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Abstract: Diarrhea and fever are prevalent childhood illnesses with potentially severe consequences, especially when they co-occur. This study investigates the prevalence and determinants of diarrhea, fever, and their coexistence among children under-five in Bangladesh. Data from the 2017-18 Bangladesh Demography and Health Survey (BDHS) were analyzed using multivariable stepwise logistic regression with backward selection. This study found that 5.0% for diarrhea, 34.0% for fever, and 3.0% for the coexistence of both illnesses. Common factors associated with childhood diarrhea and fever included the mother's education, her attitude toward wife-beating, and the child's age (12-23 months). Diarrhea was associated with households with improved water sources and children in the Barisal division, while fever was linked to underweight children and those from more affluent backgrounds. The coexistence of both was significantly linked to underweight children, higher birth orders, and children from the Rajshahi division. Notably, child illnesses were associated with parental education, higher socio-economic status, and access to improved drinking water sources. Diarrhea affects one in 20 children, fever affects one in three, and the coexistence of both conditions affects one in 35 children in Bangladesh. The findings need further research and policy reviews to develop effective interventions and improve child health in Bangladesh.

Keywords: children; morbidity; comorbidity; determinants; Bangladesh

1. Introduction

Diarrhea and fever in children are two serious public health problems in low- and middle-income countries. Worldwide diarrhea alone contributes to around 0.5 million under-five children's death every year and is the second leading cause of death in children under five years old [1,2]. Globally, there are nearly 1.7 billion cases of childhood diarrhea are recorded every year [2,3]. According to UNICEF (2021), approximately 5 million under-five children died worldwide, of which, about 30% were attributed due to infectious diseases, many of which present with diarrhea and fever [4,5]. Fever in children occurs mostly due to an infection (such as strep throat, the flu, chickenpox, pneumonia), inflammation and trauma [6], malaria, dengue, chikungunya, typhoid, and diarrhea [7]. Developing countries often face a high burden of childhood illness due to several factors, including

poor living conditions, limited access to healthcare, inadequate nutrition, and exposure to infectious diseases.[8] Diarrhea and fever are common health problems among children under-five in Bangladesh, as in many other developing countries [9].

Both the fever and diarrhea are among the top three causes of mortality among children in Bangladesh [1,7]. Although the under-five child mortality has decreased from 44/1000 live births in 2011 to 27/1000 in 2021 [10,11] and achieved the Millennium Development Goal-4 (MDG-4) target of 48/1000 LBs by the year 2015, childhood illness has not declined at the same pace [1]. Every year in Bangladesh approximately 0.5 million children's deaths occur due to diarrhea which is more than AIDS, malaria, and measles combined [7]. However, metrics with regard to under-five child deaths due to fever are yet to be revealed [12].

Factors associated with childhood diarrhea and fever are multifaceted, and both outcomes had complex interplay with maternal-child factors (e.g. mothers' education, unemployment status of mothers, age of children, infant and child feeding practice), environmental factors (e.g. drinking water, type of toilet facilities, household waste, and hygiene) and socioeconomic status in developing countries including Bangladesh, Ghana, Senegal, and Ethiopia [1,9,13–16]. However, factors associated with the coexistence of diarrhea and fever among under-five children are still underreported in Bangladesh. An earlier study in Bangladesh reported that poor socio-economic status and untreated water supply were associated with the coexistence of diarrhea and cough [17]. Diarrhea and fever when they occur together in children can create an adverse health hazard, such as malnutrition, increased risk of infections, electrolyte imbalances, reduced cognitive function, and others [18–20]. To the best of our knowledge, there has been no study conducted in Bangladesh using the most recent nationally representative survey to explore the factors linked to the coexistence of diarrhea and fever. Therefore, this study aims to determine the factors associated with diarrhea, fever, and the coexistence of diarrhea and fever among under-five children in Bangladesh based on the most recent Bangladesh Demographic and Health Survey.

2. Materials and Methods

2.1. Study design and participants

Cross-sectional data from a nationally representative sample namely the Bangladesh Demographic and Health Survey 2017-18 (BDHS 2017-18) was used in this study. In BDHS 2017-18, the data collection was started in October 2017 and finished in March 2018.

