Assessing Biological Vulnerability of Acute Respiratory Tract Infection Among Children: Evidence from Bangladesh Demographic and Health Survey 2017-18

Rashmi Rashmi
International Institute for Population Sciences

Ronak Paul (greenophenn@gmail.com)
International Institute for Population Sciences

Research Article

Keywords: Comorbidity, Children under-five years, Infectious diseases, Respiratory Infection, Biological vulnerability, Vulnerability to COVID-19, Bangladesh

Posted Date: May 7th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-477731/v1

Abstract

Background: Acute respiratory tract infections (ARIs) are the leading infectious disease worldwide and continues to be the single largest morbidity contributor in children. One of the most densely populated countries, Bangladesh also threatens by alarming under-five childhood morbidity, which has aggravated in past years with the COVID-19 pandemic. This study attempts to understand the biological factors affecting the pre-existing respiratory tract infections in under 5 children of Bangladesh.

Methods: The present study uses data from 8398 children aged below 5 years during the survey from the Demographic and Health Survey of Bangladesh (BDHS 2017-18). Both bivariate and multivariate analyses were performed to understand the biological vulnerability factors of pre-existing acute respiratory tract infections (ARIs) in under five Bangladeshi children and relate them with the potential impact of the COVID-19 pandemic. Further, to show effectively the effect of different risk factors on child morbidity status, we have summarized all the results into prediction graphs at various levels of one variable as the other variable changes

Results: Children aged one year were 1.40 [95% CI: 1.16, 1.67] and 2.01 [95% CI: 1.70, 2.36] times more likely to experience single morbidity and comorbidity respectively compared to children aged four years. We observe that male children were 1.18 [95% CI: 1.07, 1.31] times more likely to experience comorbidity compared to their female counterparts. Prediction graphs confirm the multivariate analysis as the probability of comorbidity remains higher in the monsoon season among children, with little change in the summer and winter seasons. Further, Rajshahi administrative division followed by Barisal and Rangpur shows the highest probability of comorbid condition in Bangladesh.

Conclusion: Biological factors emerged as the prominent contributor in child ARIs condition. More care is required as the nationwide lockdown due to the COVID-19 pandemic had not only isolated the people from physical communication but also disrupted the health care facilities to care for the pre-existing morbidity condition among Bangladeshi children. Insightful strategies are required to prevent infectious diseases in children right from their homes by focusing on their biological vulnerabilities.

1. Background

With the quick spread of the COVID-19 pandemic, health authorities had also prioritized the well-being of individuals especially the vulnerable section of society. While data from Italy shows that the elderly were more susceptible to fatality from this disease [1], studies also show that children were most likely to be spared from the direct mortality status through COVID-19 involvement [2]. However, the indirect effect of COVID-19 on children due to interruption in health care facilities and services was yet to be discovered. A study from 118 low- and middle-income countries by the Johns Hopkins Bloomberg School of Public Health shows that the indirect effect of reduction in health coverage services during a pandemic can be the reason for 2 million under-five deaths which in turn would be responsible for bringing back the decades of progress across the world [3]. One of the most densely populated countries worldwide,

Bangladesh is also threatened by the indirect effect of COVID-19 on children's health as they still face an alarming situation in under five childhood morbidity [4].

Diarrhoea and respiratory tract infections including fever, cough, and breathing problems are the common infectious diseases that are prevalent across Bangladeshi children [5]. In 2015, a systematic analysis projected the death of 4.4 million under 5 children due to infectious diseases like diarrhoea and respiratory tract infections in 2030 [6]. Acute Respiratory Tract Infection, caused by virus or bacteria, is classified as upper respiratory tract infections (URIs) (airways from nostrils to vocal cords including paranasal sinuses and middle ear) and lower respiratory tract infections (LRIs) (airways from trachea and bronchi to the bronchioles and the alveoli) [7]. In developing countries, ARIs remains to be the single largest illness as it is responsible for 70% of under-five morbidity condition [8]. ARIs are the common cause of illness and mortality among under 5 age children who suffer from an average of three to six episodes regardless of their living condition [9]. The situation can be worsened when the child experiences other conditions like fever and cough along with acute respiratory infection. As such comorbidity can lead to further extension of ARIs to infection, inflammation and reduced lung function [7]. Comorbidity is defined as the occurrence of more than one morbid condition in the same individual either at the same time or in some causal sequence [10]. Today, it is common to experience more than one morbid condition for an individual as the comorbid condition is not limited to any age group. The situation can be more precisely explained by introducing the term biological vulnerability as it defines a condition when an individual who is vulnerable to something is more likely to get affected by it [11]. For instance, children under 5 years of age are more biologically vulnerable to infectious diseases as they are more likely to get affected by such diseases. Further, to understand such a condition it is essential to consider the situation of comorbidity which can be the causal sequence of a disease.

Studies have associated ARIs with the exposure, environment, and background of children [12]. Evidence also shows that the risk of acute respiratory infection was common in younger ages [13, 14]. A study from Bangladesh had shown that smoking habits among family members, location of the kitchen, and type of cooking fuels play an important role in acute respiratory infection incidence [15]. Studies have also shown that urban and male children were lesser likely to experience these diseases due to a preference for better food and health care facilities [15]. Numerous factors like parental education, household income and living condition were found to be associated with ARIs [13, 16–18]. According to UNICEF, approximately 33 million Bangladeshi children are residing in poor living conditions with deprivation from basic human needs like food, health, education and sanitation [19]. Studies have shown that the poor living condition of children is highly associated with their deteriorated health which can be further aggravated due to lack of access to improved water and sanitation sources [20, 21]. In Bangladesh, water and sanitation insecurity had continued to be the largest challenge throughout the years as still, 60% of the population are lacking the proper accessibility which had further increased the burden of infectious disease like acute respiratory tract infection (ARIs) [22].

Despite numerous efforts to reduce the mortality condition in under-five children, Bangladesh continues to experience high ARI-related mortality of one in every five deaths [23, 24]. Moreover, with COVID-19,

immense pressure is expected on Bangladeshi children who are already facing health-related challenges. In this regard, it is reasonable to understand the current situation of pre-existing morbidity conditions (in terms of acute respiratory tract infections) of under-five Bangladeshi children. Recently released data of Demographic and Health Survey of Bangladesh (BDHS 2017-18) provides an opportunity to understand the morbidity condition of under-five children. To the best of our knowledge, this is the most recent data which provides national-level information from Bangladesh, before the outbreak of the COVID-19 pandemic. This study can provide insights for the planning of mitigation strategies to take care of under-five children during and after the COVID-19 pandemic. The present study aims to provide the biological vulnerability factors of pre-existing respiratory tract infection in under five Bangladeshi children.

