B_i + \beta_8 R_i + \varepsilon_i) \quad (2)$$

$$\widehat{NCD_i} = \lambda_i = exp(\gamma_o + \gamma_1 HPI_i + \gamma_2 Roof_i + \gamma_3 Floor_i + \gamma_4 Wall_i + \gamma_5 P_i + \gamma_6 S_i + \gamma_7 B_i + \gamma_8 R_i + e_i) \quad (3)$$

NCD shows number of children suffering from diarrhea under age five, i show different cross sections (households) and α_i, β_i, γ_i are slope parameters. WPI, SPI, and HPI denote water poverty index, sanitation poverty index, and hygiene poverty index, respectively. Roof, Floor, and Wall are household characteristics. P, S, and B depict Punjab, Sindh, Balochistan provinces, respectively. R is region, while μ_i, ε_i, and e_i represents error terms. 'exp' shows the expected number of occurrences of a phenomenon. Parameters are interpreted as the effect of change in independent variable on the conditional mean.

[1] Other material is an option for poor material.

3.4. Zero-inflated Poisson (ZIP) regression model

ZIP model is used to understand the impact of water, sanitation and hygiene poverty on child health (equations 4 and 5) as the dependent variable is a count variable.

$$\log \mu_i = \beta_o + \beta_1 x_{i1}, + \cdots .. + \beta_{j1} x_{ij} \qquad (4)$$
$$logit \pi_i = = \gamma_o + \gamma_1 x_{i1}, + \cdots .. + \gamma_{j1} x_{ij} \qquad (5)$$

Here, i = 1,2,….n; j= 1,2,…k. βs represent independent variables which affect poisson state whereas γs represent independent variables which effect overdispersion of zeros (Annisa et al., 2020). Null hypothesis is that independent variable has no effect on number of children with diarrhea against the alternative that independent variable has effect on dependent variable.

Poisson regression model implies assumption of equal value of mean and variance of dependent variable. If variance exceeds the mean, over dispersion (excess of zeros) exists (Fenta, Fenta, & Ayenew, 2020). Over dispersion can lead to invalid results when unaddressed. Likelihood ratio (LR) chi-squared test (G^2) (equation 6) checks overdispersion. NB regression relaxes assumption of equal variance and mean. LR chi-squared test shows whether coefficients of all predictors are zero. In NB regression, alpha greater than zero and chi-squared value equal to or less than 0.05 indicates over dispersion (Shaaban, Peleteiro, & Martins, 2021; Xu, Zhu, & Han, 2017).

$$G^2 = 2 \sum_i O_i \ln\left(\frac{O_i}{E_i}\right) \qquad (6)$$

Here, O_i is observed frequency for zeros and E_i is expected frequency of zeros in dependent variable.

If the number of zeros are in abundance, poisson regression model is modified into ZIP model to account for overabundance of zeros. In ZIP regression model, zeros exist in two ways. Structural zeros with probability π_i, and sampling zeros where probability may occur as $(1 - \pi_i)$, indicating towards standard poisson count, hence, further chances of zeros (Fenta et al., 2020). Equations 7 and 8, show the mean and variance of ZIP model,

$$E(y_i) = (1-\pi_i)\ \mu_i \qquad (7)$$
$$Var(y_i) = \mu_i = (1-\pi_i) = (1 + \pi_i \mu_i) \qquad (8)$$

Likelihood ratio based Vuong test is used to compare the poisson and ZIP models if excess zeros exist. A significant z value shows that ZIP model is preferred (Shaaban et al., 2021; Xu et al., 2017). Akaike information criteria (AIC) and Bayesian Schwartz information criteria (BIC) compare the model fitness in count data models. AIC criteria evaluates model with multiple parameters (equation 9); whereas, BIC is used for multiple parameters and larger sample size (equation 10).

$$AIC = -2 \ln L + 2p \qquad (9)$$
$$BIC = -2 \ln L + p \ln(n) \qquad (10)$$

Here *ln L, p, n* show fitted log likelihood, number of parameters and sample size, respectively.

4. Results and Discussion

This study has evaluated the effect of water poverty, sanitation poverty, and, hygiene poverty on child health in Pakistan. The MWPI, MSPI, and MHPI obtained from Qurat-ul-Ann and Bibi (2022) are used as independent variables (see table 1). Adjusted multidimensional headcount ratio) shows that 51.2 percent of the households are poor in 30 percent of the water poverty dimensions (table 1). Water poverty incidence is high in rural areas relative to urban areas. Balochistan and KP has higher incidence of multidimensional water poverty compared to Sindh and Punjab. Percentage of multidimensional sanitation poor households is 66.4 percent with higher rural sanitation poverty. KP, Sindh and Balochistan have more than 50 percent of sample households as sanitation poor. Multidimensional hygiene poverty is 54.6 percent (table 1).

