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An overview of diarrhea among infants and under-five in Punjab-Pakistan

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ABSTRACT

Background: Diarrhea, pneumonia, malnutrition, tuberculosis, measles, and fever are the leading causes of mortality in children under five-years of age (0–59 months), whereas diarrhea alone is the world's second-biggest cause of mortality in this population. This study is particularly important for Pakistan as it focuses on one of the main causes of infant mortality, diarrhea, which is a major challenge for Pakistan to achieve the Sustainable Development Goals to reduce infant mortality to 12/1000 live births by 2030.
Aim: This study was planned to investigate the various household, parental, environmental, and child-related factors causing diarrheal diseases in children aged 0–59 months in Punjab Pakistan.
Methods: The study used the data of 38,405 households from the Multiple Indicator Cluster Survey (MICS) 2017–18, directed by the Punjab Bureau of Statistics. Comprehensive descriptive statistics, i.e., cross-tabulations and logistic regression were used for the detailed analysis.
Findings: The results showed that infants are more probable to get diarrhea than older children. A wide range of influences were found to affect the probability of a child getting diarrhea, including child-specific, mother-specific and environment-specific ones. One prominent finding was that, at the mother level, the education of the mother played a significant role in reducing diarrhea among children under five-years of age (0–59 months).
Discussion: The results of the study contribute to the literature by highlighting that it is an interplay of factors that result in diarrhea. Hence, improving the source of drinking water, e.g., tap water and bottled water, can decrease the occurrence of diarrhea, especially in poor households. It was also revealed that households with a toilet facility of flush have less probability of their children being diagnosed with diarrhea than toilet facilities in open drains and fields. On the child level, results suggested that birth order matters as well, with the firstborn child having a lower probability of contracting diarrhea than siblings born after.
Application to practice: Interventions targeting infants and mothers of infants aimed at reducing diarrhea are expected to be very effective to reduce child mortality, one of the main child health challenges faced by Pakistan.

Introduction

Over the last five-six decades, the world has achieved great improvements in lowering child mortality, especially infant mortality. The Infant Mortality Rate (IMR) declined globally to 29 deaths per thousand live births compared to 65 deaths per thousand live births in 1990 (World Health Organization, 2023). In 1990, there were 8.8 million annual newborn fatalities; by 2017, that number has dropped to 4.1 million. The African region had the highest rate of children dying before reaching the age of one year (51 per one thousand live births), which was more than six times higher than the European Region (8 per 1000 live births) (World Health Organization, 2023). Sustainable Development Goals (SDGs) for reducing the global IMR target to reduce mortality to twelve deaths per thousand live births by the year 2030 (World Health Organization, 2021). Thus, in countries like Pakistan, it is important to reinforce the targets of reducing infant mortality and clarify the main factors at play.

The leading causes of infant mortality are pneumonia, malnutrition, diarrhea, tuberculosis, measles, and fever, although many of these deaths could be completely avoided with proper care and treatment (Nasir et al., 2021). Among these causes, diarrhea is the world's

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second-biggest cause of childhood mortality, with around 1.3 million children under the age of five dying each year (Nasir et al., 2021). Childhood diarrhea kills more children under the age of five than acquired immunodeficiency syndrome (AIDS), malaria, and measles combined (Lamichhane et al., 2017; UNICEF, 2009; World Health Organization, 2021). An estimated 2.5 billion diarrhea cases occur in children under the age of five annually, and this rate remains relatively consistent over the last two decades (Melese et al., 2019).

Pakistan accounts for half of all global infant deaths (Abbas et al., 2021). Pakistan is ranked 17th highest rate of infant mortality with 54/1000 live births and the neighboring countries of Pakistan are performing far better as Afghanistan is ranked 37th with 45/1000 live births followed by India at 79th with 27/1000 live births, Bangladesh at 85th with 24/1000 live births, and Sri Lanka at 177th with 6/1000 live births (World Bank, 2022).

The Pakistan Medical Association says inappropriate delivery techniques are one of the causes of these high mortality rates (Nasir et al., 2021). Deliveries at home are not intrinsically hazardous, but mother and infant death rates are higher in rural areas due to a lack of health facilities and unskilled delivery attendants (Nasir et al., 2021). Even though mortality rates have decreased in the past few decades, millions of children still die each year due to avoidable or treatable factors such as bacterial pneumonia, malnutrition, diarrhea, tuberculosis, measles, fever, and dengue fever (Nasir et al., 2021).

Diarrhea, defined as having three or more loose or watery stools within 24 h, is the world's 8th largest cause of illness and premature mortality (Levine et al., 2017). Diarrhea causes long-term malnutrition and psychological changes, in addition to premature death (Guerrant et al., 1992). The burden of diarrhea is disproportionately high in low and middle-income countries due to a lack of access to water, sanitation, hygiene, and nutrition (Montgomery & Elimelech, 2007). Mortality due to diarrhea is widespread in underdeveloped nations due to a lack of affordable health care and inefficient diarrhea treatment (Fischer Walker et al., 2012).

Pakistan still ranks highly in deaths attributable to diarrhea despite a decline in under-five-year (0–59 months) mortality over the past few decades. To develop suitable preventative interventions that can be combined with enhanced case management, it is therefore required to have a better understanding of the risk factors in rural and urban areas of Punjab, Pakistan. This study evaluated the risk factors for diarrhea in children under the age of five (0–59 months) in rural and urban areas of Punjab, Pakistan, in order to determine the main causes of the disease in these areas. This study was the first attempt which reported diarrhea prevalence among under-five children (0–59 months) linked with information on knowledge and practices about diarrhea in Punjab, Pakistan using Multiple Indicator Cluster Survey (MICS) 2017–18. The main objective of the study was to investigate the various household, parental, environmental, and child-related factors influencing diarrheal disease in children under the age of five (0–59 months) in Punjab Pakistan.

