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# Impact of sustainable household environment and knowledge of healthy practices on childhood morbidity in South Asia: Analysis of survey data from Bangladesh, Nepal and Pakistan

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**Abstract:**

**Objectives:** Incidence of diarrhea and acute respiratory infection (ARI) is considerably high among South Asian children. The study aims to compare the impacts of potential predictors on episodes of these diseases.

**Design:** The study analyzed the latest, nationally representative cross sectional survey data from the Demographic and Health Survey.

**Setting:** Three countries were analyzed: Bangladesh, Nepal and Pakistan.

**Participants:** Ever-married women aged between 12 and 49 years living in selected households provided information on 23,940 children under age of five years and born to the interviewed women.

**Primary outcomes measures:** The morbidity status of the children was recorded with respect to episodes of diarrhea and/or ARI in the two weeks preceding data collection.

**Results:** Consuming unhygienic drinking water increased the risks of childhood diarrhea, and use of solid fuel for indoor cooking increased the risk of ARI, across all three countries investigated. However far more significant were the effects of mother's education, with incomplete primary education leading to an odds of diarrhea approaching twice that of a mother with secondary education or higher (OR = 1.71 in Bangladesh, 95% CI 1.17 to 2.50).

**Conclusions:** Results from the current research underline the importance of developing and implementing integrated strategic plans for mothers and children in the countries investigated. Promoting hygienic water and sanitation facilities can help reduce the incidence of childhood diarrhea, and replacing indoor solid fuel cooking arrangements with cleaner fuel or more airy conditions can help reduce the incidence of ARI, but these strategies need to be integrated with education for women to raise the likelihood that reduced risks are actually realised.

**Strengths and limitations of this study**

- The study utilized some of the largest and most recent cross-sectional surveys conducted in the countries analyzed
- Three countries were compared: Bangladesh (2014), Nepal (2011) and Pakistan (2012).
- Information regarding the disease episodes was provided for a single point of time so that the seasonal variations in the incidence of the disease episodes are not addressed in the data.
- The disease episodes are determined on the basis of self-reporting of mothers over a short recall period (two weeks)
- The datasets do not represent same time point for the studied countries, though the largest time difference is only three years.

## Introduction

Infectious diseases are responsible for approximately half of the child deaths worldwide<sup>1</sup>, where pneumonia and diarrhea are two of the leading causes<sup>2,3</sup>. In addition to deaths, several diarrheal episodes lead to long-term nutritional deficits, whereas, childhood respiratory infections cause increased risk of reduced lung capacity<sup>4,5</sup>. The greatest proportions of severe episodes of these infections are experienced in the south Asian and African regions and within these regions, the incidence of the diseases is even higher for poorer countries and among disadvantaged children<sup>6,7</sup>.

Considering the consequences of diarrhea and ARI episodes on mortality and long-term adverse health outcomes, numerous studies have been conducted to identify associated risk factors. Existing literature suggests that younger children are more likely to suffer from infectious diseases than older cohorts, and consequently, a higher proportion of diarrhea and pneumonia related deaths happen in the first two years of life<sup>7-9</sup>. Due to differentials in food intake, standard of living and availability of health care facilities, urban-rural variations are also evident in childhood morbidity<sup>10,11</sup>. Educated mothers are knowledgeable about healthy environment and possible risks of their child being exposed to infectious diseases, and hence, occurrence of infectious diseases is significantly associated with the educational status of mother<sup>12-14</sup>. In addition to formal education, access to mass media helps to create awareness and form knowledge of communicable diseases<sup>15-17</sup>. In addition to these risk factors, poorer individuals within impoverished settings face relatively higher burden of infectious diseases, and children in wealthy families are more protected from diarrhea and ARI<sup>18-20</sup>. A review of published articles<sup>21</sup> concluded that residential crowding significantly increased the risk of severe respiratory disease. Using solid fuel for cooking is a major source of household air pollution and responsible for a variety of respiratory diseases<sup>22-24</sup>.

Investigating 171 Demographic and Health Surveys (DHS) in 70 low- and middle-income countries over the period 1986–2007, researchers<sup>25</sup> concluded that access to improved sanitation and water was associated with lower risk of childhood diarrhea. Similar relationships have been observed elsewhere<sup>26-28</sup>. Considering the fact that a large proportion of diarrhea related mortality is attributable to either unsafe drinking water, inadequate sanitation, or insufficient hygiene, the post-2015 goals in public health emphasize raising awareness of health related sustainable development policies<sup>29</sup>. As a part of Goal 3 of the Sustainable Development Goals (SDG), the UN is aiming to end epidemics of water-borne

1 and other communicable diseases by 2030. Goal 6 emphasizes ensuring the availability of  
2 water and sanitation for all<sup>30</sup>.

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5 The objective of this study is to advise on the relative importance of the SDG, in the light of  
6 evidence around the incidence of diarrhea, ARI and comorbidity among preschoolers from  
7 three south Asian countries, Bangladesh, Nepal and Pakistan. The first aim will be to  
8 compare the incidence of diarrhea and ARI across the three countries. Secondly,  
9 characteristics of children with relatively higher risks of morbidity will be identified. Thirdly,  
10 the impacts of potential predictors on the incidence of the episodes will also be compared. Of  
11 particular interest in the light of the SDG is the relative importance of sustainable household  
12 environment compared to other predictors such as maternal education and household wealth.  
13 The aims will be achieved by analyzing the latest releases of nationally representative DHS  
14 datasets from the relevant countries. All aims will lead to suggestions regarding the  
15 development of feasible and effective plans that fit with the SDG and are likely to reduce  
16 childhood morbidity in the region.  
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## 27 **Data and methods**

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29 This study utilized nationally representative, cross-sectional DHS datasets from three south  
30 Asian countries – Bangladesh (2014), Nepal (2011) and Pakistan (2012). These developing  
31 countries are homeland of about 400 million people (Bangladesh 169 million, Nepal 32  
32 million and Pakistan 199 million)<sup>31</sup> and share common historical, social and cultural  
33 background. In terms of per capita GDP, they trail the world (Pakistan 152<sup>nd</sup>, Bangladesh  
34 156<sup>th</sup> and Nepal 172<sup>nd</sup>)<sup>32</sup>. On the other hand, the countries represent a variety of child  
35 morbidity outcomes as well as a range of exposures to poverty and unhygienic household  
36 environment. The DHS consists of a nationally representative sample of households obtained  
37 through a two-stage stratified sampling procedure. Ever-married women aged between 12 and  
38 49 years living in the selected households were approached for interview. Information  
39 regarding the respondents, their children and households was collected during the survey. The  
40 present study extracted necessary information from the surveys and analyzed morbidity status  
41 of 23 940 children (7 760 from Bangladesh, 5 140 from Nepal and 11 040 from Pakistan)  
42 under age of five years and born to the interviewed women. Though the DHS adopted  
43 appropriate survey methodology to obtain a representative sample, the final sample does not  
44 guarantee a complete representativeness at national and regional levels. To ensure the  
45 representativeness of the sample at various levels, sampling weights were calculated  
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separately for each sampling stage and cluster based on sampling probabilities. The sample weights were incorporated into the analyses.