2. Data, Variables And Methods

2.1 Data source

The current study used the most recent Demographic and Health Survey of Bangladesh conducted during 2017-18 (hereby referred to as BDHS 2017-18). The National Institute for Population Research and Training (NIPORT) has conducted BDHS 2017-18 under the stewardship of the Ministry of Health and Family Welfare (MoHFW) of Bangladesh. The survey provided crucial information on information on childhood mortality levels, maternal and child health, fertility and fertility preferences, utilization of family planning methods, newborn care, women's empowerment, selected non-communicable diseases (NCDS) and availability and accessibility of health and family planning services at the community level. The survey follows a two-stage stratified sample design. Further details regarding sample design, survey instruments, fieldwork and training of staff, data collection and processing, and response rates are available in the BDHS 2017-18 reports [24].

We used the data for 8759 children aged under-five years born to 7562 mothers aged 15–49 years in Bangladesh. However, we dropped the records of 361 children who were not alive during the survey period and had no information regarding their morbidity status. Therefore, the analytical sample for this study is 8398 children under five years of age.

2.3 Outcome variables

The outcome variable of morbidity status comes from the mother's responses regarding the knowledge of their children's morbidity. BDHS 2017-18 collected information regarding whether the children had suffered from fever, cough, and acute respiratory infections (ARI) within two weeks before the survey. We combined these three variables into a single variable of morbidity status with contained three categories which are – children who did not suffer from any of the three morbidities ("no condition"); children who suffered from "single condition"; and children experiencing two and more conditions ("comorbidity"). The advantage of this approach is that it aloows us to take into account the severity of the children's infirmity [5].

2.4 Explanatory variables

Guided by extant research, we identified relevant factors that are associated with the occurrence of morbidity among children [5, 12, 13]. Accordingly, we included relevant explanatory variables, conditional upon their availability in BDHS 2017-18. The child-related characteristics are – age in years (less than one, one, two, three, four) and gender (male, female). The parent-related characteristics are – mother's level of education (no formal education, upto primary, secondary and above), father's level of education (no formal education, upto primary, secondary and above). The household-level factors are – household sanitation condition (poor, average, good), household members drink treated water (no, yes), type of handwashing place (Private space, Public place, No handwashing place), shares toilet with other households (Not shared, Shared by two households (HH), Shared by three HH, Shared by four and more HH), wealth quintile (poorest, poor, middle, rich, richest), the religion of household head (Islam, Hinduism, others). Further, the season during the interview (Summer, Monsoon, Winter), place of residence (City Corporation, urban areas other than City Corporation, Rural areas), and administrative division (Dhaka, Chittagong, Barisal, Khulna, Mymensingh, Rajshahi, Rangpur, Sylhet) were also included.

Taking a cue from extant research, the household sanitation condition variable was constructed from three variables – type of source of drinking water, type of sanitation facility and the number of members per room in the household [25]. Respondents were asked about the source of household drinking water and as per prevalent standards, we recoded the source of household drinking water into two categories – "unimproved" coded as 0 (consisting of "dug, open well", "river", "pond", "truck" and "bottled" categories from the original variable) and "improved" coded as 1 (consisting of "piped", "tube well", "hand pump", "covered well" and "rainwater" categories from the original variable) [26]. Similarly, we recoded the type of household toilet facility into – "unimproved" coded as 0 (consisting of "defecation in open fields" and "traditional pit latrine" categories from the original variable) and "improved" coded as 1 (consisting of "ventilated improved pit latrine" and "flush toilet" categories from the original variable) [26]. Similarly, households with less than 3 members per room were coded as "1" and those with 3 or more members were coded as "0". After this, we added the three variables to obtain a household sanitation condition score. Households with a score of 3, score of 2 and score less than 2 were categorized as having "good", "average" and "poor" sanitation condition respectively.

To avoid multicollinearity, we coded a new wealth quintile variable after excluding information on household water source and toilet facility. The wealth quintile variable was prepared using standard procedures that are documented elsewhere [27].

2.5 Statistical methods

We performed bivariate and multivariate analysis to realize the study objectives. Owing to the categorical nature of the outcome variable, the bivariate association was examined using the chi-square test for association. Equivalently, multivariable analysis was performed by estimating multinomial regression models. The multivariate association of morbidity status of children with the explanatory variables was shown using relative risk ratios. Relative risk ratio gives the risk (multiple times) of having comorbidity (or single morbidity) compared to having no morbidity among those children belonging to a particular category of an explanatory variable given the effect of all the other explanatory variables remain constant

[28]. To show effectively the effect of different risk factors on child morbidity status, we have summarized the regression output into graphs of predicted probability [29].

We checked for multicollinearity in the regression model and found the mean value of the variance inflation factor (VIF) to be less than 1.25. Therefore, multicollinearity is negligible [30]. Further, the Hausman-McFadden test revealed that our estimated model did not violate the independence from irrelevant alternatives (IIA) assumption [31]. All statistical estimations were performed using the STATA software version 13.0 [32].

3. Results

3.1 Sample description

Table-1 shows the characteristics of 8,398 children aged under five years during BDHS 2017-18. Nearly 21% of children were in the age group less than 1 year and 52% of children were male. Nearly, 7% and 15% of children had a mother and father with no schooling education. One in every ten children comes from a household with poor sanitation conditions and 89% of children are from households where drinking water is untreated. Public space handwashing was common (64%) and most of the children did not share toilets with their family members (67%). Nearly, 27% of the population belongs to the poorest wealth quintile households and 65% reside in rural areas. In terms of population numeric, Chittagong is the largest division (17%) followed by the Dhaka division (15%) which includes the country's capital city Dhaka.