In BDHS 2017-18, used multistage stratified sampling technique was used to collect the data. At the first stage, the BDHS selected a total of 672 primary sampling units (PSUs) (192 PSUs from urban and 480 PSUs from rural) from 293,579 PSUs (according to the national census 2011) using probability proportional to EA size. In the second stage, 20,160 households were selected for data collection with 30 households from each selected PSU using an equal probability systematic sampling technique. This multistage sampling technique, including its sampling weight, helps reduce potential sampling bias. In the BDHS data, sample weights were calculated in each sampling stage, and each cluster and stratum were considered that had been adjusted for non-response to obtain the final standard weights. In addition, all ever-married women aged 15–49 years with children aged less than 5 years from the preselected households were interviewed without replacement and change in the implementing stage to prevent selection bias. Women verbal consent for collecting children's data, including demography, health, and nutrition. A total of 8,759 children under-five were listed, and a further 7,663 children were selected for analysis after excluding missing information (see Figure 1). Detail description was found in the BDHS 2017-18 report [7].
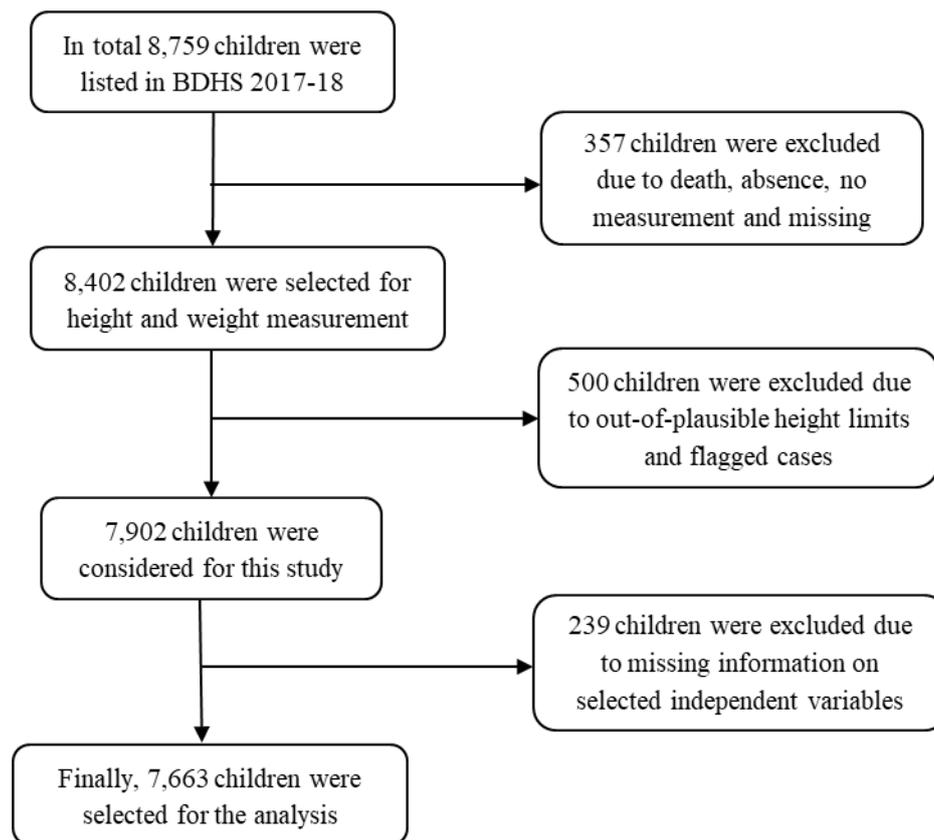
Figure 1. Selection of the sample size

2.2. Outcome Variables

The outcome variables were diarrhea, fever, and the comorbid condition of diarrhea and fever among under-five children. In BDHS 2017-18, Diarrhea refers to children who had diarrhea in the 2 weeks preceding the survey and received oral rehydration solution (ORS), and advice or treatment from health facilities or qualified health providers [7]. Fever refers to children who had a fever prior to two weeks of the survey and received advice or treatment from health facilities or qualified health providers [7]. The coexistence of diarrhea and fever refers to the simultaneous presence of both illnesses in a child in the two weeks preceding the survey.

2.3. Independent Variables and Operational Definition

Variables found significantly associated with child illness in various studies were included in this study [1,9,13–19,21,22]. Variables including maternal characteristics were age of the mothers (in years) (15-19, 20-24, 25-29, 30-34, 34-39, ≥ 40), parents' education (both parents uneducated, only father uneducated, only mother uneducated, both parents educated), mothers' currently working (no, yes), underweight mother (no, yes), mothers received antenatal care (no, yes), mothers received postnatal care (no, yes), mothers attitude toward wife-beating (not justified, justified), mother's decision-making autonomy (practiced, not practiced). Child characteristics include the age of the children (0-11 months, 12-23 months, 24-35 months, 36-47 months, 48-59 months), sex of the children (male, female), underweight children (no, yes), birth order of children (first, second, third, fourth and above), and small birth weight (no, yes, not weighted). Household characteristics include mass media exposure (no, yes), source of drinking water (improved, unimproved), type of toilet facility (improved, unimproved), and solid waste use in cooking (no, yes). Finally, contextual factors were wealth index (poorest, poorer, middle, richer, richest), place of residence (urban, rural), and region of residence (Barisal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet). Supplementary Table S1 contains the operational definitions for reference.