Methodology

Data source

We used data from a nationally representative survey, i.e., Multiple Indicator Cluster Survey (MICS)" conducted by the Punjab Bureau of Statistics in 2017–18. The United Nations Children's Fund (UNICEF) created the MICS as an international household survey program to gather equivalent evaluations of >125 main indicators that are used to measure the condition of women and children in Punjab, Pakistan. Both households and their representatives in both urban and rural areas of Punjab, which is divided into 9 organizational divisions and 36 districts, are included in the MICS. This data was collected with the help of three questionnaires: one for each household, one for individual women (ages 15–49), and one for children under the age of five. The urban and rural areas within each district were identified as the main sampling strata. Using the listing of households from the population census, 2017 for each sample enumeration area, the sample of households was selected in two stages. In the first stage, enumeration blocks, i.e., the Primary Sampling Units (PSUs) were selected, and in the second stage, 20 households were selected using systematic sampling with the random start from each of the PSUs. The data was publicly available at https://mics.unicef.org/surveys.

Statistical analysis

Descriptive statistics, cross-tabulation, and regression analysis were performed on data to meet the objective of the study. All analyses were carried out by using STATA software version 14.0.

Diarrhea was assessed based on the women's responses to the question: (a) has the child had diarrhea in the last 2 weeks? The women's response to the above question was recorded as "yes" and "no" options. In this study, the incidence or occurrence of diarrhea among under five children was used as the dependent variable. A brief list of factors reported in previous literature to impact pediatric diarrhea is shown in Fig. 1. These variables were used in this study as the independent variables and include:

- Child-related factors such as gender of children (male, female), a child's age (less than months, 12–23 months, 24–35 months, 36–47 months, and 48–59 months), birth order (1st, 2–3, 4–6 and greater than 7th);
- Mother's related factors such as mother's age (<25 years, 25–29, and >29 years), her educational level (preschool, primary, middle, secondary, and higher), whether she has health insurance (yes, no), mother's access to the mobile phone (yes, no);
- Household-level variables such as the age of the father and the household wealth status (low-income group, middle-income group, and high-income group) are included;
- Geographic level variables, such as the area of residence (rural, urban), and region of residence (nine divisions of Punjab Province of Pakistan);
- Environmental-related variables, including the source of drinking water (piped, motor, pump, and bottled water), type of toilet facility (septic tank, open drain, and fields), location of the toilet facility (dwelling, plot), sharing of toilet facility (yes, no), and water available for hand washing (yes, no).

Model specification

Due to the dichotomous nature of the dependent variable, a logistic regression model was used to study the incidence of diarrhea associated with different explanatory or independent variables as defined above, following a similar set of studies (Nadeem et al., 2022; Rayhan & Khan, 2006). Let:

$$P_i = Pr\left(Y = \frac{1}{x = x_i}\right) \tag{1}$$

Here P_i is the probability of the incidence of diarrhea among under-five children. The model can be rewritten as.

$$Log\left(\frac{P}{1-P_i}\right) = log\ \ it(P_i) = \beta_o + \beta_i X_i \tag{2}$$

This is the simple representation of the logistic regression model with one independent variable. Here P_i is the probability of the incidence of diarrhea among under-five children, X_i is the independent variable, and β_i shows the log of odds for under-five diarrheal incidence. Therefore, we can write the model in terms of ratio as.

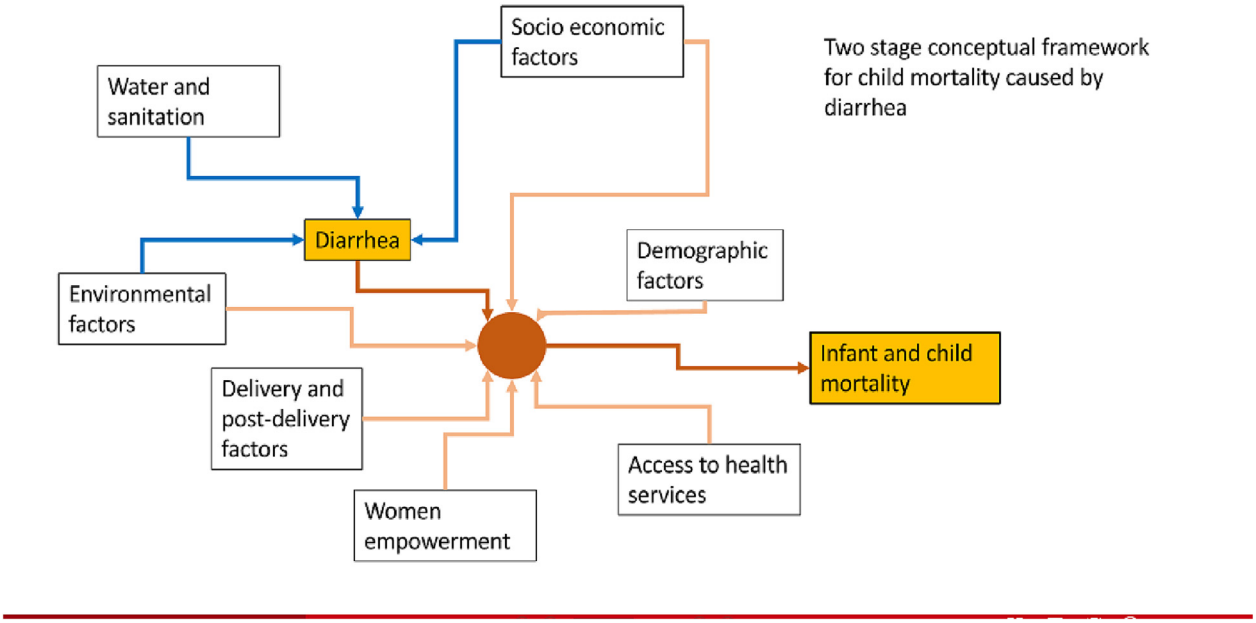

Fig. 1. Determinants of diarrhea among under-five children (0–59 months).

$$\frac{P}{1-P_i} = exp(\beta_o + \beta_i X_i) \tag{3}$$

It can also be written in terms of the probability of the outcome, i.e., the incidence of under-five diarrhea as.

$$P_i = \frac{exp(\beta_o + \beta_i X_i)}{1 + exp(\beta_o + \beta_i X_i)} \tag{4}$$

Contrariwise to eq. (4), the probability of the outcome, i.e., no incidence of under-five diarrhea is.

$$1 - P_i = \frac{1}{1 + exp(\beta_o + \beta_i X_i)} \tag{5}$$

Introducing a residual term, (4) can be modified to:

$$P_i = P_i + \varepsilon_i = \frac{exp(\beta_o + \beta_i X_i)}{1 + exp(\beta_o + \beta_i X_i)} + \varepsilon_i \tag{6}$$

Before employing the model, all the variables were tested for their significant impact on the incidence of diarrhea (a standard approach, also used by similar studies, see e.g., Nadeem et al. (2022). Then, the five different combinations of independent (explanatory) variables listed in the previous section as shown in Fig. 1 were employed in four different models, each building upon the previous one.