Table 1
Absolute (N) and percentage (%) distribution of children under-five years by demographic, parent-related, household socio-economic and spatial covariates

Characteristics	Total population	
	N	%
Age of child (in years)		
Four	1,694	20.2
Three	1,587	18.9
Two	1,655	19.7
One	1,666	19.8
Less than 1 year	1,796	21.4
Gender of child		
Female	4,027	48.0
Male	4,371	52.0
Mother's level of education		
Secondary and above	5,371	64.0
Upto primary	2,420	28.8
No formal education	607	7.2
Father's level of education		
Secondary and above	4,356	51.9
Upto primary	2,811	33.5
No formal education	1,231	14.7
Household sanitation condition		
Poor	931	11.1
Average	3,061	36.4
Good	4,406	52.5
Water treated before drinking		
Yes	926	11.0
No	7,472	89.0
Type of handwashing place		

Characteristics	Total population	
	N	%
Private space	2,726	32.5
Public space	5,374	64.0
No handwashing place	298	3.5
Shares Toilet with other households		
Not shared	5,624	67.0
Shared by 2 HH	1,311	15.6
Shared by 3 HH	690	8.2
Shared by 4 and more HH	773	9.2
Household wealth quintile		
Richest	1,641	19.5
Rich	1,646	19.6
Middle	1,438	17.1
Poor	1,400	16.7
Poorest	2,273	27.1
Religion of household head		
Islam	7,694	91.6
Hinduism	655	7.8
Others	49	0.6
Type of season		
Summer	662	7.9
Winter	7,233	86.1
Monsoon	503	6.0
Place of residence		
City corporation	776	9.2
Other urban areas	2,152	25.6
Rural areas	5,470	65.1
Country administrative division		

Characteristics	Total population	
	N	%
Dhaka	1,246	14.8
Chittagong	1,393	16.6
Barisal	863	10.3
Khulna	872	10.4
Mymensingh	991	11.8
Rajshahi	874	10.4
Rangpur	934	11.1
Sylhet	1,225	14.6
Overall	**8,398**	**100**

Table-2 provides the morbidity profile of under-five Bangladeshi children. We found that 54.5% of children had no morbidity within two weeks before the survey. In comparison, there were 18.4% of children in single morbid condition, co-morbidity was common among 27.1% of Bangladeshi children. Among all comorbid condition, children experiencing both fever and cough was high (15.1%). While only respiratory infection contributes to 0.5% of the population, however, the combined condition of respiratory infections accompanied by fever and cough increases the prevalence to 9% in the total population.

Table 2
Morbidity profile of children under-five years

Morbidity profile of children	Population distribution		Comorbidity status	Population distribution	
	N	%		N	%
No morbidity	4,574	54.5	No condition	4,574	54.5
Only fever	680	8.1	Single condition	1,545	18.4
Only cough	820	9.8			
Only respiratory infection	45	0.5			
Fever and Cough	1,270	15.1	Comorbidity	2,279	27.1
Cough and Respiratory infection	195	2.3			
Fever and Respiratory infection	58	0.7			
Fever, Cough and Respiratory infection	756	9.0			
Overall	**8,398**	**100**		**8,398**	**100**

3.2 Bivariate analysis

Table-3 shows the bivariate association between morbidity incidence and the explanatory variables. Morbidity condition was higher in children aged one year than those with other age categories (Single morbidity: 20.2%; Comorbidity: 33%). Approximately 29% of male children experienced comorbidity compared to 26% in females. Nearly 27.7% of children who drink untreated water experienced comorbidity compared to 23% of children who drink treated water. The incidence of comorbidity was higher if households do not practice handwashing (30.9%) in comparison to those households which used private (27.4%) and public space for handwashing (26.8%). Moreover, the incidence of comorbidity was higher during the monsoon season and in rural areas. Further, comorbidity incidence was higher (more than 31%) in the Barisal, Rajshahi, and Rangpur divisions. The association of morbidity status with stunting status, father’s education level, and household sanitation condition were not statistically significant.

Table 3
Bivariate association between morbidity incidence and the demographic, parent-related, household socio-economic and spatial covariates

Characteristics	Total population	Comorbidity status						χ2 test of association
		No condition		Single condition		Comorbidity		
	N	N	%	N	%	N	%	
Age of child (in years)								
Four	1,694	1,026	60.6	312	18.4	356	21.0	χ2 = 99.94; p-value = 0.001
Three	1,587	942	59.4	262	16.5	383	24.1	
Two	1,655	896	54.1	307	18.5	452	27.3	
One	1,666	780	46.8	336	20.2	550	33.0	
Less than 1 year	1,796	930	51.8	328	18.3	538	30.0	
Gender of child								
Female	4,027	2,260	56.1	739	18.4	1,028	25.5	χ2 = 11.29; p-value = 0.004
Male	4,371	2,314	52.9	806	18.4	1,251	28.6	
Mother's level of education								
Secondary and above	5,371	2,884	53.7	1,048	19.5	1,439	26.8	χ2 = 14.97; p-value = 0.005
Upto primary	2,420	1,334	55.1	401	16.6	685	28.3	
No formal education	607	356	58.6	96	15.8	155	25.5	
Father's level of education								
Secondary and above	4,356	2,381	54.7	806	18.5	1,169	26.8	χ2 = 3.44; p-value = 0.488
Upto primary	2,811	1,507	53.6	533	19.0	771	27.4	
No formal education	1,231	686	55.7	206	16.7	339	27.5	
Household sanitation condition								
Poor	931	544	58.4	157	16.9	230	24.7	χ2 = 8.90; p-value = 0.064
Average	3,061	1,639	53.5	555	18.1	867	28.3	
Good	4,406	2,391	54.3	833	18.9	1,182	26.8	
Water treated before drinking								

Note – (a) Morbidity status of children categorized into No condition, Single condition, and Comorbidity

Characteristics	Total population	Comorbidity status						χ2 test of association
		No condition		Single condition		Comorbidity		
	N	N	%	N	%	N	%	
Yes	926	570	61.6	148	16.0	208	22.5	χ2 = 21.29; p-value = 0.001
No	7,472	4,004	53.6	1,397	18.7	2,071	27.7	
Type of handwashing place								
Private space	2,726	1,474	54.1	504	18.5	748	27.4	χ2 = 2.66; p-value = 0.615
Public space	5,374	2,946	54.8	989	18.4	1,439	26.8	
No handwashing place	298	154	51.7	52	17.4	92	30.9	
Shares Toilet with other households								
Not shared	5,624	3,092	55.0	1,023	18.2	1,509	26.8	χ2 = 9.48; p-value = 0.148
Shared by 2 HH	1,311	680	51.9	251	19.1	380	29.0	
Shared by 3 HH	690	357	51.7	135	19.6	198	28.7	
Shared by 4 and more HH	773	445	57.6	136	17.6	192	24.8	
Household wealth quintile								
Richest	1,641	955	58.2	303	18.5	383	23.3	χ2 = 23.18; p-value = 0.003
Rich	1,646	875	53.2	302	18.3	469	28.5	
Middle	1,438	770	53.5	269	18.7	399	27.7	
Poor	1,400	761	54.4	277	19.8	362	25.9	
Poorest	2,273	1,213	53.4	394	17.3	666	29.3	
Religion of household head								
Islam	7,694	4,161	54.1	1,424	18.5	2,109	27.4	χ2 = 13.55; p-value = 0.009
Hinduism	655	375	57.3	115	17.6	165	25.2	
Others	49	38	77.6	6	12.2	5	10.2	
Type of season								