Table 1: Household Multidimensional (Water, Sanitation, Hygiene) Poverty Indices

		Overall	Rural	Urban	KP	Punjab	Sindh	Balochistan
MWPI	M_0	0.512**	0.046	0.025	0.055	0.011	0.052	0.115
MSPI	M_0	*0.664***	0.619	0.331	0.522	0.498	0.519	0.588
MHPI	M_0	*0.546***	0.373	0.141	0.522	0.498	0.519	0.588

N=24,809, Authors' own calculation from Qurat-ul-Ann and Bibi (2022).

37.3 percent of rural households and 14.1 percent urban households are multidimensional hygiene poor. Maximum number of children in a household who get some prevalence of diarrhea is 3 (table 2).

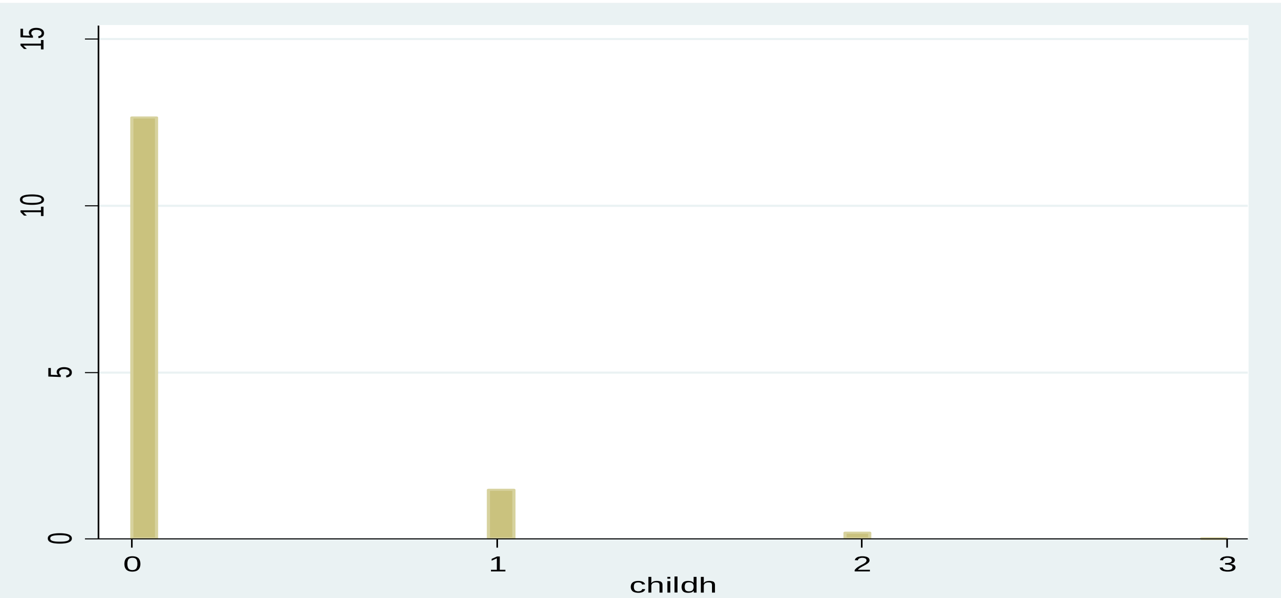
Table 2: Number of Children under age five having diarrhea

bg	0	1	2	3	Total
Frequency	18,667	2,181	293	19	21,160

Authors' own Calculation

18,667 households have children with no diarrhea symptoms, while 2,181 households have one child with diarrhea in the last fifteen days before the survey was conducted (table 2). Figure 1 shows frequency of children with diarrhea. Higher variance than mean (table 3) suggests a significant amount of over-dispersion.

Figure 1: Number of Children with diarrhea



*Note: child shows number of children suffering from diarrhea

Table 3: Descriptive Statistics

	Mean	Variance
Number of children with diarrhea	0.133	0.148

Authors' own Calculation.