Results

In MICS 2017–18, a total of 53,840 households were listed as the sample, out of which 52,765 households were engaged by the data collection teams and 51,660 households successfully responded, resulting in a 97.9% response rate. From these households, with a 99.4% response rate, 79,040 women (ages 15 to 49) were successfully interviewed out of 79,510 women. From these women who responded, 42,408 has at least one child under the age of five. Therefore, after merging all these datasets in Stata software, 42,408 children were included and after cleaning the data, 39,428 observations on children were kept. Finally, after deleting missing values, the final count for observations on children was 39,024 which was the sample used in the analysis. The steps are shown in Fig. 2.

Descriptive statistics results

Table 1 shows the descriptive statistics of the sample at different levels. The outcome variable incidence of diarrhea reveals that 13.7% of all children were suffering from diarrhea during the two weeks before the survey date. It was found that among the children, 51.6% were male, following the gender distribution in the sample. The age of the children was categorized into five groups – results revealed that 20.6% of children were younger than 12 months; 19.9% were between 12 and 23 months old; 19.7% were between 24 and 35 months old, 20.7% were between 36 and 47 old, and 19.1% were between 48 and 59 months old. Birth order is categorized into four groups; The results show that the largest percentage of respondents (42.06%) identified their birth order as 2–3. The next largest percentage (27.45%) identified their birth order as 4–6, followed by 24.96% who identified their birth order as 1st. The smallest percentage of respondents (6.03%) identified their birth order as greater than seventh child.

Descriptive statistics related to the mother's level variables revealed that 17.63% of mothers were younger than 25, 31.3% of mothers were 25 to 29 years and 59.9% of mothers were older than 29 years of age. The education of mothers was categorized into preschool (43.3%), primary (20.3%), middle (10.3%), secondary (13.4%), and higher (12.7%); it was clear that as education levels increase, the number of mothers having completed the level falls. Mothers' access to health insurance and information about childcare is negatively related to mortality. About 2.6% of women had access to health insurance, while 43.8% of mothers had access to a mobile phone. Further, household-level variables showed that 32.8% of fathers were categorized as younger than 30 years, 65.6% were between 31 and 60 years of age, and 0.3% were over 60 years of age. The wealth status was categorized into three groups: 'poor' (44.9%), 'middle' (39.8%), and 'rich' (15.3%).

The area of residence, i.e., rural-urban, and the administrative divisions of the province of Punjab showed that 73.6% of respondents belong to rural areas against 26.4% in urban areas of Punjab. These

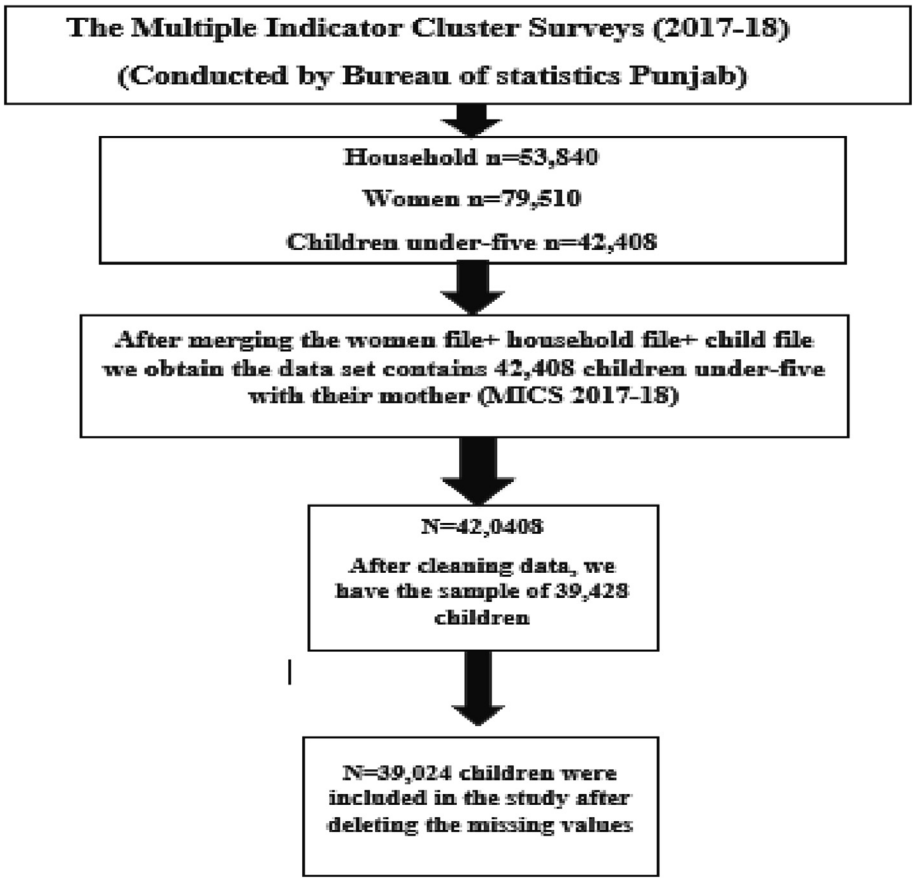

Fig. 2. The selected sample used in the analysis.

results were nearly similar to the population census distribution among rural-urban of the Punjab province. The province of Punjab has 9 administrative divisions at the time of data collection and the percentage distribution of the respondents among these is also presented in Table 1.