## **Dependent and independent variables**

The dependent variables in the study come from mother's responses to questions on recent (within two weeks preceding the survey) episodes of diarrhea and ARI of their children aged below five years. The children were categorized as those suffering or not suffering from these episodes.

The set of independent variables considered as potential predictors were decided upon using the existing literature, availability of information in the survey datasets, and the knowledge of the researchers of the study region. To compare the prevalence of morbidity over ages, children were categorized as those aged less than one year, between one and three years and from three to five years. The place of residence of children is categorized as rural or urban. Educational attainment, and access to mass media were considered as a proxy of knowledge and understanding of mother regarding exposure to infectious diseases and their consequences on their children. Mothers were categorized as those with no or incomplete primary level, complete primary to incomplete secondary level and complete secondary or above level of education. Mothers were also classified on the basis of having or not having access to any of mass media, radio, television or newspapers. This study used household economic status as a potential predictor which is obtained from the wealth score created by DHS. The score is calculated using principal components analysis from variables comprising household construction materials (roof, ceiling and floor), possessions (televisions and bicycles) and dwelling characteristics (source of drinking water, sanitation facilities). Detailed about the calculation of the wealth scores is available at the survey report<sup>33</sup>. On the basis of wealth score, children were classified as those coming from a household classified as poor (lower 20%), middle (middle 40%) and rich (upper 20%). The variables, source of drinking water, type of toilet facility, crowding, type of cooking fuel and type of floor material were considered as indicators of sustainable household environment. Households were categorized on the basis of having or not having a hygienic water source on the premises. Households were categorized as using improved unshared, improved shared or unimproved toilets. The number of adults per living room indicates crowding, and households were categorized as those with up to two adults per living room, and two or more adults per living room. On the basis of cooking practice, the households were categorized as those using or not using solid fuel while cooking inside the house. Finally, children were categorized as

1 living in houses with the floor made of mud or else. All information was extracted from the  
2 datasets mentioned in the previous section.  
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## 5 6 **Statistical Analysis**

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8 The dependent variables (incidence of Diarrhea and ARI), as well as the predictor variables  
9 considered in the study, are categorical. Bivariate chi-square analyses were carried out to  
10 compare the incidence of the diseases among the levels of the selected predictors.  
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13 Given the dichotomous nature of the dependent variables, multiple binary logistic regression  
14 models were fitted to assess the impact of selected predictors on childhood morbidity. The  
15 model considers logarithm of odds (ratio of the probability of occurring to not occurring) as a  
16 linear additive function of the predictors. Exponentials of the estimated parameters referred  
17 as the odds ratio (OR), estimate the changes in the odds with unit change in the predictors  
18 (for continuous predictor) or changes in the level of predictors compared to baseline (for  
19 categorical predictor). Separate multiple logistic regression models were fitted to the data  
20 from individual countries. To focus the models for each disease, the model for diarrhea  
21 excluded the variable cooking fuel as predictor, whereas the model for ARI excluded source  
22 of drinking water and type of toilet facility as predictors. Statistical analysis was conducted in  
23 SPSS 21.0<sup>34</sup> using a weighted analysis to account for the survey weights and clustered  
24 structure of the sample.  
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## 34 **Results**

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36 Distributions of respondents for various levels of selected predictors are presented in Table 1.  
37 Incidence of diarrhea was considerably lower for the children in Bangladesh (5.7%) with  
38 respect to Nepal (13.8%) and Pakistan (22.5%). A considerably higher percentage of children  
39 from Pakistan were suffering from ARI (15.9%) than Bangladesh (5.4%) and Nepal (4.6%).  
40 Percentages of children suffering from co-morbidity was highest in Pakistan and lowest in  
41 Bangladesh (Figure 1). Age distributions of children were consistent over the studied  
42 countries. Most of the children in the studied settings lived in rural areas, ranging from 70.3%  
43 in Pakistan to 90.6% in Nepal. The percentage of mothers with both lower (no or incomplete  
44 primary) and higher (completed secondary or higher) educational levels were highest in  
45 Pakistan (62.5% and 17.9%), whereas the percentage of mothers with no or incomplete  
46 primary level of education was lowest in Bangladesh (32.7%). The highest proportion of  
47 children whose mother had access to any of the mass media was from Nepal (84.4%). Among  
48 the studied countries, percentages of children from households using hygienic and unshared  
49 toilet facilities was lowest in Nepal (35.9%). Using solid fuel while cooking inside home was  
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1 rare in Bangladesh (9.6%) and common in Nepal (57.4%) and Pakistan (59.8%). Finally, a  
2 higher percentage (71.7%) of children of Pakistan were from household sharing more than  
3 two adults a room.  
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7 In the bivariate analyses, children suffering from ARI are were more likely to suffer from  
8 diarrhea and vice-versa (Table 2). Older children were significantly less likely to suffer from  
9 either episode than the younger. With the exception of episodes of ARI in Nepalese children,  
10 educational status of mother showed a significant impact on the incidence of episodes of both  
11 infections. Mother's access to mass media showed significant impact on both episodes in  
12 Bangladesh only. Except for the incidence of diarrhea in Bangladesh, wealth status of  
13 household showed significant impact on childhood morbidity. The impact of place of  
14 residence was statistically significant in the ARI for the children in Bangladesh and Pakistan.  
15 In all except one setting, the source of drinking water did not show any significant impact on  
16 any disease episode, whereas type of toilet facility showed a significant impact on the  
17 incidence of diarrhea in Nepal and Pakistan. The number of adults per living room showed a  
18 significant impact on the incidence of diarrhea in Bangladesh and Nepal. Children from  
19 households using solid cooking fuel inside the house were significantly more likely to suffer  
20 from ARI with respect to those from households not using solid fuel for cooking inside the  
21 home.  
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33 Adjusted ORs of suffering from diarrhea and their associated CI for the predictor variables  
34 are presented in Table 3. Once the effect of other variables was controlled for, in all the three  
35 countries, age of children and educational status of mother showed significant impact on  
36 incidence of diarrhea. In Bangladesh, Nepal and Pakistan, children below one year of age,  
37 were 0.61 (OR 1.61, CI = 1.23 – 2.12), 2.11 (OR 3.11, CI = 2.46 – 3.93) and 1.67 (OR 2.67,  
38 CI = 2.35 – 3.02) times more likely to suffer from diarrhea with respect to those aged above  
39 three years (the reference category). With respect to the reference category, children aged  
40 between one and three years were also significantly more likely to suffer from diarrhea. In  
41 Bangladesh, children from mothers with no or incomplete primary and incomplete secondary  
42 educational levels were 71% (OR 1.71, CI = 1.71 – 2.50) and 68% (OR 1.68, CI = 1.20 –  
43 2.36) more likely to suffer from diarrhea with respect to those from mothers with secondary  
44 or higher level of education. In Pakistan, children from households categorized as poor and  
45 middle wealth status were significantly more likely to suffer from diarrhea with respect to  
46 those from well-off households. However, the impact of wealth on the incidence of diarrhea  
47 was not significant for the children from Bangladesh and Pakistan. Children from households  
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1 using shared and hygienic toilet facilities were more likely to suffer from diarrhea, however  
2 the impact is statistically significant for the children in Nepal only.  
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4 The ORs of suffering from ARI with associated CI for the studied variables were presented in  
5 Table 4. Like diarrhea, younger children were significantly more likely to suffer from ARI  
6 than older children. In Bangladesh and Pakistan, children from mothers with lower  
7 educational level were more likely to suffer from ARI than those from higher educational  
8 level. In Pakistan, with respect to the children from mothers with secondary or higher level of  
9 education, those from mothers with no or primary and incomplete secondary level of  
10 education were 32% (OR = 1.32, CI = 1.10 – 1.58) and 25% (OR = 1.25, CI = 1.04 – 1.50)  
11 more likely to suffer from ARI. However, the relationship of maternal education and ARI of  
12 children is not significant in Nepal. In Bangladesh and Nepal, children from households  
13 categorized as poor or middle were significantly more likely to suffer from ARI with respect  
14 to those from well-off households. However, the impact of wealth on ARI is not significant  
15 for Nepal. In Bangladesh, children from households using solid fuel and cooking inside the  
16 house were 62% (OR = 1.62, CI = 1.21 – 2.16) more likely to suffer from ARI, however, the  
17 effect is not significant in Nepal and Pakistan. Over the countries, neither the number of  
18 adults living per room nor the household floor material showed consistent impacts on either  
19 diarrhea or ARI.  
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## 32 Discussion