2.4. Statistical Analyses

The background characteristics of the respondents were assessed using descriptive statistics. Bivariate analysis (Chi-square test) was used to explore the prevalence of diarrhea, fever, and the coexistence of diarrhea and fever. The stepwise logistic regression with backward elimination analysis was used to identify the factors associated with diarrhea, fever, and comorbid conditions of diarrhea and fever. Variables found significant at p < 0.25 in the Chi-square test were entered into the regression analysis [23–25]. The results of regression analysis were assessed using odds ratios (ORs) and 95% confidence interval (CI) where p<0.05. To control the effect of the complex survey design (multistage sampling stage including its sampling weight), bivariate analysis analyses of this study were performed using Stata's 'svyset' command. Variance Inflation Factor (VIF) was used to evaluate the possible collinearity, and there was no multicollinearity problem identified among the study variables (VIF<5 for all variables). All statistical analyses were performed in Stata version 17 (StataCorp LP, College Station, Texas).

3. Results

3.1. Background characteristics

More than one-third (35.0%) of the total mothers belonged to the age group 20-24 years. Only 7.0% (3.8%+3.2%) of mothers had no formal education. Two out of five mothers (59.0%) were underweight. Furthermore, more than half (52.2%) of the children were male More than 40.0% of children belonged to poor socio-economic status. Approximately two-thirds (66.0%) of children were living in rural areas of Bangladesh (see Table 1).

Table 1. Background characteristics of the study variables.

Variables	Number	(%)	No of response/ missing or excluded
Total	**7,663**	**100.0**	**8,759/1,096**
Dependent variables			
Diarrhea			8,759/361
Fever			8,759/361
Independent variables			
Age of the mothers (in years)			
15-19	938	12.2	8,759/0
20-24	2,679	35.0	
25-29	2,146	28.0	
30-34	1,295	16.9	
34-39	481	6.3	
≥ 40	124	1.6	
Parents' education			
Both parents uneducated	295	3.8	8,759/153
Only father uneducated	865	11.3	
Only mother uneducated	243	3.2	
Both parents educated	6,260	81.7	
Mother currently working			
No	4,561	59.5	8,759/0
Yes	3,102	40.5	
Underweight mother			
No	6,537	85.3	8,759/0
Yes	1,126	14.7	

Mothers received antenatal care [#]			
No	364	8.0	8,759/3,747
Yes	4,175	92.0	
Mothers received postnatal care [#]			
No	1,509	33.3	8,759/ 3,753
Yes	3,025	66.7	
Mother's attitude towards wife beating			8,759/0
Not justified	6,266	81.8	
Justified	1,397	18.2	
Mother's decision-making autonomy			
No	6,581	85.9	8,759/154
Yes	1,082	14.1	
Age of the children			
0-11 months	1,677	21.9	8,759/447
12-23 months	1,577	20.6	
24-35 months	1,481	19.3	
36-47 months	1,414	18.4	
48-59 months	1,514	19.8	
Sex of the children			
Male	3,996	52.2	8,759/0
Female	3,667	47.8	
Underweight children			
No	5,972	77.9	8,759/709
Yes	1,691	22.1	
Birth order of the children			
First	2,903	37.9	8,759/0
Second	2,507	32.7	
Third	1,298	16.9	
Fourth and above	955	12.5	
Small birth weight [#]			
No	1,816	38.3	8,759/3,455
Yes	325	6.9	
Not weighted	2,594	54.8	
Mass media exposure			
No	2,774	36.2	8,759/0
Yes	4,889	63.8	
Source of drinking water			
Improved	6,659	86.9	8,759/0
Unimproved	1,004	13.1	
Type of toilet facility			
Improved	4,362	56.9	8,759/0
Unimproved	3,301	43.1	
Solid waste use in cooking			
No	2,219	29.0	8,759/6
Yes	5,444	71.0	
Wealth index			
Poorest	1,707	22.3	8,759/0
Poorer	1,545	20.2	
Middle	1,382	18.0	
Richer	1,535	20.0	

Richest	1,494	19.5	
Place of residence			
Urban	2,605	34.0	8,759/0
Rural	5,058	66.0	
Division			
Barisal	800	10.4	8,759/0
Chattogram	1,246	16.2	
Dhaka	1,079	14.1	
Khulna	810	10.6	
Mymensingh	911	11.9	
Rajshahi	796	10.4	
Rangpur	879	11.5	
Sylhet	1,142	14.9	

#, information available only for children aged 0-23 months.

3.2. Prevalence of diarrhea, fever, and coexistence of diarrhea and fever

The overall prevalence of diarrhea, fever, and coexistence of diarrhea and fever among children under 5 were approximately 5.0%, 34.0%, and 3.0%, respectively. Children aged 12-23 months (9.1%), children of mothers with no formal education (when fathers were educated) (8.7%), children of teenaged (15-19 years) mothers (6.4%), children from the socio-economically middle class (6.1%), and children of mothers with no justified attitude towards wife-beating (5.2%) had a significantly higher prevalence of diarrhea (see Table 2).