The next set of variables is related to environmental factors. The percentage distribution showed that the toilet facility was located at the dwelling in 40% of the observations, 13% shared a toilet, while water for hand washing was available to 94%. For drinking water types such as water from pipelines, tube well, other improved water sources, and unimproved water sources were included; the percentage distribution among these categories is also presented in Table 1 below.

Unadjusted risk factors of incidence of diarrhea among under-five children (0–59 months)

The results are presented in Table 2. Diarrhea was more prevalent in children younger than one year (18.7%). In age groups, two, three, and above, the prevalence decreased to 9.8 and 8.1% respectively. In comparison to 13.2% of girls, 14.09% of boys reported having diarrhea.

The results of the birth order show that the firstborn child has the lowest mortality rate (13.74%), followed by children in the second to third birth order (13.36%), and the children in the fourth to sixth birth order (13.64%). Children born seventh or later have the highest mortality rate of 15.60%, which is significantly higher than the other birth orders. This suggests that the later a child is born, the higher the risk of death before the age of five.

The prevalence of diarrhea declined as the mother's age increased: 12% of children with mothers older than 30 years had diarrhea compared to 17% of children with mothers younger than 25 years old. A similar trend was observed with mothers' levels of education, where the lowest prevalence (11.5%) of children with diarrhea was observed among higher-educated mothers compared to 15% among children of less-educated mothers. It was found that 10.6% of children of mothers with health insurance were diagnosed with diarrhea. On the other hand, 13.76% of the children of mothers without health insurance were diagnosed with diarrhea. Finally, 12% of the children of mothers with access to a mobile phone were diagnosed with diarrhea, against 14.9% of children of mothers without access to mobile phones.

We also took into account the wealth of households in rural and urban areas of Punjab, Pakistan because the wealth status of the household, as well as the region of the residence, appeared to be strong predictors of childhood diarrhea occurrence. The results revealed that poor families were more likely to have children with diarrhea than rich families (16.2 against 10.5%). No significant difference was observed in diarrhea incidence between rural and urban areas (13.9 against 12.9%). Divisional-level statistics highlighted that the DG Khan division had the highest level of diarrhea among children (25%), and the Gujranwala division had the lowest level of diarrhea (16.8%).

Environmental factors showed a higher incidence of diarrhea in households that used water from tube wells/motor pumps/hand pumps (14%), while a lower incidence of diarrhea was reported in households that used packed/bottled sources of water (12%). The type of toilet facility in a family also played an important role in diarrheal disease. The results showed that children born into a family that used unimproved toilets (bucket or field) were more prone to get diarrhea than those who were born into families with access to improved toilets (15% against 12%, see Table 2). The result further showed that those who used a “flush to pit latrine” had a prevalence of 13% of child diarrhea and 17% of respondents gave no results.

The results also showed that a child born into a family that used plots was more likely to suffer from the diarrheal disease than those who were born into families with access to the dwelling (14% against 11%).

Table 1
Descriptive statistics ($N = 39,024$).

Variables	Percentage (n)
Diarrhea incidence in under-five children (two weeks before the survey)	
Yes	13.67 (5333)
No	86.33 (33,691)
i. Child-level variables	
Gender of the children	
Male	51.60 (20,138)
Female	48.40 (18,886)
Age of the children (years)	
0–11 months	20.63 (8052)
12–23 months	19.88 (7757)
24–35 months	19.74 (7705)
36–47 months	20.67 (8068)
48–59 months	19.07 (7442)
Birth order	
1st	24.96 (9546)
2–3	42.06 (16,413)
4–6	27.45 (10,713)
Greater than 7th	6.03 (2352)
ii. Mother-level variables	
Age of mother (in years)	
≤25	17.63 (6878)
25–29	31.48 (12,285)
>29	50.89 (19,861)
Education of mother (schooling years)	
Preschool	43.26 (16,880)
Primary	20.26 (7907)
Middle	10.33 (4033)
Secondary	13.35 (5210)
Higher	12.68 (4947)
No response	0.12 (47)
Mother has health insurance	
Yes	2.61 (1020)
No	97.26 (37,956)
No response (code = 99)	0.12 (48)
Mother has access to mobile	
Yes	43.84 (17,110)
No	56.12 (21,900)
No response	0.04 (14)
iii. Household-level variables	
Father's age (in years)	
≤30	32.83 (12,811)
31 to 60	65.60 (25,599)
>60	0.28 (108)
Do not know	0.02 (8)
No response	1.28 (498)
Wealth status	
Poor	44.85 (17,504)
Middle	39.77 (15,518)
Rich	15.26 (5955)
No response	0.12 (47)
iv. Geographic variables	
Area of residence	
Rural	73.59 (28,717)
Urban	26.41 (10,307)
Region of residence (Divisions of the Punjab province)	
Bahawalpur	8.82 (3442)
DG Khan	11.01 (4297)
Faisalabad	12.06 (4708)
Gujranwala	16.83 (6569)
Lahore	12.61 (4920)
Multan	11.65 (4546)
Rawalpindi	10.74 (4191)
Sahiwal	6.42 (2504)
Sargodha	9.86 (3847)
v. Environmental level variables	
Source of drinking water	
Piped into dwelling/yard/neighbor	17.55 (6848)
Motor pump/hand pump	68.33 (26,665)
Drum, crane/tanker/packed/bottled water	12.32 (4982)
No response	1.36 (529)
Type of Toilet facility	
Flush to piped sewerage	16.69 (6512)
Flush to septic tank	45.42 (17,725)
Open drain /field/others	37.33 (14,566)
No response	0.57 (221)
Location of the toilet facility	
Dwelling	39.94 (15,587)
Plot	43.57 (17,002)
No response	16.49 (6435)
Toilet facility shared	
Yes	13.30 (5192)
No	70.16 (27,378)
No response	16.54 (6454)
Water available for hand washing	
Yes	94.32 (36,806)
No	3.62 (1414)
No response	2.06 (804)

Note: Figures in parenthesis are frequencies.
(Source: MICS, 2017–18 survey data analysis)

The results further showed that 25% of respondents gave no results. The results of this study showed the variable had a statistically significant association with child diarrhea at a *P*-value of 0.000. The shared toilet facility had an impact on the health of the child. The results showed that the likelihood of childhood diarrhea was higher in the households that used a shared toilet facility (16%), while the lowest incidence of diarrhea was reported in households that had not used a shared toilet (12%) and households with access to water for hand washing had slightly less childhood diarrhea as compared to the household with no access to water for hand washing.