Note – (a) Morbidity status of children categorized into No condition, Single condition, and Comorbidity

Characteristics	Total population	Comorbidity status						χ2 test of association
		No condition		Single condition		Comorbidity		
	N	N	%	N	%	N	%	
Summer	662	386	58.3	113	17.1	163	24.6	χ2 = 7.07; p-value = 0.132
Winter	7,233	3,933	54.4	1,335	18.5	27.2	30.0	
Monsoon	503	255	50.7	97	19.3	151		
Place of residence								
City corporation	776	495	63.8	140	18.0	141	18.2	χ2 = 39.06; p-value = 0.001
Other urban areas	2,152	1,150	53.4	399	18.5	603	28.0	
Rural areas	5,470	2,929	53.5	1,006	18.4	1,535	28.1	
Country administrative division								
Dhaka	1,246	722	57.9	229	18.4	295	23.7	χ2 = 57.30; p-value = 0.001
Chittagong	1,393	800	57.4	230	16.5	363	26.1	
Barisal	863	445	51.6	161	18.7	257	29.8	
Khulna	872	471	54.0	202	23.2	199	22.8	
Mymensingh	991	524	52.9	195	19.7	272	27.4	
Rajshahi	874	434	49.7	174	19.9	266	30.4	
Rangpur	934	482	51.6	166	17.8	286	30.6	
Sylhet	1,225	696	56.8	188	15.3	341	27.8	
Overall	**8,398**	**4,574**	**54.5**	**1,545**	**18.4**	**2,279**	**27.1**	

Note – (a) Morbidity status of children categorized into No condition, Single condition, and Comorbidity

3.2 Multivariate analysis

Table-4 gives the multivariate association of morbidity status and the explanatory variables. Children aged one year were 1.40 [95% CI: 1.16, 1.67] and 2.01 [95% CI: 1.70, 2.36] times more likely to experience single morbidity and comorbidity respectively compared to children aged four years. We observe that male children were 1.18 [95% CI: 1.07, 1.31] times more likely to experience comorbidity compared to their female counterparts. Mothers with primary education show a lower chance of single morbid condition in their children [OR: 0.82; 95% CI: 0.71, 0.95]. Households with average sanitation conditions experience a

higher probability of comorbidity than those with poor sanitation conditions [OR: 1.28; 95% CI: 1.07, 1.54]. Further, it is observed that children have a 1.64 [95% CI: 1.20, 2.26] times higher likelihood of comorbidity during the monsoon season in comparison to the summer season. Furthermore, children residing in rural areas and urban areas than city corporation involved 1.55 [95% CI: 1.22, 1.98] and 1.58 [95% CI: 1.25, 2.01] times greater risk of comorbidity respectively compared to living in areas under city corporation. In the multivariate analysis, the association of morbidity status with the father's education, religion and the facility of shared toilets loses its statistical significance. While observing the administrative division, Rajshahi [OR: 1.60; 95% CI: 1.24, 2.06] shows the higher likelihood of comorbidity followed by Barisal [OR: 1.53; 95% CI: 1.18, 2.00] and Rangpur [OR: 1.51; 95% CI: 1.17, 1.95] as compared to Dhaka.

Table 4
Relative risk ratio showing the multivariate association between morbidity incidence and the demographic, parent-related, household socio-economic and spatial covariates

Characteristics	Morbidity Status			
	Single condition		Comorbidity	
	RRR	95% CI	RRR	95% CI
Age of child (in years)				
Four®				
Three	0.91	(0.76–1.10)	1.16	(0.98–1.38)
Two	1.12	(0.93–1.34)	1.43*	(1.21–1.69)
One	1.40*	(1.16–1.67)	2.01*	(1.70–2.36)
Less than 1 year	1.14	(0.95–1.36)	1.64*	(1.39–1.93)
Gender of child				
Female®				
Male	1.06	(0.95–1.20)	1.18*	(1.07–1.31)
Mother's level of education				
Secondary and above®				
Upto primary	0.82*	(0.71–0.95)	1.02	(0.90–1.16)
No formal education	0.78	(0.60–1.01)	0.91	(0.73–1.14)
Father's level of education				
Secondary and above®				
Upto primary	1.11	(0.96–1.28)	1.00	(0.88–1.14)
No formal education	1.02	(0.83–1.25)	1.01	(0.85–1.20)
Household sanitation condition				
Poor®				
Average	1.17	(0.95–1.44)	1.28*	(1.07–1.54)
Good	1.20	(0.96–1.48)	1.22*	(1.01–1.48)
Water treated before drinking				

Note – (a) RRR: relative risk ratio; (b) 95% Confidence Interval (CI) is given in brackets; (c) Statistical significance is denoted by asterisks where * denotes p-value < 0.05; (d) ® denotes reference category; (e) Morbidity status of children categorized into: no condition, single condition, comorbidity

Characteristics	Morbidity Status			
	Single condition		Comorbidity	
	RRR	95% CI	RRR	95% CI
Yes®				
No	1.21	(0.97–1.51)	1.05	(0.86–1.27)
Type of handwashing place				
Private space®				
Public space	0.94	(0.81–1.09)	0.84*	(0.74–0.96)
No handwashing place	1.08	(0.75–1.53)	1.03	(0.76–1.38)
Shares Toilet with other households				
Not shared®				
Shared by 2 HH	1.09	(0.92–1.28)	1.13	(0.98–1.31)
Shared by 3 HH	1.15	(0.92–1.42)	1.17	(0.97–1.42)
Shared by 4 and more HH	0.96	(0.77–1.20)	0.97	(0.80–1.19)
Household wealth quintile				
Richest®				
Rich	1.07	(0.88–1.31)	1.27*	(1.06–1.52)
Middle	1.07	(0.85–1.34)	1.18	(0.96–1.44)
Poor	1.17	(0.92–1.49)	1.10	(0.88–1.36)
Poorest	1.06	(0.84–1.35)	1.25*	(1.02–1.54)
Religion of household head				
Islam®				
Hinduism	0.91	(0.73–1.14)	0.89	(0.73–1.09)
Others	0.52	(0.22–1.25)	0.31*	(0.12–0.80)
Type of season				
Summer®				
Winter	1.14	(0.89–1.45)	1.09	(0.88–1.35)