33 Incidence of two major infectious diseases, diarrhea and ARI, is relatively high among young  
34 children in the South Asian region. The study was conceived with a broad objective of  
35 comparing the impact of potential predictors, in particular sustainable household environment  
36 and maternal education, on disease episodes among preschoolers from three South Asian  
37 countries, Bangladesh, Nepal and Pakistan.  
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45 **Data limitations:** The study utilized one of the largest and most recent cross-sectional  
46 surveys conducted in each of Bangladesh (2014), Nepal (2011) and Pakistan (2012). The  
47 surveys have attractive features that make them appealing for quantitative analysis. For  
48 example, the DHS Program collects and processes reasonably accurate, nationally  
49 representative data on health and population in developing countries. The surveys collect  
50 information on morbidity status of children and covers a wide range of variables regarding  
51 the children, their parents and the households they live in. However, DHS are cross-section  
52 surveys which collect information regarding the disease episodes for a single point of time.  
53 The seasonal variations in the incidence of the disease episodes are not addressed in the data.  
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Moreover, the disease episodes are determined on the basis of self-reporting of mother, and not followed by any clinical examination. To reduce the reporting bias due to memory lapse, a short recall period (two weeks) is considered while collecting morbidity related information. Finally, the datasets do not represent same time point for the studied countries, though the largest time difference is only three years.

**Comparison of incidence:** The highest incidence rates were in Pakistan for both diarrhea and ARI, and in Nepal, for diarrhea. Bangladesh is considered as a paradox in terms of better health achievement despite economic poverty<sup>35,36</sup>. Even the disadvantaged children from Bangladesh (from households categorized as poor and using unhygienic water and toilet facilities) possess lower risk of suffering from diarrhea with respect to economically advantaged children in Nepal and Pakistan.

**What didn't have a clear effect on incidence:** Some potential predictors were not found to have a significant effect on incidence of diarrhea and/or ARI, namely rural-urban setting. Source of drinking water, number of adults sharing a living room and floor materials all showed inconsistent effects on the incidence of childhood diarrhea.

**What did have a clear effect on incidence:** In all the three studied countries, bivariate analyses showed that the presence of diarrhea significantly increases the likelihood of the incidence of ARI, and vice-versa. However, it is important not to include diarrhea in the multiple model of ARI incidence, and vice versa, because of the possible confounding effect. Similar results were observed in previous studies where the epidemiology of diarrhea and ARI overlapped. This may be because of shared risk factors or compromised immune function<sup>37-39</sup>. Health policy needs to take a holistic approach to combatting childhood infections due to the clear presence of co-morbidity, at least in the case of diarrhea and ARI shown in this paper.

Younger children possess significantly higher risks of suffering from morbidity than the older; the result is consistent with previous studies in Bangladesh and elsewhere<sup>8,14</sup>. The immune may not be developed at earlier ages, the younger children may be infected from unhygienic feeding practices (water, bottles etc.) and unclean surroundings. Diarrhea pathogens, like *E. coli*, are commonly transmitted via impure water, unhygienic utensils or food handling<sup>40</sup>. While crawling, children explore their immediate environment and may pick up infections. Inappropriate dietary supplementation may also hinder children's developing immune system, which can be overcome through exclusive breastfeeding for recommended