Similarly, fever was more common among children aged 12-23 months with a prevalence of 40.0%, and those who were underweight (38.5%). It was also higher in children whose mothers had a justified attitude towards wife-beating (38.7%) and received postnatal care (38.2%). Children of fourth and higher birth order had a significantly higher prevalence of fever (37.0%) (see Table 2).

Children aged 12-23 months (4.8%) and those with a second birth order (3.4%) had a significantly higher prevalence of coexistence of fever and diarrhea. Additionally, the prevalence of this coexistence of fever and diarrhea was higher among children of underweight mothers (3.8%) and those whose mothers had a justified attitude towards wife-beating (2.9%) (see Table 2).

Table 2. Prevalence of under-5 child acute morbidity and co-morbidity.

Variables	Diarrhea		Fever		Comorbidity	
	n	Prevalence (95% CI)	n	Prevalence (95% CI)	n	Prevalence (95% CI)
Total	**386**	**4.9 (4.3-5.5)**	**2561**	**33.7 (32.3-35.2)**	**218**	**2.7 (2.3-3.2)**
Age of the mothers (in years)						
15-19	61	6.4 (4.9-8.3)	352	37.1 (33.5-40.9)	39	3.9 (2.8-5.5)
20-24	141	5.2 (4.3-6.2)	857	32.5 (30.4-34.7)	69	2.6 (2.0-3.3)
25-29	120	5.3 (4.3-6.4)	732	33.8 (31.4-36.3)	66	2.8 (2.1-3.6)
30-34	46	3.3 (2.4-4.6)	428	33.7 (30.8-36.7)	32	2.5 (1.6-3.7)
34-39	12	2.7 (1.5-4.8)	153	33.7 (29.0-38.6)	6	1.3 (0.5-3.0)
≥ 40	6	3.8 (1.5-8.9)	39	30.4 (22.2-40.1)	6	3.8 (1.5-8.9)
Chi-square p values	*p* = 0.008		*p* = 0.301		*p* = 0.114	

Parents' education						
Both parents uneducated	10	4.8 (2.5-8.9)	105	34.4 (28.5-40.7)	6	2.8 (1.2-6.2)
Only father uneducated	34	3.5 (2.4-4.9)	276	32.4 (28.9-36.0)	16	1.5 (0.9-2.6)
Only mother uneducated	20	8.7 (5.5-13.4)	73	29.3 (23.5-35.8)	10	3.7 (1.9,7.2)
Both parents educated	322	4.9 (4.3-5.6)	2107	34.0 (32.4-35.7)	186	2.9 (2.4-3.4)
Chi-square p values	$p = 0.032$		$p = 0.467$		$p = 0.172$	
Mother currently working						
No	242	5.1 (4.5-5.9)	1552	34.4 (32.6-36.2)	139	3.0 (2.5-3.5)
Yes	144	4.5 (3.7-5.4)	1009	32.7 (30.7-34.8)	79	2.4 (1.9-3.1)
Chi-square p values	$p = 0.246$		$p = 0.214$		$p = 0.175$	
Underweight mother						
No	67	6.0 (4.6-7.8)	2163	33.5 (32.0-35.1)	174	2.6 (2.2-3.0)
Yes	319	4.7 (4.2-5.3)	398	34.7 (31.4-38.2)	44	3.8 (2.8-5.2)
Chi-square p values	$p = 0.070$		$p = 0.508$		$p = 0.021$	
Mothers received antenatal care						
No	27	7.5 (4.9-11.3)	138	39.0 (32.8-45.4)	13	3.3 (1.8-5.8)
Yes	285	6.6 (5.8-7.5)	1533	36.8 (35.0-38.7)	163	3.8 (3.2-4.5)
Chi-square p values	$p = 0.216$		$p = 0.518$		$p = 0.623$	
Mothers received postnatal care						
No	100	6.8 (5.6-8.4)	530	34.7 (32.1-37.5)	55	3.7 (2.8-4.8)
Yes	212	6.6 (5.7-7.7)	1140	38.2 (36.0-40.4)	121	3.8 (3.1-4.7)
Chi-square p values	$p = 0.819$		$p = 0.040$		$p = 0.822$	
Mothers attitude towards wife beating						
No	332	5.2 (4.6-5.9)	2019	32.5 (31.0-34.1)	187	2.9 (2.5-3.5)
Yes	54	3.4 (2.5-4.6)	542	38.7 (35.8-41.7)	31	1.9 (1.3-2.8)
Chi-square p values	$p = 0.012$		$p = 0.0001$		$p = 0.042$	
Mother's decision-making autonomy						
No	51	4.6 (3.4-6.2)	379	34.7 (31.3-38.4)	192	2.8 (2.3-3.2)
Yes	335	4.9 (4.3-5.6)	2182	33.5 (32.0-35.1)	26	2.5 (1.7-3.8)
Chi-square p values	$p = 0.699$		$p = 0.521$		$p = 0.699$	
Chi-square p values	$p = 0.091$		$p = 0.009$		$p = 0.255$	
Age of the children						