Results of the logistic regression

Logistic regression was employed to measure the impact of variables on the occurrence of child diarrhea. The dependent variable was the occurrence of child diarrhea, and it was 1 if yes, and 0 otherwise. Table 3 explained the effects of child-level variables. It revealed no significant differences in the likelihood of stunting by gender of the child and urban-rural residence. The age of the child was inversely proportional to the occurrence of child diarrhea, and it was significant. The results showed that the probability of occurrence of child diarrhea was highest among children between one and two years of age and falls with age. Children younger than 1 year are slightly less affected – we will return to this point in the discussion. The variable of birth order was not significant and will not be discussed here. Another important variable was the geographic location of the children; therefore, all nine divisions of Punjab were added to the logistic regression analysis. Bahawalpur Division was the omitted category. It was found that the probability of occurrence of child diarrhea was significantly higher in Dera Ghazi Khan Division followed by Sargodha, Multan, and Rawalpindi. However, a significantly lower rate of incidence was found in the Sargodha region.

Table 4 explains both child and maternal level factors. These results of child-level variables are in line with model 1 with the exception that rural children were significantly more likely to suffer from diarrhea. The variable of the mother's age showed interesting results. Mothers younger than 25 years are the omitted category, and it was found that the probability of occurrence of diarrhea among children increased as their mother's age increased beyond 30 years old. Mothers associated with the class of middle and secondary education were found less likely

Table 2
Unadjusted risk factors of death incidence among under-five children (0–59 months).

Variables	Incidence of diarrhea		*P* value
	Yes	No	
i. Child level variable			
Gender of the children			0.013
Male	14.08	85.92	
Female	13.22	86.78	
Age of the children (years)			0.000
<11 months	18.68	81.32	
12–23 months	19.04	80.96	
24–35 months	12.62	87.38	
36–47 months	9.63	90.37	
48–59 months	8.10	91.90	
Birth order			0.032
1st	13.74	86.26	
2–3	13.36	86.64	
4–6	13.64	86.36	
Greater than 7th	15.60	84.40	
ii. Mother level variable			
Age of Mother at birth (in Years)			0.000
≤25	17.16	82.84	
25–29	14.46	85.54	
>29	11.97	88.03	
Education of mother (schooling years)			0.000
Preschool	15.21	84.79	
Primary	14.05	85.95	
Middle	13.22	86.78	
Secondary	11.52	88.48	
Higher	10.45	89.55	
No response	10.64	89.36	
Women have health insurance			0.008
Yes	10.59	89.41	
No	13.76	86.24	
No response	8.33	91.67	
Mother has Access to Mobile			0.000
Yes	12.03	87.97	
No	14.94	85.06	
No response	14.29	85.71	
iii. Household-level variables			
Father's age (in years)			0.000
≤30	15.89	84.11	
31 to 60	12.53	87.47	
>60	15.74	84.26	
Do not know	12.50	87.50	
No response	14.46	84.54	
Wealth Status			0.000
Poor	16.22	83.78	
Middle	11.99	88.01	
Rich	10.53	89.47	
No response	10.64	89.36	
iv. Geographic variables			
Area of Residence			0.012
Rural	13.93	86.07	
Urban	12.93	87.07	
Region of Residence			0.000
Bahawalpur	12.03	87.97	
DG Khan	24.99	75.01	
Faisalabad	13.49	86.51	
Gujranwala	8.91	91.09	
Lahore	10.87	89.13	
Multan	15.16	84.84	
Rawalpindi	13.65	86.35	
Sahiwal	10.54	89.46	
Sargodha	14.69	85.31	
iv. Environmental related variables			
Source of drinking water			0.001
Piped into dwelling/yard/neighbor/tanker	12.76	87.24	
Tubewell/motor pump/hand pump	14.12	85.88	
packed/bottled water	12.79	87.21	
No response	10.78	89.22	
Type of Toilet facility			0.000
Flush to piped sewerage/septic tank	11.55	88.45	
Flush to pit latrine/ open drain/improved pit latrine	13.01	86.99	
Bucket /field/others	15.36	84.64	
No response	16.74	83.26	
Location of the toilet facility			0.000
Dwelling	11.60	88.40	
Plot	14.49	85.51	
No response	16.49	83.51	
Toilet facility shared			0.000
Yes	16.43	83.57	
No	12.48	87.52	
No response	16.47	83.53	
Water available for hand washing			0.8666
Yes	13.66	86.34	
No	14.07	85.93	
No response	13.31	86.69	

Note: Figures in parenthesis are frequencies.
(Source: MICS, 2017–18 survey data analysis)

to see their children suffering from diarrhea. Having access to a mobile phone had a significant impact on child diarrhea. It was found from the results that the probability of occurrence of child diarrhea was higher when the mother did not possess a mobile phone.

Table 5 shows the occurrence of child diarrhea due to household-level variables and shows similar results as models 1 and 2. The results showed that the age of the husband/child's father has no significant impact on the occurrence of child diarrhea. The wealth index had a significant impact on the occurrence of child diarrhea, and it is evident from the results that households with poor wealth conditions had the highest probability of their children being diagnosed with child diarrhea followed by households with middle incomes.

Table 6 shows the occurrence of child diarrhea due to environmental variables and confirms earlier results. The results showed that in the source of drinking water, the households who had piped into

Table 3
Occurrence of child diarrhea due to child-level and geographic variables (Model-1).