Note – (a) RRR: relative risk ratio; (b) 95% Confidence Interval (CI) is given in brackets; (c) Statistical significance is denoted by asterisks where * denotes p-value < 0.05; (d) ® denotes reference category; (e) Morbidity status of children categorized into: no condition, single condition, comorbidity

Characteristics	Morbidity Status			
	Single condition		Comorbidity	
	RRR	95% CI	RRR	95% CI
Monsoon	1.36	(0.95–1.94)	1.64*	(1.20–2.26)
Place of residence				
City corporation®				
Other urban areas	1.03	(0.80–1.33)	1.58*	(1.25–2.01)
Rural areas	1.02	(0.79–1.32)	1.55*	(1.22–1.98)
Country administrative division				
Dhaka®				
Chittagong	0.91	(0.71–1.18)	1.27*	(1.00–1.61)
Barisal	1.12	(0.84–1.50)	1.53*	(1.18–2.00)
Khulna	1.35*	(1.03–1.77)	1.19	(0.91–1.54)
Mymensingh	1.20	(0.92–1.56)	1.33*	(1.04–1.70)
Rajshahi	1.21	(0.92–1.60)	1.60*	(1.24–2.06)
Rangpur	1.05	(0.79–1.40)	1.51*	(1.17–1.95)
Sylhet	0.91	(0.70–1.19)	1.36*	(1.08–1.73)
Number of children	**8,398**		**8,398**	

Note – (a) RRR: relative risk ratio; (b) 95% Confidence Interval (CI) is given in brackets; (c) Statistical significance is denoted by asterisks where * denotes p-value < 0.05; (d) ® denotes reference category; (e) Morbidity status of children categorized into: no condition, single condition, comorbidity

Results of the multivariate analysis were further confirmed by showing the predicted probability graphs for the factors having a statistically significant association with morbidity status. Figure-1 shows that the probability of acquiring single or comorbid (or multiple morbid) conditions increases with the decreasing age. Here, the highest single or comorbid condition is seen in the child's first year of life. The probability of acquiring comorbidity condition among male children is higher, while little change in single morbidity condition is noticed across both genders (Figure-2). Figure-3 shows that the probability of comorbidity increases in the monsoon season among children, with little change in the summer and winter seasons. Children residing in other urban areas show a higher probability of comorbid conditions (figure-4). While observing the administrative division of Bangladesh, a scattered picture is noticed. The probability of comorbidity condition was higher at the Rajshahi division (figure-5).

4. Discussion

Although children are not the face of the COVID-19 pandemic, the impact of this universal crisis can be lifelong for them [2]. COVID-19 mitigation strategies have usually enforced social distancing and isolation measures. However, such strategies may sometimes disrupt life-saving health services. Studies have shown that a sudden outbreak of pandemic had affected regular health care facilities and services [33]. In Bangladesh, acute respiratory infections (ARIs) are the most common morbidity condition which needs proper attention throughout the year. So, keeping in view the COVID-19 situation, the present study uses recent national-level data of Bangladesh to highlight the vulnerability factors of under-five childhood morbidity.

We found a strong effect of age on the incidence of ARIs along with fever and cough and these results are consistent with the previous Bangladesh studies [5]. It has been usually found that children at their younger ages can get exposed to contaminated water, soil, and food easily as at these ages they usually crawl and tries to explore the environment. However, older ages children who have already moved towards this exposure are well-versed with their environment and sometimes build a strong immunity till that age. Incidence of comorbidity condition among under-five children also varies according to household wealth index in both single and multiple morbidity conditions. Multiple morbidities were found to be significantly higher among monsoon seasons which is consistent with a previous study showing the health impact of climate change [34]. However, in contrast to a previous Bangladesh study, the present study shows that comorbidity condition is higher among male children than females [35]. Rajshahi administrative division followed by Barisal and Rangpur shows the highest probability of comorbid condition. This may be due to the higher indigenous population in this area. Also, a WHO report has shown that throughout the decade, poverty in few administrative divisions like Rangpur had increased facing a weak health care system [36]. Results from predicted probability also confirm the pre-existing demographic risk factors of under-five childhood morbidity in Bangladesh. As the age and sex of the child, place of residence and administrative division of Bangladesh emerged as the detrimental factor for under-five morbidity. Water and sanitation condition (like sharing toilets with more people in a household) doesn’t affect significantly the morbidity status. These findings are consistent with a Bangladesh study where improved water and sanitation sources were not found to be significantly associated with childhood morbidity [37]. Further, another study had also provided evidence that water, sanitation and handwashing interventions did not affect the linear growth of children in Bangladesh [18]. This might be due to the reason that most of the Bangladeshi population lack proper access to improved water and sanitation sources. And the combined effect of both water and sanitation interventions should be considered for bringing favourable changes [37]. Also, there is the necessity to consider the other unobserved factors which may play role in comorbid conditions.

The current pandemic can even worsen the situation of food insecurity, poverty, hunger, and malnutrition across the world. Previous studies have also shown the impact of the pandemic on the mental health of children [38]. Although the government had taken different measures to protect the well-being of children, the pandemic had increased the existing inequities and burdened the country with the risk of childhood

disease or death. So, the unprecedented situation of COVID-19 draws our attention towards strengthening the public care facilities and identify the vulnerability factors which lead to the morbidity condition of children. The present study is also backed with the recent national-level data of under-five children in Bangladesh which will help us to evaluate the situation just before the pandemic. Our study will also help policymakers to explore different mitigation strategies.

However, our study has some limitations too. First, our study provides only a cross-sectional view of the scenario and therefore does not allow us to examine causality. Second, the morbidity incidence was evaluated from the self-reported information provided by women. However, the short recall period of morbidity (two weeks before the survey) makes the chances of recall bias minimal. Also, there is a need to consider the unobserved factors which affect the association.

5. Conclusion

The nationwide lockdown due to the COVID-19 pandemic had not only isolated the people from physical communication but also disrupted the health care facilities critical for mitigating the pre-existing morbidity condition among Bangladeshi children. During the pandemic, it was found that the access to regular health care services and continuity of care become worsened. Our study urges a greater investment by the government to mitigate the adverse impact of the pandemic and to enhance the programs which can reduce the effect of vulnerability factors. Although some of our findings suggest that individual intervention of water and sanitation may have no big advantages, both individual and combined investments are required according to delivering convenience. This may be promoted by sensitisation of individuals about insightful strategies to prevent infectious diseases in children right from their homes by focusing on their biological vulnerabilities.