0-11 months	101	5.7 (4.5-7.2)	608	36.8 (34.3-39.5)	63	3.5 (2.6-4.7)
12-23 months	147	9.1 (7.7-10.8)	635	40.0 (37.0-43.1)	77	4.8 (3.8-6.1)
24-35 months	73	5.0 (3.9-6.3)	488	33.3 (30.5-36.3)	41	2.8 (2.0-3.8)
36-47 months	38	2.5 (1.8-3.5)	413	29.4 (26.8-32.1)	20	1.2 (0.8-2.0)
48-59 months	27	1.5 (1.0-2.3)	417	27.9 (25.2-30.7)	17	1.0 (0.6-1.7)
Chi-square p values		*p*<0.001		*p*<0.001		*p*<0.001
Sex of the children						
Male	221	5.3 (4.5-6.2)	1357	34.4 (32.7-36.3)	123	3.0 (2.5-3.7)
Female	165	4.4 (3.7-5.2)	1204	32.9 (30.9-34.9)	95	2.4 (1.9-3.0)
Chi-square p values		*p* = 0.116		*p* = 0.200		*p* = 0.130
Underweight children						
No	304	4.8 (4.2-5.5)	1908	32.4 (30.8-34.0)	163	2.6 (2.2-3.1)
Yes	82	5.1 (4.0-6.5)	653	38.5 (35.8-41.3)	55	3.3 (2.4-4.4)
Chi-square p values		*p* = 0.678		*p* = 0.0001		*p* = 0.170
Birth order of the children						
First	143	4.8 (4.0-5.7)	909	31.8 (29.7-33.9)	78	2.5 (2.0-3.2)
Second	144	5.6 (4.7-6.8)	850	33.9 (31.7-36.2)	87	3.4 (2.6-4.3)
Third	63	4.8 (3.7-6.1)	454	35.2 (32.4-38.1)	36	2.9 (2.0-4.0)
Fourth and above	36	3.4 (2.3-4.9)	348	37.0 (33.4-40.7)	17	1.6 (0.9-2.8)
Chi-square p values		*p* = 0.088		*p* = 0.036		*p* = 0.057
Small birth weight						
No	134	6.9 (5.7-8.3)	637	35.1 (32.7,37.6)	77	4.0 (3.1-5.0)
Yes	26	7.7 (5.1-11.5)	132	41.8 (35.6-48.2)	12	4.0 (2.1-7.2)
Not weighted	163	6.3 (5.4-7.4)	964	37.4 (35.2-39.6)	93	3.5 (2.8-4.4])
Chi-square p values		*p* = 0.616		*p* = 0.087		*p* = 0.776
Mass media exposure						
No	124	4.5 (3.6-5.6)	952	34.2 (32.0-36.5)	68	2.6 (1.9-3.5)
Yes	262	5.1 (4.4-5.8)	1609	33.4 (31.7-35.2)	150	2.8 (2.3-3.4)
Chi-square p values		*p* = 0.395		*p* = 0.545		*p* = 0.664
Source of water						
Improved	351	5.0 (4.5-5.7)	2247	34.0 (32.5-35.5)	195	2.8 (2.4-3.3)
Unimproved	35	3.7 (2.7-5.3)	314	31.6 (28.4-35.0)	23	2.4 (1.5-3.7)