Table 4: Model Selection- Likelihood Ratio Chi-Square Test and Vuong Test

Effect on No. of children with diarrhea	Likelihood ratio squared test for N.B α ($p \geq chibar^2$)	Decision-Over dispersion	Vuong Test ZIP z ($p > z$)	Decision-Preferred Model
WPI	0.85 (0.00)	Significant	5.25 (0.00)	ZIP
SPI	0.84 (0.00)	Significant	5.13 (0.00)	ZIP
HPI	0.86 (0.00)	Significant	5.25 (0.00)	ZIP over ZINB

Authors' own Calculation.

Likelihood ratio chi-square test value α of 0.85 for water poverty effect on child health (model 1), 0.84 for SPI (model 2), and 0.86 for HPI (model 3) with significant probability value

(0.00) revealed over dispersion of zeros in the outcome variable. Vuong test statistic is significant with 0.00 p-value suggesting ZIP regression is best fit and preferred over simple Poisson regression. Smallest AIC and BIC value (for model 1) under ZIP regression model makes it a best-fit for model 1 (water poverty effect) (table 5). Model 2 has lowest AIC and BIC values under ZIP regression model indicating it as best fit. Model 3 has smallest AIC and BIC values, for two models; ZIP and ZINB, both being best fit models but this study chose ZIP for model 3 (table 5). Z value of each *ai* is significant at 5%, hence H_0 is rejected, depicting significant effect on number of children with diarrhea except α_7 and α_8 .

Table 5: Model Selection Criteria for Count Regression Models

		(1)		(2)		(3)	
Model	**df**	**AIC**	**BIC**	**AIC**	**BIC**	**AIC**	**BIC**
Poisson	9	17386.19	17457.83	17355.89	17427.53	17392.35	17463.99
NB	10	17289	17368.6	17261.69	17341.29	17294.10	17374.32
ZIP	11	17256	17344	17232.66	17320.22	17263.15	17350.71
ZINB	12	17258	17344	17234.66	17330.18	17263.15	17350.71

Authors' own Calculation

Expected change in log number of children with diarrhoea for a one-unit decrease in WPI is $e^{-3.23}$ or 0.0395 holding other variables constant. Households with poor floor and roof material have an expected log number of children with diarrhoea of $e^{0.179}$ (=1.196) and $e^{0.147}$ (1.158) higher than that of if improved materials were used for floor and roof. Poor wall material used has a higher expected change in log number of children with diarrhoea of $e^{-0.532}$ (0.587) compared to households with better wall material. Household in Punjab have a lower expected change in log number of children with diarrhea of $e^{-0.169}$ or 1.184 compared to KP. Households in Balochistan, have higher diarrhoea incidence among children age five by $e^{1.886}$ times than KP. Logit model of effect of water poverty on child heath explains the model effect on zeros and a significant impact of poor wall on number of children with diarrhea (table 6). Water poverty results show negative impact on child health, probably due to poor households' characteristics and hygiene.

Table 6: Effect on Child Health in Pakistan: ZIP Regression Results

						Logit selection				
	α	**Z**	**p**	**C.I (95%)**		**α**	**z**	**p**	**C.I (95%)**	
Model (1)										
WPI	-3.23	-2.8	0.005	-0.5488	-0.9654					
Floor	0.179	3.25	0.001	0.0715	0.2885					
Wall	-0.532	-4.28	0.000	-0.7762	-0.2884	-1.398	-3.4	0.001	-2.1975	-0.5975
Roof	0.147	2.54	0.011	0.0338	0.26035					
Punjab	-0.169	-2.97	0.003	-0.2819	-0.0578					
Sindh	0.064	1.14	0.255	-0.0465	0.17502					
Balochistan	1.886	2.85	0.004	0.0591	0.3182					
Region	-0.0763	-1.56	0.119	-0.1724	0.19736					
α	-1.2547	-15.3	0.000	-1.4153	-1.0943	0.2537	1.84	0.065	-0.013	0.4237
Model (2)										
	β	Z	p	C.I (95%)		β	z	p	C.I (95%)	
SPI	0.3798	5.67	0.000	0.2485	0.511					
Floor	0.1446	2.61	0.009	0.0359	0.253					
Wall	-0.5367	-4.32	0.000	-0.7804	-0.293	-1.376	-3.3	0.001	-2.189	-0.5637
Roof	0.1217	2.11	0.035	0.0085	0.2348					
Punjab	-0.1576	-2.81	0.005	-0.2677	-0.0475					
Sindh	0.0598	1.07	0.287	-0.0502	0.17					
Balochistan	0.1628	2.47	0.014	0.0335	0.2921					
Region	-0.1265	-2.55	0.011	-0.2235	-0.293					
β	-0.1458	-17.1	0.000	-1.6256	-1.292	0.164	1.44	0.149	-0.0589	0.38645
Model (3)										
	ɣ	Z	p	C.I (95%)		ɣ	z	p	C.I (95%)	
HPI	0.091	1.19	0.233	-0.0589	0.242					
Floor	0.167	2.95	0.003	0.0562	0.278					
Wall	-0.549	-4.41	0.000	-0.793	-0.31	-1.3791	-3.4	0.001	-2.172	-0.586
Roof	0.133	2.29	0.022	0.0192	0.25					
Punjab	-0.135	-2.40	0.016	-0.2455	-0.025					
Sindh	0.084	1.49	0.137	-0.0264	0.194					
Balochistan	0.186	2.81	0.005	0.0563	0.32					
Region	-0.089	-1.80	0.072	-1.8758	0.01					
ɣ	-1.3098	-15.9	0.000	-1.47	-1.1488	0.203	3.41	0.001	-2.172	-0.586