6. List Of Abbreviations

ARIs: Acute Respiratory Tract Infections

NCDs: Non-communicable Diseases

BDHS: Bangladesh Demographic Health Survey

COVID-19: Coronavirus Disease-2019

UNICEF: United Nations International Children’s Emergency Fund

NIPORT: National Institute for Population Research and Training

MoHFW: Ministry of Health and Family Welfare

7. Disclosure Statements

Ethics approval and consent to participate:

The data is freely available in the public domain and survey agencies that conducted the field survey for the data collection have collected prior consent from the respondent. The local ethics committee of the International Institute for Population Sciences (IIPS), Mumbai, ruled that no formal ethics approval was required to research this data source.

Consent for publication:

Not applicable

Availability of data and materials:

The study uses a secondary source of data that is freely available in the public domain through:

https://dhsprogram.com/data/dataset/Bangladesh_Standard-DHS_2017.cfm?flag=0

Competing Interests:

The authors declare that they have no competing interests.

Funding:

Authors did not receive any funding to carry out this research.

Author's Contribution:

The concept was drafted by RR; RP contributed to the analysis design, RP and RR advised on the paper and assisted in paper conceptualization. RP and RR contributed to the comprehensive writing of the article. All authors read and approved the final manuscript.

Acknowledgements:

We are thankful to Dr Hemkothang Lhungdim and Dr Harihar Sahoo of the International Institute for Population Sciences (IIPS) for their insightful comments and suggestion on an earlier version of this paper which was presented at the IIPS Seminar 2021.

8. References

1. Rate C-F. Characteristics of Patients Dying in Relation to COVID-19 in Italy Onder G, Rezza G, Brusaferro S. JAMA Published online March. 2020;23.
2. UN. UN Policy Brief: The Impact of COVID-19 on children. 2020.
3. Roberton T, Carter ED, Chou VB, Stegmuller AR, Jackson BD, Tam Y, et al. Early estimates of the indirect effects of the COVID-19 pandemic on maternal and child mortality in low-income and middle-

income countries: a modelling study. The Lancet Global Health. 2020;8:e901–8.

4. Balabanova D, Mills A, Conteh L, Akkazieva B, Banteyerga H, Dash U, et al. Good Health at Low Cost 25 years on: lessons for the future of health systems strengthening. The Lancet. 2013;381:2118–33.
5. Kamal MM, Hasan MM, Davey R. Determinants of childhood morbidity in Bangladesh: evidence from the demographic and health survey 2011. BMJ open. 2015;5:e007538.
6. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. The Lancet. 2016;388:3027–35.
7. Jamison DT, Breman JG, Measham AR, Alleyne G, Claeson M, Evans DB, et al. Disease control priorities in developing countries. The World Bank; 2006.
8. Selvaraj K, Chinnakali P, Majumdar A, Krishnan IS. Acute respiratory infections among under-5 children in India: A situational analysis. Journal of natural science, biology, and medicine. 2014;5:15.
9. Monto AS, Ullman BM. Acute respiratory illness in an American community: the Tecumseh study. Jama. 1974;227:164–9.
10. Valderas JM, Starfield B, Sibbald B, Salisbury C, Roland M. Defining comorbidity: implications for understanding health and health services. The Annals of Family Medicine. 2009;7:357–63.
11. Hazelden F. The Stress-Vulnerability Model | Behavioral Health Evolution. 2016. https://www.bhevolution.org/public/stress-vulnerability.page.
12. Black RE. Diarrheal diseases and child morbidity and mortality. Population and Development Review. 1984;10:141–61.
13. Richardson A. Factors influencing acute respiratory infection of children in Bangladesh. International Journal of Statistics and Systems. 2013;8:239–50.
14. Ferdous F, Das SK, Ahmed S, Farzana FD, Malek MA, Das J, et al. Diarrhoea in slum children: observation from a large diarrhoeal disease hospital in D haka, B angladesh. Tropical Medicine & International Health. 2014;19:1170–6.
15. Azad SMY, Bahauddin KM, Uddin MH, Parveen S. Indoor air pollution and prevalence of acute respiratory infection among children in rural area of Bangladesh. Indoor Air. 2014;4.
16. Azad KMAK. Risk factors for acute respiratory infections (ARI) among under-five children in Bangladesh. Journal of Scientific Research. 2009;1:72–81.
17. Pinzón-Rondón ÁM, Aguilera-Otalvaro P, Zárate-Ardila C, Hoyos-Martínez A. Acute respiratory infection in children from developing nations: a multi-level study. Paediatrics and international child health. 2016;:1–7.
18. Luby SP, Rahman M, Arnold BF, Unicomb L, Ashraf S, Winch PJ, et al. Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: a cluster randomised controlled trial. The Lancet Global Health. 2018;6:e302–15.
19. UNICEF. 33 million children in Bangladesh live in poverty. 2009. 2009. https://www.unicef.org/media/media_51925.html.