Chi-square p values		$p = 0.089$		$p = 0.180$		$p = 0.486$
Type of toilet facility						
Improved	228	5.0 (4.3-5.8)	1450	33.7 (31.9-35.5)	129	2.8 (2.3-3.4)
Unimproved	158	4.7 (3.9-5.6)	1111	33.7 (31.8-35.7)	89	2.6 (2.0-3.3)
Chi-square p values		$p = 0.522$		$p = 0.952$		$p = 0.623$
Solid waste use in cooking						
No	99	4.2 (3.4-5.2)	669	31.1 (28.8-33.6)	56	2.4 (1.8-3.2)
Yes	287	5.2 (4.5-5.9)	1892	34.8 (33.1-36.5)	162	2.9 (2.4-3.4)
Chi-square p values		$p = 0.091$		$p = 0.009$		$p = 0.255$
Wealth index						
Poorest	84	4.9 (3.8-6.2)	600	35.0 (32.5-37.5)	47	2.7 (2.0-3.8)
Poorer	77	4.8 (3.8-6.1)	522	33.5 (30.7-36.5)	42	2.7 (2.0-3.7)
Middle	84	6.1 (4.7-7.9)	471	35.0 (32.0-38.1)	45	3.4 (2.4-4.6)
Richer	58	3.4 (2.6-4.5)	537	35.0 (32.1-38.0)	40	2.2 (1.5-3.1)
Richest	83	5.3 (4.1-6.7)	431	29.6 (26.8-32.6)	44	2.7 (2.0-3.7)
Chi-square p values		$p = 044$		$p = 0.034$		$p = 0.484$
Place of residence						
Urban	132	4.6 (3.7-5.7)	805	31.8 (29.4-34.3)	72	2.7 (2.0-3.6)
Rural	254	5.0 (4.3-5.7)	1756	34.4 (32.6-36.2)	146	2.8 (2.3-3.3)
Chi-square p values		$p = 0.567$		$p = 0.095$		$p = 0.833$
Division						
Barisal	51	6.5 (5.0-8.3)	296	38.3 (34.0-42.7)	24	3.1 (2.0-4.7)
Chattogram	67	5.3 (4.1-7.0)	412	33.3 (30.0-36.7)	43	3.3 (2.3-4.7)
Dhaka	44	4.1 (3.0-5.4)	340	31.8 (28.5-35.2)	19	1.7 (1.1-2.7)
Khulna	33	3.9 (2.8-5.4)	238	31.2 (27.1-35.6)	18	2.2 (1.4-3.5)
Mymensingh	47	5.0 (3.7-6.7)	301	33.7 (29.9-37.7)	30	3.2 (2.2-4.5)
Rajshahi	49	6.1 (4.6-8.1)	278	35.5 (30.9-40.3)	29	3.6 (2.4-5.4)
Rangpur	37	4.5 (3.0-6.7)	312	36.4 (32.2-40.7)	22	2.7 (1.6-4.4)
Sylhet	58	4.8 (3.5-6.6)	384	34.3 (31.4-37.2)	33	2.9 (2.0-4.2)
Chi-square p values		$p = 0.239$		$p = 0.297$		$p = 0.124$

Notes: CI, Confidence Interval; n, number of children.

Children aged 12-23 months had a significantly higher likelihood of getting diarrhea with an odd of 6.46 (Adjusted odds ratio (AOR): 6.46, 95% CI: 4.12-10.13, p < 0.001) compared to children aged

48-59 months. Children of mothers with no formal education (AOR=1.87, 95% CI=1.16-3.02, p = 0.010) and children from the Barisal division (AOR = 1.69, 95% CI=1.06-2.70, p=0.027) were significantly associated with diarrhea. Contrary, children from socio-economically richer (AOR=0.62, 95% CI=0.43-0.89, p = 0.010) and household with unimproved water sources (AOR=0.66, 95% CI=0.47-0.94, p = 0.021) negatively impacted childhood diarrhea (Table 3).

For the outcome, fever, children aged 12-23 months (AOR = 1.78, 95% CI =1.53-2.08, p = <0.001), being underweight (AOR = 1.36, 95% CI=1.21-1.53, p <0.000) and fourth & above birth ordered children (AOR = 1.27, 95% CI =1.08-1.49, p = 0.005) were associated with fever. On the other hand, the children of mothers with no formal education (when fathers were educated) had 15.0% (AOR = 0.85, 95% CI =0.72-1.00, p = 0.046) lower chances of getting fever than children with educated parents (Table 3).

Similarly, children aged 12-23 months (AOR = 5.17, 95% CI =2.94-9.12, p <0.001); from the Rajshahi division (AOR = 2.21, 95% CI =1.34-3.64, p = 0.002); being underweight 1.44, 95% CI =1.04-1.99, p = 0.028) were associated with the coexistence of diarrhea and fever. On the other hand, children with educated mothers had 49.0% (AOR = 0.51, 95% CI= 0.29-0.91, p= 0.023) lower chances of having a coexistence of diarrhea and fever than children of educated parents (Table 3).

Table 3. Risk factors of under-five child diarrhea, fever, and coexistence of diarrhea and fever.