Ind. Variables with code's description	Odds ratios	Std. Err.	P > | z |
Gender of the child (Male = 1, 2 Female)	0.958	0.033	0.205
Child age (Omitted category is 48 to 59 months)			
0–11 months	1.040	0.048	0.376
12–23 months	0.616	0.031	0.000
24–35 months	0.467	0.250	0.000
36–47 months	0.360	0.220	0.000
Birth order (1 to 6 Years = 1, otherwise 2)	0.999	0.774	0.998
Area residence (1 = urban and 2 = rural)	1.041	0.398	0.291
Division (Bahawalpur is the omitted category)			
Dera Ghazi Khan	2.542	0.199	0.000
Faisalabad	1.094	0.903	0.276
Gujranwala	0.784	0.061	0.002
Lahore	0.948	0.077	0.511
Multan	1.391	0.109	0.000
Rawalpindi	1.189	0.096	0.033
Sahiwal	0.938	0.090	0.508
Sargodha	1.458	0.121	0.000
_Cons	0.188	0.024	0.000

Dep. Variable = Ch_diarrh (1 = Yes & 0 = No).
LR Chi2 (15) = 966.46, Prob > chi2 = 0.0000, Pseudo R2 = 0.0399, log = −11,641.934.

Table 4
Occurrence of child diarrhea due to child, mother, and geographic level variables (Model-2).

Ind. Variables with code's description	Odds ratios	Std. Err.	P > | z |
Child's gender (Male = 1, 2 otherwise)	0.958	0.033	0.211
Child age (Omitted category is 48–59 months)			
0–11 months	1.058	0.049	0.221
12–23 months	0.634	0.032	0.000
24–35 months	0.485	0.026	0.000
36–47 months	0.377	0.023	0.000
Birth_order (1 to 6 Years = 1, otherwise 2)	1.048	0.085	0.555
Area residence (1 = Urban and 2 = rural)	1.098	0.043	0.017
Division (Bahawalpur is the omitted category)			
Dera Ghazi Khan	2.500	0.197	0.000
Faisalabad	1.135	0.094	0.125
Gujranwala	0.844	0.067	0.035
Lahore	0.977	0.079	0.780
Multan	1.400	0.110	0.000
Rawalpindi	1.303	0.107	0.001
Sahiwal	0.953	0.091	0.615
Sargodha	1.490	0.123	0.000
Mother Age (Years), Omitted category ≥25 years			
<25 >30 years	0.929	0.044	0.118
>30 years	0.796	0.038	0.000
Mother's Education (omitted category is college/university degree or higher than 12			
Preschool	1.011	0.046	0.811
Primary	0.967	0.057	0.564
Middle	0.829	0.047	0.001
Secondary	0.783	0.048	0.000
Higher	1.189	0.130	0.115
No Response	1068	0.040	0.081
_cons	0.122	0.033	0.000

Dep. Variable = ch_diarrhea (1 = Yes & 0 = No).
Chi2 (15) =1040.15, Prob >chi2 = 0.0000, R2 = 0.0429, log = −11,605.087.

Table 5
Occurrence of child diarrhea due to child, mother, household, and geographic level variables (Model-3).

Ind. Variables with code's description	Odds ratios	Std. Err.	P > | z |
Child's gender (Male = 1, 2 otherwise)	0.959	0.033	0.224
Child age (Omitted category is 48–59 months)			
0–11 months	1.061	0.049	0.201
12–23 months	0.635	0.033	0.000
24–35 months	0.487	0.026	0.000
36–47 months	0.379	0.023	0.000
Birth order (1 to 6 Years = 1, otherwise 2)	1.035	0.084	0.673
Area Residence (1 = Urban and 2 = rural)	1.170	0.048	0.000
Division (Bahawalpur is the omitted category)			
Dera Ghazi Khan	2.427	0.192	0.000
Faisalabad	1.170	0.975	0.058
Gujranwala	0.902	0.073	0.201
Lahore	1.020	0.084	0.792
Multan	1.410	0.112	0.000
Rawalpindi	1.390	0.116	0.000
Sahiwal	0.962	0.092	0.689
Sargodha	1.501	0.124	0.000
Mother Age (Years), Omitted category ≥25 years			
<25 >30 years	0.939	0.045	0.190
<30 years	0.816	0.044	0.000
Mother's Education (omitted category is college/university degree or higher than 12			
Preschool	1.047	0.049	0.330
Primary	1.029	0.062	0.630
Middle	0.906	0.054	0.102
High	0.879	0.590	0.052
Mother health Insurance (Yes = 1, 2 otherwise)	1.182	0.130	0.128
Mobile (Yes = 1, 2 otherwise)	1.043	0.039	0.262
Father age (omitted category is <60 years)			
≥30 years	0.959	0.040	−0.330
<30> 60 years	0.863	0.378	0.738
Wealth index (omitted category is rich)			
Poor	0.835	0.037	0.000
Middle	0.755	0.053	0.000
_cons	0.129	0.034	0.000

Dep. Variable = Ch_diarrh (1 = Yes & 0 = No).
LR Chi2 (15) =1061.38, Prob > chi2 = 0.0000, Pseudo R2 = 0.0438, log = −11,594.472.

dwelling/yard/neighbor facility of drinking water had the highest probability of their children being diagnosed with diarrhea followed by the drinking facility of motor pump/hand pump and then drum, crane/tanker/packed/bottled water. On the other hand, households with a toilet facility of flush had less probability of their children to be diagnosed with diarrhea than those with toilet facilities in open drains and fields. The households with toilets in their house dwellings had less probability of their children being diagnosed with diarrhea than the households with toilet facilities in open plots. The results also revealed that if the toilet facility was shared, the probability of child diarrhea was higher, while if the household had a hand wash facility the probability of child diarrhea was lower.

Discussion

Using descriptive statistics and cross-tabulation, this study examined the socioeconomic, demographic, household, and environmental factors related to diarrhea in children under the age of five (0–59 months) in Punjab, Pakistan, using data from the subnational-level MICS 2017–18. In models, it is discovered that factors such as a child's age, gender, birth order, mother's education level, age, health insurance coverage, mother's smartphone access, father's age, family wealth, status, rural and urban areas, water source, improved or unimproved water, toilet facility, location of the toilet, and hand washing facility, all played a significant role in a child's risk of diarrhea.