1 periods of time. Breastfeeding data is available in the DHS surveys, however it has not been  
2 included in the current analyses due to its high degree of confounding with age.  
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5 Of most interest is the result that maternal educational status showed significant positive  
6 impact on reducing the incidence of diarrhea and ARI, and that the effects are more evident  
7 when the educational attainment is at least secondary or higher.  
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10 **Conclusion:** For these countries with relatively higher incidence of infectious diseases on the  
11 worldwide scale, our study shows that sustainable household environment in terms of  
12 flooring, water, toilet and cooking facilities was not found to have the greatest impact on  
13 childhood diseases. Nor was wealth a main driver, as its impact on childhood morbidity was  
14 only statistically significant in half of the settings considered in this paper. Of far more  
15 importance was knowledge base of a child's primary caregiver (typically the mother)  
16 regarding the potential risks of infection, and the impacts of infection on survival and well-  
17 being. These results indicate that the Sustainable Development Goal of good health and  
18 wellbeing needs to be tackled not just through the goals of clean water and sanitation for all,  
19 and the ending of poverty, but also through the goal of quality education. According to our  
20 findings, maternal education is effective in reducing child morbidity only when it is at  
21 complete secondary level or higher. However, it is highly ambitious to upgrade the  
22 educational level of all women to at least secondary. An effective basic knowledge base  
23 formed through policies that incorporate health education in school curricula at primary and  
24 secondary level has a higher chance of making an impact, especially since the female primary  
25 school enrolment rate in Nepal and Bangladesh is already above 90%. Well-developed  
26 motivational programs incorporating mass media, health professionals, community health  
27 workers, community leaders, government and non-government organisations may help  
28 improve population awareness of the causes and consequences of infectious diseases. These  
29 programs may be more essential for the countries like Pakistan where the percentages of  
30 children suffering infectious diseases are relatively higher and female school enrolment rate  
31 is relatively lower.  
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48 Contributorship: MMH conceptualised the study. The methodology was developed by MMH  
49 and AR. Data interpretation and drafting of the paper were undertaken by MMH and AR.  
50 Both authors made contributions to the overall manuscript and are responsible for the drafting  
51 of the manuscript.  
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54 Competing interests: None declared.  
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57 Survey Program (<https://dhsprogram.com/>).  
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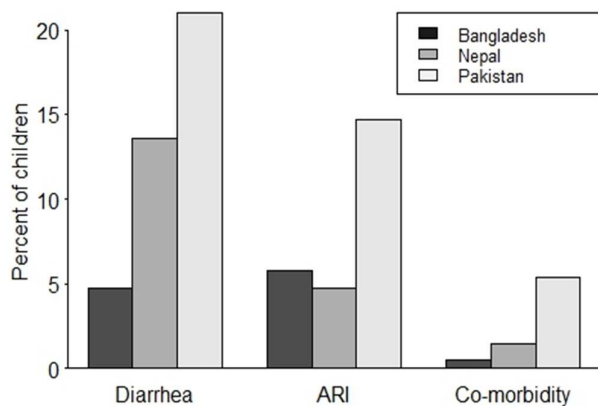


Figure 1 Percentage of children suffering from diarrhea, ARI and co-morbidity

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Table 1 Number (Percentages) of respondents for various levels of the selected predictors in Bangladesh, Nepal and Pakistan

Background Characteristics	Percentages of respondents		
	Bangladesh (N = 7760)	Nepal (N = 5140)	Pakistan (N= 11040)
<b><i>Prevalence of Diarrhea</i></b>	<b>5.7</b>	<b>13.8</b>	<b>22.5</b>
<b><i>Prevalence of ARI</i></b>	<b>5.4</b>	<b>4.6</b>	<b>15.9</b>
<i>Age of child</i>			
0-11 months	19.5	19.9	19.8
12-35 months	41.2	39.2	39.4
36+ months	39.3	40.9	40.8
<i>Type of Place of Residence</i>			
Rural	74.4	90.6	70.3
Urban	25.6	9.4	29.7
<i>Mother's education</i>			
Incomplete Primary	32.7	61.0	62.5
Incomplete Secondary	51.5	25.3	19.6
Secondary or Higher	15.8	13.7	17.9
<i>Access to elect media</i>			
No access	38.7	15.2	29.8
Have access	61.3	84.8	70.2
<i>Source of drinking water</i>			
Unhygienic/not in premises	21.1	36.1	22.9
Hygienic	78.9	63.9	77.1
<i>Toilet facility</i>			
Unhygienic Shared	10.4	49.0	25.4
Un-Unshared, Hy-Shared	26.7	15.0	11.5
Hygienic unshared	62.9	35.9	63.2
<i>Number of adults per room</i>			
More than 2 persons	40.9	43.2	71.7
Up to 2 persons	59.1	56.8	28.3
<i>Household cooking fuel</i>			
In home-solid fuel	9.6	57.4	59.8
Not solid fuel inside	90.4	42.6	40.2
<i>Household floor material</i>			
Mud	68.9	75.4	47.3
Not Mud	31.1	24.6	52.7

	Diarrhea	ARI	Diarrhea	ARI	Diarrhea	ARI
<i>Childhood ARI/ Diarrhea</i>						
Suffered	9.8 <sup>***</sup>	9.3 <sup>***</sup>	30.1 <sup>***</sup>	10.1 <sup>***</sup>	30.2 <sup>***</sup>	23.7 <sup>***</sup>
Not suffered	5.4	5.1	13.1	3.8	20.4	13.6
<i>Age of child</i>						
0-11 months	6.4 <sup>***</sup>	7.7 <sup>***</sup>	18.3 <sup>***</sup>	5.6 <sup>***</sup>	30.2 <sup>***</sup>	18.1 <sup>***</sup>
12-35 months	6.8	6.0	19.0	6.0	27.2	17.9
36+ months	4.1	3.5	6.7	2.9	14.2	12.8
<i>Place of residence</i>						
Rural	5.7	5.7 <sup>**</sup>	13.9	4.6	22.7	16.4 <sup>**</sup>
Urban	5.6	4.3	13.4	5.0	21.9	14.6
<i>Mother's educational status</i>						
Inco primary	6.1 <sup>***</sup>	5.2 <sup>***</sup>	14.2 <sup>**</sup>	4.6	23.5 <sup>***</sup>	16.4 <sup>***</sup>
Inco secondary	6.0	6.1	14.8	5.1	23.0	16.3
Secondary Higher	3.8	3.3	10.5	4.1	18.5	13.4
<i>Wealth status of household</i>						
Poor	6.3	6.5 <sup>***</sup>	13.5 <sup>*</sup>	4.7 <sup>***</sup>	23.5 <sup>***</sup>	15.6 <sup>***</sup>
Middle	5.3	5.2	15.0	5.5	23.6	17.0
Rich	5.2	3.3	11.8	2.2	17.1	13.7
<i>Access to electronic media</i>						
No access	6.4 <sup>**</sup>	6.0 <sup>*</sup>	15.8	4.7	23.2	15.9
Have access	5.2	5.0	13.5	4.6	22.2	15.8
<i>Source of drinking water</i>						
Unhygienic	6.8 <sup>**</sup>	6.1	14.1	4.7	21.7	15.5
Hygienic	5.4	5.2	13.7	4.6	22.7	16.0
<i>Toilet facility</i>						
Unhygienic Shared	6.1	7.3 <sup>***</sup>	15.5 <sup>***</sup>	4.8	24.2 <sup>**</sup>	15.5
Un-Unshared, Hy-Shared	5.8	6.4	12.0	5.6	23.5	15.8
Hygienic unshared	5.6	4.6	12.3	4.1	21.8	16.0
<i>Number of adults per room</i>						
More than 2 persons	5.0 <sup>*</sup>	5.3	14.8 <sup>*</sup>	4.8	22.7	15.7
Up to 2 persons	6.1	5.4	13.1	4.6	21.9	16.2
<i>Household cooking fuel</i>						
In home-solid fuel	7.8 <sup>***</sup>	8.1 <sup>***</sup>	12.9 <sup>**</sup>	5.2 <sup>**</sup>	23.7 <sup>***</sup>	16.4 <sup>*</sup>
Not solid fuel inside	5.4	5.1	15.1	3.8	20.6	15.1
<i>Household floor material</i>						
Mud	6.0 <sup>*</sup>	5.8 <sup>***</sup>	14.3	5.0 <sup>**</sup>	23.3 <sup>*</sup>	15.8
Not Mud	4.9	4.4	12.5	3.6	21.7	15.9
Overall	5.7	5.4	13.8	4.6	22.5	15.9