Risk factors	Diarrhea		Fever		Coexistence of diarrhea and fever	
	AOR (95% CI)	*p* values	AOR (95% CI)	*p* values	AOR (95% CI)	*p* values
Parents' education						
Both parents uneducated	1.15 (0.65-2.03)	0.626	0.88 (0.67-1.14)	0.320	1.07 (0.52-2.21)	0.852
Only father uneducated	0.70 (0.47-1.04)	0.081	0.85 (0.72-1.00)	0.046	0.51 (0.29-0.91)	0.023
Only mother uneducated	1.87 (1.16-3.02)	0.010	0.70 (0.53-0.94)	0.016	1.31 (0.66-2.62)	0.442
Both parents educated®	1.00		1.00		1.00	
Mother's attitude towards wife beating						
No®	1.00		1.00		1.00	
Yes	0.63 (0.46-0.86)	0.100	1.30 (1.15-1.47)	<0.001	0.64 (0.42-0.97)	0.033
Age of the children						
0-11 months	3.97 (2.49-6.32)	<0.001	1.57 (1.35-1.83)	<0.001	3.77 (2.11-6.74)	<0.001
12-23 months	6.46 (4.12-10.13)	<0.001	1.78(1.53-2.08)	<0.001	5.17 (2.94-9.12)	<0.001
24-35 months	3.32 (2.06-5.34)	<0.001	1.32 (1.13-1.54)	0.001	2.78 (1.52-5.07)	0.001
36-47 months	1.64 (0.96-2.80)	0.068	1.08 (0.92-1.27)	0.346	1.24 (0.62-2.50)	0.542
48-59 months®	1.00		1.00		1.00	
Underweight children						
No®			1.00		1.00	
Yes			1.36 (1.21-1.53)	<0.001	1.44 (1.04-1.99)	0.028

	AOR (95% CI)	p-value	AOR (95% CI)	p-value	AOR (95% CI)	p-value
Birth order of the children						
First®			1.00			
Second			1.11 (0.99-1.24)	0.083		
Third			1.17 (1.02-1.35)	0.025		
Fourth and above			1.27 (1.08-1.49)	0.005		
Source of drinking water						
Improved®	1.00					
Unimproved	0.66 (0.47-0.94)	0.021				
Wealth index						
Poorest	0.92 (0.65-1.31)	0.650	1.21 (1.03-1.43)	0.018		
Poorer	0.88 (0.62-1.25)	0.484	1.13 (0.96-1.32)	0.142		
Middle	1.12 (0.81-1.56)	0.487	1.22 (1.04-1.44)	0.011		
Richer	0.62 (0.43-0.89)	0.010	1.23 (1.05-1.44)	0.009		
Richest®	1.00		1.00			
Division						
Dhaka®	1.00				1.00	
Barisal	1.69 (1.06-2.70)	0.027			1.80 (0.93-3.46)	0.079
Chattogram	1.33 (0.96-1.83)	0.085			1.93 (1.24-3.01)	0.004
Khulna	1.02 (0.65-1.60)	0.927			1.34 (0.73-2.45)	0.345
Mymensingh	1.24 (0.80-1.91)	0.336			1.85 (1.05-3.25)	0.033
Rajshahi	1.66 (1.15-2.41)	0.007			2.21 (1.34-3.64)	0.002
Rangpur	1.08 (0.71-1.64)	0.715			1.54 (0.89-2.66)	0.121
Sylhet	1.22 (0.79-1.90)	0.369			1.66 (0.93-2.97)	0.089

Notes: AOR, Adjusted odds ratio; CI, Confidence Interval and ®, Reference Category.

4. Discussion

The overall prevalence of diarrhea, fever, and coexistence of diarrhea and fever among children under-five were around 5.0%, 34.0%, and 3.0%, respectively in Bangladesh. The prevalence of diarrhea was higher in some neighboring countries, such as 29% in Afghanistan, 19% in Pakistan, and 10% in Myanmar, followed by 9% in India, 8% in Nepal, and 4% in Maldives [22,26]. Similarly, the prevalence of fever in Bangladesh was followed by Afghanistan (29%), Myanmar (24%) and Nepal (21%). However, the prevalence of fever was higher in Pakistan (38%) compared to Bangladesh [26]. While the reporting of the coexistence of diarrhea and fever was inadequate in Bangladesh, it is noteworthy that the prevalence of the coexistence of multiple illnesses was higher in Pakistan compared to Bangladesh, regardless of the combination of diarrhea and fever [27,28]. In addition, the

prevalence of diarrhea and coexistence of diarrhea and fever was significantly higher among children aged 12-23 months and fever was highly prevalent among children born with low birth weight.