20. Rahman M, Ashraf S, Unicomb L, Mainuddin AKM, Parvez SM, Begum F, et al. WASH Benefits Bangladesh trial: system for monitoring coverage and quality in an efficacy trial. Trials. 2018;19:1–8.
21. Tofail F, Fernald LCH, Das KK, Rahman M, Ahmed T, Jannat KK, et al. Effect of water quality, sanitation, hand washing, and nutritional interventions on child development in rural Bangladesh (WASH Benefits Bangladesh): a cluster-randomised controlled trial. The Lancet Child & Adolescent Health. 2018;2:255–68.
22. Hedrick S. Water In Crisis - Spotlight Banglasdesh. The Water Project. 2016. https://thewaterproject.org/water-crisis/water-in-crisis-bangladesh.
23. Halder AK, Gurley ES, Naheed A, Saha SK, Brooks WA, El Arifeen S, et al. Causes of early childhood deaths in urban Dhaka, Bangladesh. PLoS One. 2009;4:e8145.
24. NIPORT, Ministry of Health and Family Welfare & I. Bangladesh Demographic and Health Survey, 2017-18. NIPORT; 2020.
25. Paul R, Singh A. Does early childhood adversities affect physical, cognitive and language development in indian children? Evidence from a panel study. SSM-Population Health. 2020;12:100693.
26. WHO-UNICEF. MEETING THE MDG DRINKING WATER SANITATION TARGET A N D A Mid-Term Assessment of Progress. 2004.
27. Rutstein SO, Johnson K. The DHS wealth index. DHS comparative reports no. 6. Calverton: ORC Macro. 2004.
28. Cameron AC, Trivedi PK. Microeconometrics: Methods and Applications . Cambridge University Press. 2005. http://cameron.econ.ucdavis.edu/mmabook/mma.html. Accessed 23 Jun 2020.
29. Long JS, Freese J. Regression models for categorical dependent variables using Stata. Stata press; 2006.
30. Ender P. collin": Stata command to compute collinearity diagnostics. 2010.
31. Cheng S, Long JS. Testing for IIA in the multinomial logit model. Sociological methods & research. 2007;35:583–600.
32. StataCorp LP. Stata 13. College Station: StataCorp LP. 2013.
33. Cash R, Patel V. Has COVID-19 subverted global health? The Lancet. 2020;395:1687–8.
34. Khan AE, Xun WW, Ahsan H, Vineis P. Climate change, sea-level rise, & health impacts in Bangladesh. Environment: Science and Policy for Sustainable Development. 2011;53:18–33.
35. Chen LC, Huq E, d'Souza S. Sex bias in the family allocation of food and health care in rural Bangladesh. Population and development review. 1981;:55–70.
36. World Bank Group. Bangladesh Poverty Assessment Facing old and new frontiers in poverty reduction. 2019.
37. Begum S, Ahmed M, Sen B. Do water and sanitation interventions reduce childhood diarrhoea? New evidence from Bangladesh. The Bangladesh Development Studies. 2011;:1–30.

38. Yeasmin S, Banik R, Hossain S, Hossain MN, Mahumud R, Salma N, et al. Impact of COVID-19 pandemic on the mental health of children in Bangladesh: A cross-sectional study. Children and youth services review. 2020;117:105277.

Figures

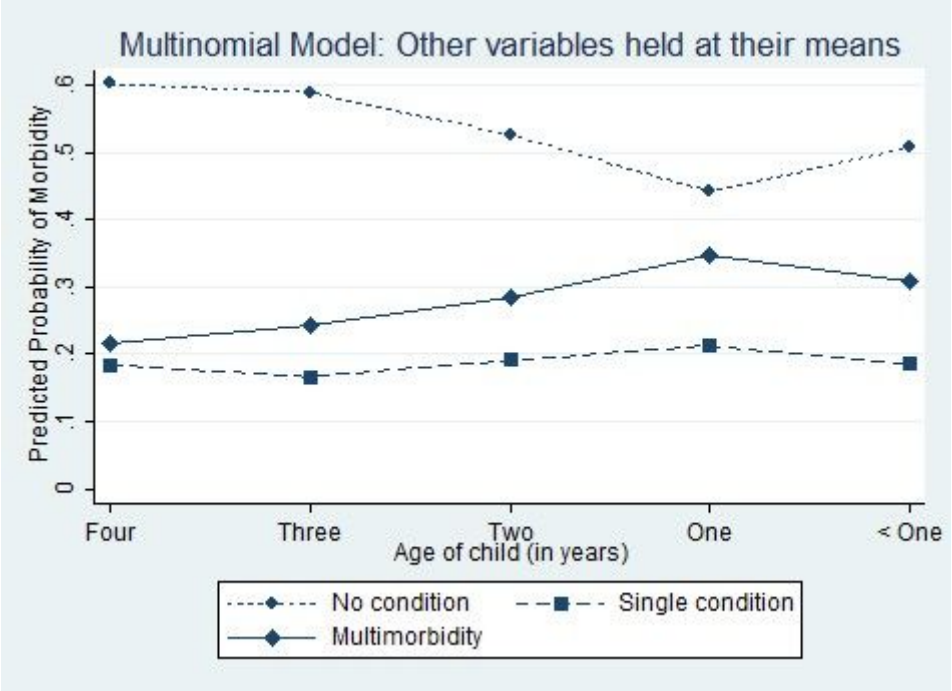

Figure 1

Adjusted Predicted probability of Morbidity by age from the multinomial regression model

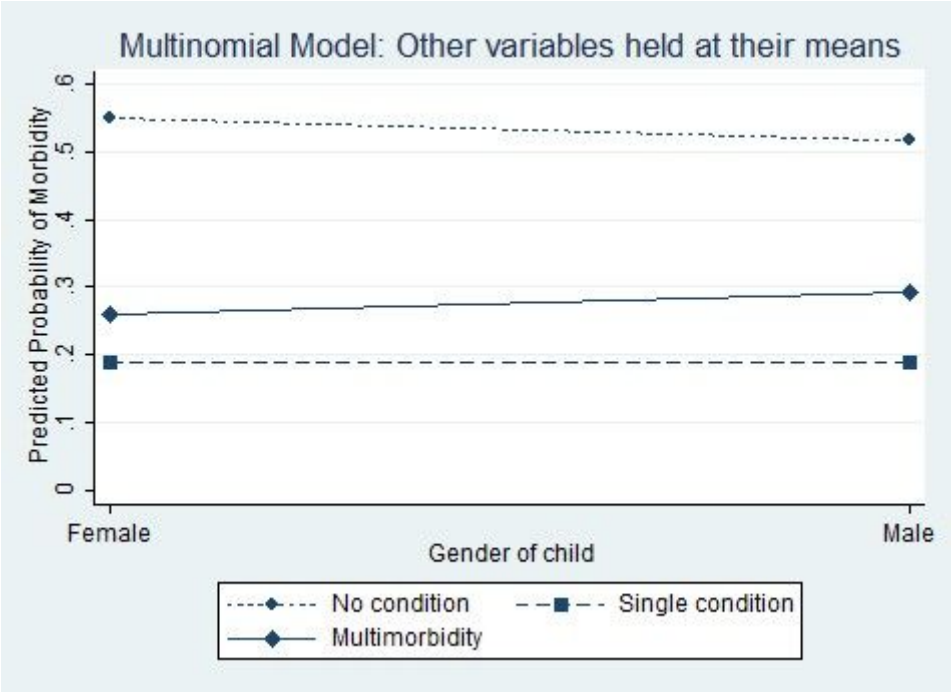

Figure 2

Adjusted Predicted probability of Morbidity by gender from the multinomial regression model