According to the study's findings, newborns had a considerably higher risk of developing diarrhea than older children do. Particularly, the likelihood of diarrhea was four times higher in children aged 0 to 11 months and three times higher in children aged 12 to 24 months. It might be because, between the ages of 7 and 24 months, when a child transitions from complementary milk feeding (breastfeeding) to other solid and semi-solid foods, this may result in unhygienic food, food contamination, a decline in the antibodies children acquired from their mother, or direct contact with contaminated dirt and animal feces. This result is in line with the previous studies from Pakistan (Ali et al., 2022), India (Gupta et al., 2015), and Ethiopia (Gebru et al., 2014). Gender was an important predictor of childhood diarrhea. In Pakistan, compared to boys (14.1%), girls are 13.2% less likely to have diarrhea (cross-tabulation). This result is in line with the study from Bangladesh (Sarker et al., 2016).

Child health outcomes were significantly impacted by childbirth order. The prevalence of diarrhea ranged from 1 to 6, with the lower birth orders having a prevalence of 13.5% and the higher birth orders having a prevalence of 15.6%. In Punjab, a mother's higher level of education was substantially correlated with a reduced under-five diarrhea prevalence. This outcome is consistent with research from Algeria and Karachi, Pakistan (Ferahtia et al., 2021; Khaliq et al., 2022). It is debatable how parents' levels of education can affect their children's health outcomes, but it is assumed that more educated parents are more likely to have access to resources and knowledge related to (health care), be relatively wealthy, and be better able to provide for their children's needs (George et al., 2014; Khaliq et al., 2022).

Another important aspect is the mother's age; as the mother was older, the prevalence of diarrhea declined. Health insurance seems to be important because mothers who possessed health insurance had access to better medical facilities than mothers without health insurance, as it gave them access to critical and practical knowledge of the correct health facilities that had to be provided to the children. Similarly, women's exposure to the media was crucial to reducing diarrhea. Previous studies by Iram and Butt (2008) presented similar results that

Table 6
Occurrence of child diarrhea due to child, mother, household, geographic, and environmental level variables (Model-4).

Ind. Variables with code's description	Odds ratios	Std. Err.	P > | z |
Child's gender (Male = 1, 2 otherwise)	0.957	0.033	0.204
Child age			
0–11 months	1.060	0.049	0.203
12–23 months	0.635	0.032	0.000
24–35 months	0.485	0.026	0.000
36–47 months	0.379	0.023	0.000
Birth order (1 to 6 Years = 1, otherwise 2)	1.048	0.085	0.563
Area residence (1 = Urban and 2 = rural)	1.152	0.053	0.002
Division			
Dera Ghazi Khan	2.454	0.204	0.000
Faisalabad	1.139	0.097	0.127
Gujranwala	0.884	0.075	0.151
Lahore	1.006	0.084	0.941
Multan	1.451	0.117	0.000
Rawalpindi	1.386	0.119	0.000
Sahiwal	0.979	0.096	0.834
Sargodha	1.512	0.127	0.000
Mother age (Years), Omitted category ≥25 years			
<25 >30 years	0.932	0.045	0.151
<30 years	0.813	0.043	0.000
Mother's education (omitted category is college/university degree or higher than 12			
Preschool	1.042	0.048	0.371
Primary			
Secondary	1.024	0.062	0.686
Middle	0.896	0.054	0.075
High	0.876	0.058	0.048
Mother health insurance (Yes = 1, 2 otherwise)	1.184	0.130	0.124
Mobile (Yes = 1, 2 otherwise)	1.044	0.039	0.255
Father age (omitted category is <60 years)			
≥30 years	0.955	0.040	0.281
<30 >60 years	0.862	0.378	0.737
Wealth index (omitted category is rich)			
Poor	0.832	0.039	0.000
Middle	0.750	0.057	0.000
Drinking water source (omitted category is the drum, crane/tanker/packed/bottled water			
Motor pump/hand pump	0.878	0.413	0.006
Piped into dwelling/yard/neighbor	1.072	0.065	0.249
Toilet facility (omitted category = Flush)			
Open drain	1.076	0.061	0.006
Fields	1.052	0.679	0.249
Location of the toilet (omitted category = dwelling)			
Plot	0.964	0.041	0.396
Shared facility (Yes = 1, 0 otherwise)	0.854	0.039	0.000
Hand washing (Yes = 1, 0 otherwise)	0.837	0.099	0.138
Cons	0.217	0.069	0.000

Dep. Variable = Ch_diarrh (1 = Yes & 0 = No).
LR Chi^2 (15) = 1092.04, Prob > chi^2 = 0.0000, Pseudo R^2 = 0.0450, log = − 11,579.14.

mothers having access to media took proper care of their children resulting in a lower incidence of diarrheal disease in their children. In general, rural communities experienced more cases of diarrhea than their metropolitan counterparts (Mengistie et al., 2013). This is true because metropolitan regions have better access to upgraded water and sanitation systems, as well as better access to medical care and knowledge of the signs and treatment of diarrhea.

Rural populations are also more likely to be impoverished, which impacts their ability to increase the standard of hygiene practices as well as their access to services (Alebel et al., 2018). Additionally, under-five diarrhea was adversely correlated with household affluence. Better living conditions and more healthcare services are available to wealthier households. This can lessen the likelihood of diarrhea in households with more resources. On the other hand, households with lower levels of wealth and prestige are less likely to have access to essential amenities like hygienic toilets, clean water, and sanitation (Asif et al., 2022).

Reducing the prevalence of diarrhea, one of the leading causes of child deaths, and access to toilet facilities lowers the chance of child mortality (Asif et al., 2022). In 2017, diarrheal disease, which kills 0.53 million people annually worldwide, was the cause of death for every tenth child (Dadonaite et al., 2019). Participating in Water Sanitation and Hygiene (WASH) programs by the United Nations Children's Fund (UNICEF) is the best way to prevent diarrheal illnesses, which can lower under-five mortality rates (Cairncross et al., 2010). The presence of fecal material in drinking water indicates the presence of enteropathogenic, which are responsible for a variety of enteric diseases, such as diarrhea, typhoid, cholera, and others. The lack of access to safe drinking water is referred to as fecal material contamination of drinking water (Loyola et al., 2020; Parvin et al., 2021). The likelihood of diarrheal and enteric infections in children was also raised by using communal restrooms and outdated restroom facilities (Hubbard et al., 2020; Ishimwe et al., 2020). However, diarrhea brought on by environmental enteric infections may be prevented by washing hands after urinating (Hubbard et al., 2020).