Table 2 Bivariate analysis showing relationships between morbidity (Diarrhea and ARI) and selected predictors

Table 3 Odds ratios and confidence intervals of diarrhea for the studied covariates from binary logistic regression models for Bangladesh, Nepal and Pakistan

Variables (Reference category) levels	Odds ratio of Diarrhea (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36+ months)</i>			
0-11 months	1.61 <sup>***</sup> (1.23 – 2.12)	3.11 <sup>***</sup> (2.46 – 3.93)	2.67 <sup>***</sup> (2.35 – 3.02)
12-35 months	1.70 <sup>***</sup> (1.36 – 2.13)	3.26 <sup>***</sup> (2.65 – 3.99)	2.29 <sup>***</sup> (2.06 – 2.55)
<i>Place of residence (Urban)</i>			
Rural	0.87 (0.67 – 1.13)	0.92 (0.68 – 1.25)	0.84 <sup>***</sup> (0.74 – 0.95)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.71 <sup>***</sup> (1.17 – 2.50)	1.41 <sup>**</sup> (1.03 – 1.93)	1.25 <sup>***</sup> (1.07 – 1.47)
Incomplete Secondary	1.68 <sup>***</sup> (1.20 – 2.36)	1.53 <sup>***</sup> (1.23 – 2.07)	1.21 <sup>**</sup> (1.03 – 1.42)
<i>Mother's access to mass media (Have access)</i>			
No access	1.16 (0.91 – 1.48)	1.08 (0.86 – 1.36)	0.99 (0.88 – 1.11)
<i>Wealth Status (Rich)</i>			
Poor	0.79 (0.48 – 1.29)	0.70 (0.47 – 1.06)	1.53 <sup>***</sup> (1.23 – 1.91)
Middle	0.78 (0.53 – 1.15)	0.93 (0.66 – 1.32)	1.50 <sup>***</sup> (1.27 – 1.78)
<i>Source of drinking water (Hygienic in premises)</i>			
Unhygienic or not in premises	1.21 (0.96 – 1.53)	1.09 (0.91 – 1.31)	0.93 (0.83 – 1.04)
<i>Toilet facility (Hygienic unshared)</i>			
Unhygienic Shared	1.05 (0.76 – 1.44)	1.27 <sup>**</sup> (1.03 – 1.57)	1.10 (0.97 – 1.26)
Unhygienic Share	1.02 (0.82 – 1.29)	0.92 (0.70 – 1.20)	1.01 (0.88 – 1.17)
<i>Number of adults per room (up to two persons per room)</i>			
More than two persons	0.76 <sup>***</sup> (0.62 – 0.94)	1.12 (0.95 – 1.33)	1.03 (0.93 – 1.14)
<i>Household floor material (Not mud)</i>			
Floor made of Mud	1.26 (0.88 – 1.81)	1.11 (0.83 – 1.48)	0.96 (0.84 – 1.10)

Table 4 Odds ratios and confidence intervals of ARI for the studied covariates from binary

Variables (Reference category) levels	Odds ratio of ARI (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36+ months)</i>			
0-11 months	2.38*** (1.82 – 3.13)	1.87*** (1.23 – 2.79)	1.24** (1.02 – 1.50)
12-35 months	1.80*** (1.41 – 2.30)	1.92*** (1.43 – 2.59)	1.42*** (1.23 – 1.62)
<i>Place of residence (Urban)</i>			
Rural	1.09 (0.82 – 1.43)	0.66 (0.41 – 1.06)	1.14 (0.98 – 1.33)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.28 (0.86 – 1.90)	0.82 (0.52 – 1.31)	1.32*** (1.10 – 1.58)
Incomplete Secondary	1.67*** (1.17 – 2.38)	0.99 (0.62 – 1.59)	1.25** (1.04 – 1.50)
<i>Mother's access to mass media (Have access)</i>			
No access	0.94 (0.74 – 1.20)	1.04 (0.71 – 1.52)	0.97 (0.86 – 1.11)
<i>Wealth Status (Rich)</i>			
Poor	2.35*** (1.42 – 3.87)	2.37*** (1.14 – 4.93)	0.95 (0.74 – 1.21)
Middle	1.66** (1.11 – 2.49)	2.76*** (1.46 – 5.25)	1.09 (0.87 – 1.31)
<i>Household cooking fuel (Not solid fuel is used and cooked outside)</i>			
Solid fuel cooked inside	1.62*** (1.21 – 2.16)	1.30 (0.95 – 1.77)	1.03 (0.90 – 1.31)
<i>Number of adults per room</i>			
More than two persons	0.93 (0.75 – 1.14)	1.05 (0.80 – 1.37)	0.95 (0.85 – 1.07)
<i>Household floor material</i>			
Mud	0.78 (0.55 – 1.08)	1.02 (0.66 – 1.57)	0.94 (0.81 – 1.09)

logistic regression models for Bangladesh, Nepal and Pakistan

# BMJ Open

## How sustainable household environment and knowledge of healthy practices relate to childhood morbidity in South Asia: Analysis of survey data from Bangladesh, Nepal and Pakistan

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2016-015019.R1
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<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Paediatrics
Keywords:	Public health < INFECTIOUS DISEASES, Community child health < PAEDIATRICS, PUBLIC HEALTH, STATISTICS & RESEARCH METHODS

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Manuscripts

1                   1                   **How sustainable household environment and knowledge of healthy**  
2                   2                   **practices relate to childhood morbidity in South Asia: Analysis of survey**  
3                   3                   **data from Bangladesh, Nepal and Pakistan**

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1 **Abstract:**

2 **Objectives:** Prevalence of diarrhea and acute respiratory infection (ARI) is considerably high  
3 among South Asian children. The objective of this study is to compare the associations of  
4 sustainable household environment and knowledge of healthy practices with episodes of  
5 these diseases among the children in the region.