This study also found that mothers with no formal education, children less than 2 years of age, and children from the richest socioeconomic status were critical factors associated with childhood diarrhea. Most of these factors were thoroughly examined and identified previously in Bangladesh, India, Pakistan, Nepal, and other African countries [9,27]. Despite notable advancements in women's education at all levels in Bangladesh, a significant proportion of females in the country still face inadequate access to education [29]. Additionally, the combination of poor-quality education, limited coverage and implementation of health education, as well as poverty, can have an impact on children's health [30,31]. Children under two years of age is critical for the health and development of children [32]. Factors such as inappropriate and imbalanced initiation of dietary patterns, an immature immune system, lack of previous exposure to pathogens like diarrheal-causing viruses, bacteria, or parasites, and a weakened digestive system in this age interval can adversely affect children's health [32,33]. Even children from higher socioeconomic backgrounds, who may have better access to resources and living conditions, can still experience diarrhea due to various reasons, such as consumption of stored, processed, raw, or undercooked food, overuse or misuse of antibiotics, and imbalanced dietary patterns [34,35]. Furthermore, research findings indicate that children from the Barisal division (southern region) have a higher likelihood of experiencing diarrhea. This increased prevalence can be attributed to climate change, frequent natural disasters, salinity, and land degradation, which have limited dietary diversity and created a substantial burden of adverse health effects in this particular region [36]. Remarkably, it was identified that an improved source of drinking water is a significant contributing factor to diarrhea among children under-five in Bangladesh. This could be attributed to various reasons, such as contamination during storage and handling, insufficient sanitation practices, issues with piped water distribution, unsafe water treatment practices, and other related factors [37]. To mitigate the adverse health outcomes in children, it would be beneficial to design and implement effective health interventions, preventive measures, and coverage that incorporate evidence-based health education, awareness programs, maternal reproductive and child health education, as well as appropriate sanitation and hygiene practices.

Educated parents, mothers justified wife beating, moderate-to-high socio-economic status, children less than 2 years of age, underweight children, and fourth and above birth order children had significant effects on childhood fever. The findings partially concurred with the previous studies conducted in Bangladesh, India, and other African countries [5,9,17,21,38]. The educational attainment of both parents is often linked to a higher socioeconomic status, leading to both parents engaging in income-generating activities. This can result in limited availability of time for children and potentially poor parenting practices, which may have negative effects on children's health [39]. Women who feel unfairly burdened by traditional gender roles in the household can create a stressful and emotionally unstable environment for their children, which can strain the parent-child relationship and lead to adverse health outcomes for the children [40,41]. Childhood undernutrition was another key factor associated with increased illness [42]. Although there is limited research on the relationship between birth order and children's health, studies have indicated that later-born children in larger families may face an elevated risk of hospitalization for infections, respiratory diseases, and issues related to the eyes and ears, possibly due to receiving less parental attention [43]. First-born children tend to receive more parental time and attention compared to their siblings, while subsequent children may receive less quality time during their early years. This discrepancy in parental attention can contribute to adverse health outcomes such as fever in children of higher birth order [44].

The coexistence of diarrhea and fever and the factors associated with it in Bangladesh has not been well documented. The current study found that only the mother's educational status (the father has no formal education) is a protective factor against the coexistence of diarrhea and fever rather than both parents' educational status. In addition, mothers do not justify wife-beating, children less than two years of age, underweight children, and Rajshahi division (mid-western region) were the

key factors associated with the coexistence of diarrhea and fever. Some of these results were consistent with previous studies irrespective of the outcome coexistence of diarrhea and fever [27,28]. The mid-western region (Rajshahi division) is one of the climate-vulnerable regions [45,46]. Frequent floods often record the highest temperature, contaminated groundwater, insufficient economic and social benefits, and poor access to basic needs pose a significant threat to human health resulting in poor child health outcomes [45–47]. Incorporating better management of climate disasters and water sources improved sanitation and hygiene, and educational intervention with poverty alleviation strategies might improve the situation of childhood illness in this region.

A remarkable finding in a recent study revealed that the educational background of both parents, their rich socioeconomic status, and improved toilet facilities were significant factors linked to childhood illness. This shift in the nature of risk factors, which now includes previously recognized protective factors, has created a challenging situation when addressing childhood illness. The lack of practical knowledge and awareness about illness, along with unhealthy lifestyles among household members, could be contributing to the relevant information gap. Further research is necessary to explore deeper into this subject area.

The main strength of this study was the utilization of a nationally representative cross-sectional sample which covers both rural and urban areas of all districts of the country as well as aids in generalizing the findings in similar settings. Additionally, BDHS 2017-2018 data was collected by using a standard questionnaire, designing a complex survey strategy, and global study model to provide credible results. Despite these advantages, we acknowledged several limitations of this study. As the data was collected based on the mother's self-reported retrospective information, the information might be affected by recall bias. The cross-sectional nature of the data interferes with drawing causal associations between dependent and independent variables. This study might be limited to generalizing the findings only for low- and middle-income countries.

5. Conclusions

In Bangladesh, the prevalence rates for diarrhea, fever, and the coexistence of these conditions among children can be expressed based on the findings: one in every twenty children experiences diarrhea, one in every three children experiences fever, and one out of every 35 children suffer from the coexistence of these conditions. Parental education, women's attitude towards wife beating, age of children, underweight children, birth order, wealth index, and region of residence were identified as key determinates of childhood illness. Both parents' educational status and rich socio-economic status were exceptionally identified as risk factors for childhood illness. Designing an evidence-based health intervention focusing on the current study findings, appropriate planning for the implementation, and incorporating a wide range of community participation from all social classes in both urban and rural areas can help in reducing childhood illness. The study also suggests extensive research and review of previous studies and policies.

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