The high endemicity of diarrheal illnesses was significantly impacted by environmental factors related to sanitation and hygiene. In this context, efforts should focus on ambient sanitation and hygiene aspects as well as maternal socio-behavioral knowledge and behaviors. The study found a considerably increased incidence of severe diarrheal disease in children whose mothers were less aware of the value of career hygiene and good sanitary practices.

The administrative divisions of the Punjab province differ significantly from one another. For instance, DG Khan, which has higher levels of diarrheal illnesses due to its lower standard of living as compared to the Rawalpindi district, has a much lower prevalence of diarrhea among children under the age of five (0–59 months) than Gujranwala. Due to its urban setting, one interpretation is feasible. Due to the area's economic disadvantage, households in the DG Khan division struggle to cover their medical expenses on a limited budget. Similar to Multan, a district like Lahore experiences fewer incidences of diarrhea due to Lahore's superior health services and status as Punjab's second-largest metropolis. However, just a small number of the districts in an Indian study were not classified as hotspots, highlighting the need for rigorous testing and inference in cluster analysis. They discovered that there was a spatial association between the occurrence of diarrhea in rural regions and the beta-coefficient, which was much greater there (Chaurasia et al., 2020).

Practical implications

Diarrheal mortality among infants and under-five children is a significant public health issue in Punjab, Pakistan. Some practical implications to consider addressing this problem are:

- Improve access to safe drinking water: The most common cause of diarrheal mortality among children is the consumption of contaminated water. Therefore, it is crucial to ensure that communities have access to safe drinking water sources. This can be achieved through the installation of water filtration systems, regular water quality monitoring, and public awareness campaigns about the importance of using safe water
- Increase awareness about hygiene and sanitation: Poor hygiene and sanitation practices also contribute to the spread of diarrheal diseases. It is essential to educate caregivers and children about proper handwashing techniques, safe disposal of feces, and the importance of keeping the environment clean
- Strengthen healthcare facilities: Adequate healthcare facilities with trained healthcare professionals are necessary to manage diarrheal illnesses effectively. Strengthening primary healthcare services and increasing access to oral rehydration therapy can help reduce mortality rates among children with diarrheal illnesses

- Improve nutrition: Malnourished children are more susceptible to diarrheal illnesses, and diarrheal illnesses can worsen malnutrition. Improving access to nutritious food and promoting good feeding practices can help reduce the incidence and severity of diarrheal illnesses
- Increase public awareness: Raising public awareness about the dangers of diarrheal illnesses and the measures to prevent them can help reduce mortality rates. This can be done through public health campaigns, community outreach programs, and partnerships with local media outlets
- Overall, addressing the problem of diarrheal mortality among infants and under-five children in Punjab, Pakistan, requires a comprehensive approach that involves improving access to safe water, promoting hygiene and sanitation practices, strengthening healthcare facilities, improving nutrition, increasing public awareness, improving the parents' education level, and several other mother health related factors such as giving birth to a child at younger age of the mother and birth order of the children.

It is, therefore, concluded that interventions targeting infants and mothers of infants aimed at reducing diarrhea are expected to be very effective to reduce child mortality, one of the main child health challenges faced by Pakistan.

Limitations

The study has limitations as some respondents may not accurately report their observations regarding certain questions, resulting in social desirability biases. The study is also limited in consideration of the retrospective birth history and ignored the explicit focus on the mechanism that facilitates the relationship between diarrheal disease occurrence and birth intervals. Furthermore, using matched and unmatched conditional logistic regression estimates may be employed to delve into the study objectives using the dataset from more than one round of MICS surveys. It will further support the policy made to specify the strategic direction for decreasing the prevalence of diarrheal disease among under five children.

Conclusions

Using the most recent representative data from the MICS 2017–18 performed by the Bureau of Statistics, we explore the predictors of childhood diarrhea among children under the age of five (0–59 months) in Punjab, Pakistan. Our findings add to the body of literature by demonstrating how enhancing the source of the water source might lessen the likelihood that the water would become polluted during delivery and, as a result, lower the incidence of diarrhea, particularly in the poorest households. Our findings also indicated that young children have a higher risk of developing diarrhea, and that risk decreases with age. As a result, interventions aimed at young children are likely to have a positive impact on the incidence of diarrhea since infant mortality is one of Pakistan's main problems with child health.

In Pakistan, a developing nation, poverty is among the most significant and urgent problems. Diarrhea is more common among children as a result of the prevalence of poverty, poor sanitation and health facilities, lower levels of education, especially among women, and bad socioeconomic situations of the population. To address the issue of newborn and child mortality in the nation, effective public policy that aims to improve the socioeconomic position of the poor and ensure the provision of health and sanitary services can be a significant solution.

Authors' contribution

All authors contributed to the theoretical basis of this study. The selection of studies was conducted by under the supervision of Dr. C.F.A. van Wesenbeeck, Associate professor Development Economics and Dr. Unnati Rani Saha, Scientific Researcher, Erasmus MC, University Medical Center Rotterdam, The Netherlands. All authors contributed to the discussion and interpretation of results. The final manuscript was read and approved by all authors. All authors have read and agreed to the published version of the manuscript.

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Ethics approval and consent to participate

The data were obtained via online registration and downloaded after the purpose of the analysis was communicated and approved. An approval letter for the use of the MICS data set was gained from beauro of statistics Punjab. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

CREDIT Statement

I, [saher jabeen], hereby sumit a research paper for publication in the Journal of Pediatric Nursing. The research paper is entitled “An Overview of Diarrhea Among Infants and Under-five in Punjab-Pakistan”. The research paper aims to analyze the prevalence of diarrhea among infants and under-five in Punjab-Pakistan, the associated risk factors, and the current public health interventions to reduce the prevalence. The research paper is the result of extensive literature review, interviews and surveys conducted in Punjab-Pakistan. I certify that the research paper is my original work and does not contain any plagiarized material.

Data availability

The dataset was demanded and retrieved from the Beauro of statistics website https://mics.unicef.org/surveys after formal online registration and submission of the project title and detailed description.

Declaration of Competing Interest

The authors declare that they have no any competing interests.

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