6 **Design:** The study analyzed the latest, nationally representative and cross sectional  
7 Demographic and Health Survey data.

8 **Setting:** Data from three countries were analyzed: Bangladesh, Nepal and Pakistan.

9 **Participants:** Women aged between 12 and 49 years living in selected households provided  
10 information on 23,940 of their children under age of five years.

11 **Primary outcomes measures:** The morbidity status of the children was recorded with  
12 respect to episodes of diarrhea and/or ARI in the two weeks preceding data collection.

13 **Results:** Consuming unhygienic drinking water increased the risks of childhood diarrhea, and  
14 use of solid fuel for indoor cooking increased the risk of ARI, across all three countries  
15 investigated. However far more significant were the effects of mother's education, with  
16 incomplete primary education leading to an odds of diarrhea approaching twice that of a  
17 mother with secondary education or higher (OR = 1.70 in Bangladesh, 95% CI 1.16 to 2.49).

18 **Conclusions:** Results from the current research underline the importance of developing and  
19 implementing integrated strategic plans for mothers and children in the countries  
20 investigated. Promoting hygienic water and sanitation facilities can help reduce the  
21 prevalence of childhood diarrhea. Replacing indoor solid fuel cooking arrangements with  
22 cleaner fuel or more airy conditions can help reduce the prevalence of ARI. However, these  
23 strategies need to be integrated with education for women to raise the likelihood that reduced  
24 risks are actually realised.



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## 1 Strengths and limitations of this study

- 2 • The study utilized some of the largest and most recent cross-sectional surveys  
3 conducted in the countries analyzed
- 4 • Three countries were compared: Bangladesh (2014), Nepal (2011) and Pakistan  
5 (2012).
- 6 • Information regarding the disease episodes was provided for a single point of time so  
7 that the seasonal variations in the prevalence of the disease episodes are not addressed  
8 in the data.
- 9 • The disease episodes are determined on the basis of self-reporting of mothers over a  
10 short recall period (two weeks)
- 11 • The datasets do not represent same time point for the studied countries, though the  
12 largest time difference is only three years.

## 1 Introduction

2 Infectious diseases are responsible for approximately half of child deaths worldwide<sup>1</sup>, where  
3 pneumonia and diarrhea are two of the leading causes<sup>2,3</sup>. In addition to deaths, several  
4 diarrheal episodes lead to long-term nutritional deficits, whereas childhood respiratory  
5 infections cause increased risk of reduced lung capacity<sup>4,5</sup>. The greatest proportions of severe  
6 episodes of these infections are experienced in the south Asian and African regions and  
7 within these regions, the prevalence of these diseases is even higher for poorer countries and  
8 among disadvantaged children<sup>6,7</sup>.

9 Considering the consequences of diarrhea and ARI episodes on mortality and long-term  
10 adverse health outcomes, numerous studies have been conducted to identify associated risk  
11 factors. Existing literature suggests that younger children are more likely to experience  
12 infectious diseases than older cohorts, and consequently, a higher proportion of diarrhea and  
13 pneumonia related deaths happen in the first two years of life<sup>7-9</sup>. Due to differentials in food  
14 intake, standard of living and availability of health care facilities, urban-rural variations are  
15 also evident in childhood morbidity<sup>10,11</sup>. Educated mothers are knowledgeable about healthy  
16 environments and possible risks of their children being exposed to infectious diseases, and  
17 hence, occurrence of infectious diseases is significantly associated with the educational status  
18 of mother<sup>12-14</sup>. In addition to formal education, access to mass media helps to create  
19 awareness and form knowledge of communicable diseases<sup>15-17</sup>. Furthermore, poorer  
20 individuals within impoverished settings face a relatively higher burden of infectious  
21 diseases, and children in wealthy families are more protected from diarrhea and ARI<sup>18-20</sup>.

22 At the end of the Millennium Development Goals (MDG) in 2015, the development policies  
23 emphasized reducing the percentage of people living in households lacking a sustainable  
24 environment in terms of durable housing structure, sufficient living area, access to safe water  
25 and access to improved sanitation. These policies were developed considering the fact that a  
26 large proportion of diarrhea-related mortality is attributable to either unsafe drinking water,  
27 inadequate sanitation, or insufficient hygiene<sup>21</sup>. Investigating 171 Demographic and Health  
28 Surveys (DHS) in 70 low- and middle-income countries over the period 1986–2007,  
29 researchers<sup>22</sup> concluded that access to improved sanitation and water was associated with  
30 lower risk of childhood diarrhea. Similar relationships have been observed elsewhere<sup>23-25</sup>. As  
31 a part of Goal 3 of the Sustainable Development Goals (SDG), the UN is aiming to end  
32 epidemics of water-borne and other communicable diseases by 2030. Goal 6 emphasizes  
33 ensuring the availability of water and sanitation for all<sup>26</sup>. A review of published articles<sup>27</sup>  
34 concluded that residential crowding significantly increased the risk of severe respiratory

1 disease. Using solid fuel for cooking is a major source of household air pollution and  
2 responsible for a variety of respiratory diseases<sup>28-30</sup>.

3 The aim of this study is to advise on the relative importance of the SDG, in the light of  
4 evidence around the prevalence of diarrhoea and ARI among preschoolers from three south  
5 Asian countries; Bangladesh, Nepal and Pakistan. The first objective will be to compare the  
6 prevalence of diarrhoea and ARI across the three countries. Secondly, characteristics of  
7 children with relatively higher risks of diarrhoea and ARI will be identified. Thirdly, the  
8 association of potential predictors with the prevalence of diarrhoea and ARI will also be  
9 compared. Of particular interest in the light of the SDG is the relative importance of  
10 sustainable household environment, in terms of safe drinking water and toilet facilities,  
11 compared to other predictors such as maternal education and household wealth. The aims will  
12 be achieved by analyzing the latest releases of nationally representative DHS datasets from  
13 the relevant countries. All analysis will lead to suggestions regarding the development of  
14 feasible and effective plans that fit with the SDG and are likely to reduce childhood diarrhoea  
15 and ARI in the region.