Source: Authors' own Calculation

There is significant impact of sanitation poverty on child health (Model 2, table 6). Expected change in log number of children with diarrhea for a one unit increase in SPI is $e^{0.3798}$ or 1.462. Floor and roof have an expected log number of children with diarrhoea $e^{0.145}$(=1.156) and $e^{0.1217}$ (=1.129), respectively, compared to the non-poor, holding other variables constant. Households with better wall material have lower expected log number of diarrhea incidence among children under age five of $e^{-0.5367}$or 1.7 than households with poor wall material. In Punjab, expected log number of children with diarrhea is $e^{-0.1576}$ or 0.854 which is less compared to KP (reference group). Balochistan has more expected log number of children with diarrhoea i.e. $e^{0.1628}$ or 1.176 times greater than KP. Expected log number of diarrhoea incidence among children in rural areas is less compared to urban areas. Hygiene poverty has no significant impact on child health. Poor quality of floor and roof lead to diarrhea incidence among children with $e^{0.167}$ or 1.182 and $e^{0.133}$ or 1.142 times, respectively. Improved wall quality decreases the number of children with diarrhea by 0.577 times. Expected log number of children with diarrhoea is 0.873 times less in Punjab compared to KP. Balochistan has 1.20 times greater diarrhea occurrence among children.

5. Conclusion and Policy Recommendations

This study estimated the impact of water, sanitation and hygiene poverty on child health (diarrhea) in Pakistan using PSLM, 2018-2019. Water poverty has a significant negative effect on diarrhea among children under age five. Household characteristics like wall has significant negative impact on child health which mean if improved wall material is used, then diarrhea prevalence decreases, whereas, roof and floor have significant direct impact on child health. The effect of household water poverty on diarrhea in young children is high in Punjab and Balochistan compared to KP. Higher multidimensional sanitation poverty has a significant direct impact on diarrhea among children. As sanitation poverty rise, the diarrhea incidence among children increases. Household characteristics have direct significant effect on the number of children in a household with diarrhea. Punjab and Balochistan have significantly higher prevalence of diarrhea in under five children due to poor sanitation facilities compared to KP. In rural areas of Pakistan, a higher significant impact on diarrhea prevalence is observed in under five children due to sanitation facilities compared to urban areas. Poor hygiene facilities have an insignificant impact on diarrhea among children under age five. Punjab and Balochistan have a greater significant impact of hygiene poverty on diarrhea in children compared to KP.

Children under age five have weaker immune system, hence they are more affected by diarrhea. Clean and safe drinking water facilities are necessary for the well-being of human beings, especially children. Balochistan, Sindh, KP, and rural areas are poorer in sanitation facilities. Due to poor policy implications, children are suffering more. It is imperative to prioritize child health issues linked to poor sanitation facilities. Children are considered future human capital, hence, focusing on their health can lead them to effectively contribute to economic growth. Targeted interventions to improve hygiene facilities in rural areas, Balochistan, KP and Sindh provinces will help to reduce the vulnerabilities of the most deprived groups. Health and hygiene concerns are paramount after COVID-19, and simple behavioural changes could bring wonders towards the epidemic control. Sanitation and hygiene behaviors can be improved by awareness programs. Using different media, the awareness to improve hygiene behaviors and conservation of safe drinking water can be enhanced.

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