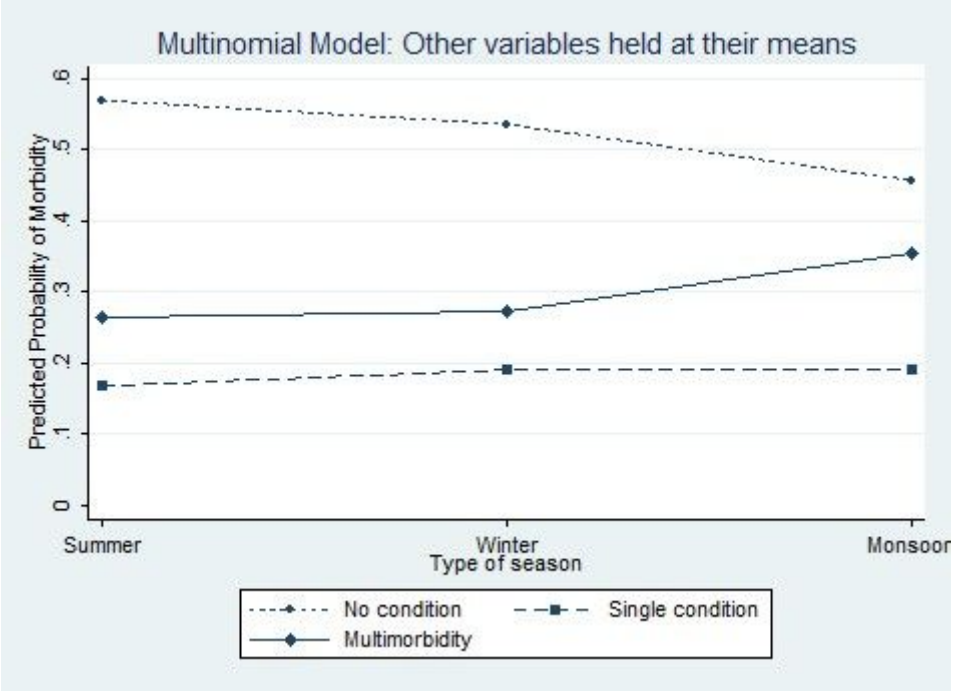

Figure 3

Adjusted Predicted probability of Morbidity by Type of season from the multinomial regression model

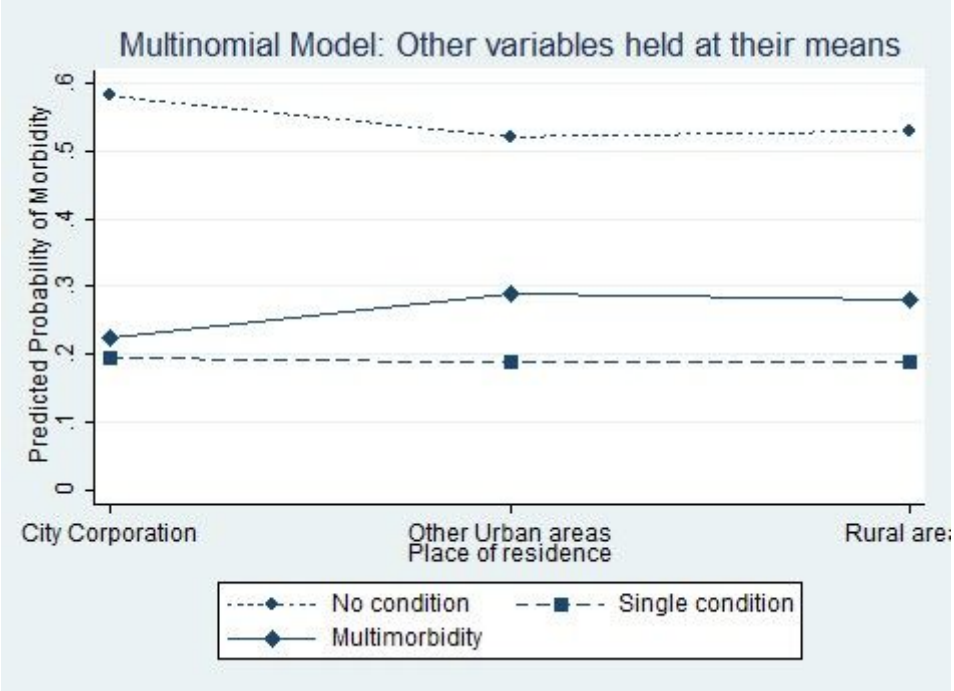

Figure 4

Adjusted Predicted probability of Morbidity by Place of residence from the multinomial regression model

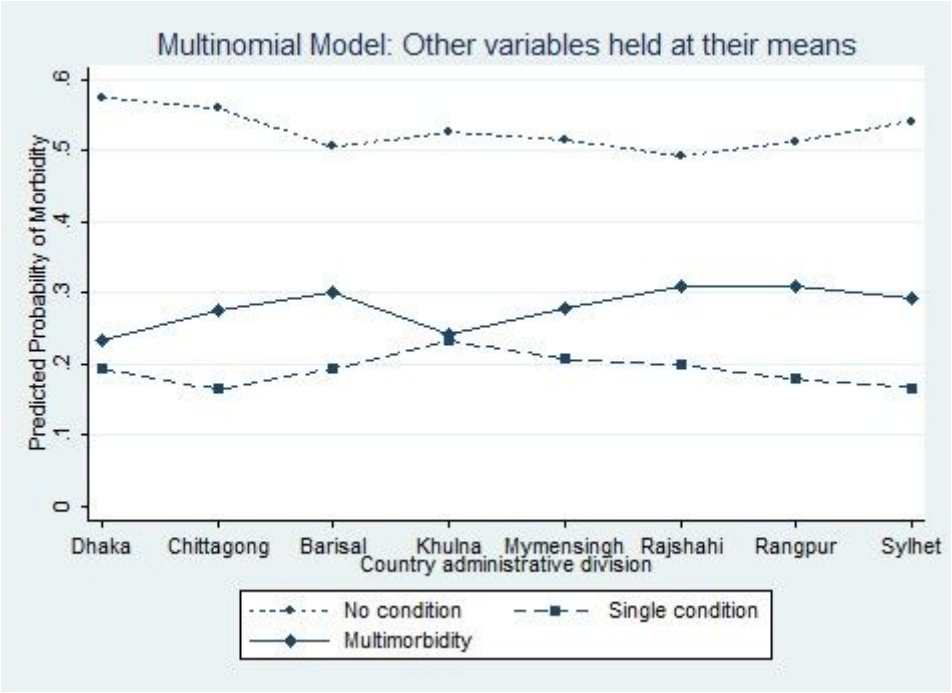

Figure 5

Adjusted Predicted probability of Morbidity by Country Administrative Region from the multinomial regression model