## 16 **Data and methods**

17 This study utilized the latest, nationally representative and cross-sectional DHS datasets from  
18 three south Asian countries – Bangladesh (2014), Nepal (2011) and Pakistan (2012). These  
19 developing countries are home to 400 million people (Bangladesh 169 million, Nepal 32  
20 million and Pakistan 199 million)<sup>31</sup> and share common historical, social and cultural  
21 background. In terms of per capita GDP, they trail the world (Pakistan 152<sup>nd</sup>, Bangladesh  
22 156<sup>th</sup> and Nepal 172<sup>nd</sup>)<sup>32</sup>. Significant variations also exist among the countries in terms of  
23 child morbidity outcomes, as well as, a range of exposures to poverty and unhygienic  
24 household environment.

25 The DHS consists of a nationally representative sample of households obtained through a  
26 two-stage stratified sampling procedure. First, sample sizes in terms of number of households  
27 (for Bangladesh 18,000 households, for Nepal 10,826 households, for Pakistan 14,000  
28 households) were calculated to provide reasonable precision for the survey indicators. In the  
29 first stage, each of the countries were divided into strata and a sample of Enumeration Areas  
30 (EAs) were selected independently from each stratum using probability proportional to size.  
31 The EAs were considered as the Primary Sampling Units. In the second stage, a systematic  
32 sampling technique was employed to select a fixed number of households from each of these  
33 EAs. Finally, ever-married women aged between 12 and 49 years living in the selected

1 households were approached for interview to collect necessary information. The DHS  
2 surveys enjoy high response rates and provide cleaned data for secondary analysis. The  
3 present study excluded children from women who were not de-jure resident at the time of  
4 interview. Episodes of diarrhea and ARI in 23 940 children (7 760 from Bangladesh, 5 140  
5 from Nepal and 11 040 from Pakistan) under age of five years and born to the selected  
6 women were analysed. Though the DHS adopted appropriate survey methodology to obtain a  
7 representative sample, the final sample does not guarantee complete representativeness at  
8 national and regional levels. To ensure the representativeness of the sample at various levels,  
9 sampling weights are included in the data for each sampling stage and cluster based on  
10 sampling probabilities. The sample weights were incorporated into the current analyses.

11 The surveys have attractive features that make them appealing for quantitative analysis: they  
12 collect information on the morbidity status of children and cover a wide range of variables  
13 regarding the children, their parents and the households they live in. The variables used in the  
14 current study will be described in the next section.

### 15 **Dependent and independent variables**

16 The dependent variables in the study come from mother's responses to questions on recent  
17 (within two weeks preceding the survey) episodes of diarrhea and ARI of their children aged  
18 below five years. The DHS identify a child experiencing ARI by asking the mother whether  
19 the child has been ill in the two weeks preceding the survey with a cough accompanied by  
20 short, rapid breathing or by difficulty in breathing that the mother considered to be chest-  
21 related<sup>14</sup>. The children were categorized as those suffering or not experiencing these episodes  
22 within two weeks before the survey. Similarly, the DHS identify a child experiencing  
23 diarrhea by asking the mother whether the child had diarrhea in the last two weeks preceding  
24 the survey.

25 The set of independent variables considered as potential predictors were decided upon using  
26 the existing literature, availability of information in the survey datasets, and the knowledge of  
27 the researchers of the study region. To compare the prevalence of diarrhea and ARI across  
28 age groups, children were categorized as those aged less than one year, between one and  
29 three years and from three to five years. A similar categorization is used by other  
30 researchers<sup>17</sup>. Households were also categorized as being in either an urban or rural setting.  
31 Educational attainment, and access to mass media have been considered as a proxy of  
32 knowledge and understanding of mother regarding exposure to infectious diseases and their

1 consequences on their children<sup>15-16</sup>. Mothers were categorized as those with no or incomplete  
2 primary level, complete primary to incomplete secondary level and complete secondary or  
3 above level of education. Mothers were also classified on the basis of having or not having  
4 access to any of radio, television or newspapers.

5 Significant positive associations between household economic status and prevalence of  
6 infectious diseases were observed in previous studies<sup>14, 20</sup>. As a proxy of household economic  
7 status, this study used the wealth score created by the DHS and calculated using principal  
8 components analysis from variables comprising household construction materials (roof,  
9 ceiling and floor), possessions (televisions and bicycles) and dwelling characteristics (source  
10 of drinking water, sanitation facilities). Details about the calculation of the wealth scores is  
11 available<sup>33</sup>. On the basis of wealth score, children were classified as those coming from a  
12 household classified as low (lower 40%), middle (middle 40%) and high (upper 20%) wealth  
13 categories.

14 Source of drinking water, type of toilet facility, crowding, type of cooking fuel and type of  
15 floor material were considered as indicators of sustainable household environment. Pipe,  
16 borehole, protected dug well, spring, or rainwater are considered as improved sources of  
17 drinking water<sup>33</sup>. Households were categorized as those having or not having an improved  
18 water source located on the premises. Sanitation using technologies such as flush toilet,  
19 ventilated pit latrine, traditional pit latrine with a slab, or composting toilet were considered  
20 as improved. Households were categorized as those with ideal (improved unshared),  
21 moderate (unimproved unshared or improved shared) or worst (unimproved shared or no  
22 facility) toilet facilities. The number of adults per living room indicates crowding, and  
23 households were categorized as those with up to two adults per living room, and two or more  
24 adults per living room. On the basis of existence of cooking practice, the households were  
25 categorized as ideal (cooking outside the house or not using solid fuel while cooking inside)  
26 or not ideal (using solid fuel while cooking inside the house). Finally, houses were  
27 categorized as having the floor made of mud or else. All information was extracted from the  
28 datasets mentioned in the previous section.

## 29 **Statistical Analysis**

30 The dependent variables (prevalence of diarrhea and ARI), as well as the predictor variables  
31 considered in the study, are categorical. Bivariate chi-square analyses were carried out to  
32 compare the prevalence of the diseases among the levels of the selected predictors.

1 Given the dichotomous nature of the dependent variables, multiple binary logistic regression  
2 models were fitted to assess the impact of selected predictors on childhood morbidity. The  
3 model considers logarithm of odds (ratio of the probability of occurring to not occurring) as a  
4 linear additive function of the predictors. Exponentials of the estimated parameters referred  
5 as the odds ratio (OR), estimate the changes in the odds with unit change in the predictors  
6 (for continuous predictor) or changes in the level of predictors compared to baseline (for  
7 categorical predictor)<sup>34</sup>. Separate multiple logistic regression models were fitted to the data  
8 from individual countries. To focus the models for each disease, the model for diarrhea  
9 excluded the variable cooking fuel as predictor, whereas the model for ARI excluded source  
10 of drinking water and type of toilet facility as predictors. Statistical analysis was conducted in  
11 SPSS 21.0<sup>35</sup> using a weighted analysis to account for the survey weights and clustered  
12 structure of the sample.

### 13 **Results**

14 Prevalence of diarrhea was considerably lower for the children in Bangladesh (5.7%) with  
15 respect to Nepal (13.8%) and Pakistan (22.5%). A considerably higher percentage of children  
16 from Pakistan were experiencing ARI (15.9%) than Bangladesh (5.4%) and Nepal (4.6%).  
17 Percentages of children experiencing co-morbidity (defined in this study as presence of both  
18 diarrhea and ARI) were highest in Pakistan and lowest in Bangladesh (Figure 1).  
19 Distributions of respondents for various levels of selected predictors are presented in Table 1.  
20 Age distributions of children were consistent over the studied countries. Most of the children  
21 in the studied settings lived in rural areas, ranging from 70.3% in Pakistan to 90.6% in Nepal.  
22 The percentage of mothers with both lower (no or incomplete primary) and higher  
23 (completed secondary or higher) educational levels were highest in Pakistan (62.5% and  
24 17.9%), whereas the percentage of mothers with no or incomplete primary level of education  
25 was lowest in Bangladesh (32.7%). The highest proportion of children whose mother had  
26 access to any mass media was from Nepal (84.4%). Among the studied countries, percentages  
27 of children from households using improved and unshared toilet facilities was lowest in  
28 Nepal (35.9%). Using solid fuel while cooking inside home was rare in Bangladesh (9.6%)  
29 and common in Nepal (57.4%) and Pakistan (59.8%). Among the studied settings, the  
30 percentage of children from household sharing more than two adults a room was highest  
31 (71.7%) in Pakistan.

32 In the bivariate analyses, children experiencing episodes of ARI (within two weeks before the  
33 survey) were more likely to experience diarrhea and vice-versa (Table 2). Older children  
34 were significantly less likely to experience either episode than the younger. With the

1 exception of episodes of ARI in Nepalese children, educational status of mother showed a  
2 significant association with the prevalence of the episodes of both infections. A mother's  
3 access to mass media showed significant association with both episodes in Bangladesh only.  
4 Except for the prevalence of diarrhea in Bangladesh, the wealth status of a household showed  
5 significant association with childhood diarrhea and ARI. Significant associations between  
6 place of residence and prevalence of ARI were also observed for children in Bangladesh and  
7 Pakistan ( $p < 0.05$ ). In all except one setting, the source of drinking water did not show any  
8 significant association with diarrhea or ARI, whereas type of toilet facility showed a  
9 significant association with the prevalence of diarrhea in Nepal and Pakistan. The number of  
10 adults per living room showed a significant association with the prevalence of diarrhea in  
11 Bangladesh and Nepal. Children from households using solid cooking fuel inside the house  
12 were significantly more likely to experience ARI with respect to those from households not  
13 using solid fuel for cooking inside the home.

14 Adjusted ORs for experiencing diarrhea and their associated confidence interval (CI) for the  
15 predictor variables are presented in Table 3. Once the effect of other variables was controlled  
16 for, in all the three countries, age of children and educational status of mother showed  
17 significant association with prevalence of diarrhea. In Bangladesh, Nepal and Pakistan,  
18 children below one year of age, were 63% (OR 1.63, CI = 1.23 – 2.16), 219% (OR 3.19, CI =  
19 2.51 – 4.05) and 156% (OR 2.56, CI = 2.26 – 2.91) more likely to experience diarrhea with  
20 respect to those aged above three years (the reference category). With respect to the reference  
21 category, children aged between one and three years were also significantly more likely to  
22 experience diarrhea. In Bangladesh, children from mothers with no or incomplete primary  
23 and incomplete secondary educational levels were 70% (OR 1.70, CI = 1.16 – 2.49) and 69%  
24 (OR 1.69, CI = 1.20 – 2.38) more likely to experience diarrhea with respect to those from  
25 mothers with secondary or higher level of education. In Pakistan, children from households  
26 categorized as low and middle wealth status were significantly more likely to experience  
27 diarrhea with respect to those with high economic status. However, for the children from  
28 Bangladesh and Pakistan, the wealth status of household was not significantly associated with  
29 the prevalence of diarrhea ( $p > 0.05$ ). Children from households using worst toilet facilities  
30 (in terms of improvement and sharing status) were more likely to experience diarrhea,  
31 however, the association is statistically significant for the children in Nepal only.

32 Adjusted ORs for experiencing ARI with associated CI for the studied variables were  
33 presented in Table 4. Like diarrhea, younger children were significantly more likely to  
34 experience ARI than older children. In Bangladesh and Pakistan, children of mothers with

1 incomplete primary or incomplete secondary level of education were more likely to  
2 experience ARI than those from secondary or higher level of education. In Pakistan, with  
3 respect to the children of mothers with secondary or higher level of education, those of  
4 mothers with incomplete primary and incomplete secondary level of education were 35%  
5 (OR = 1.35, CI = 1.13 – 1.62) and 24% (OR = 1.24, CI = 1.04 – 1.49) more likely to  
6 experience ARI. However, the relationship of maternal education and ARI of children is not  
7 significant in Nepal. In Bangladesh and Nepal, children from households categorized as low  
8 or middle wealth status were significantly more likely to experience ARI with respect to  
9 those with high status. However, the association of wealth with ARI was not significant for  
10 Nepal. In Bangladesh, children from households not using ideal cooking facilities (using solid  
11 fuel while cooking inside house) were 62% (OR = 1.62, CI = 1.22 – 2.16) more likely to  
12 experience ARI, however, the association was not statistically significant in Nepal and  
13 Pakistan ( $p > 0.05$ ). Over the countries, neither the degree of crowding nor the household  
14 floor material showed consistent association with either diarrhea or ARI.

## 15 16 **Discussion**

17 Prevalence of two major infectious diseases, diarrhea and ARI, is relatively high among  
18 young children in the South Asian region. The study was conceived with objectives of  
19 comparing the association of potential predictors, in particular sustainable household  
20 environment and maternal education, on disease episodes among preschoolers from three  
21 South Asian countries, Bangladesh, Nepal and Pakistan.

22 **Comparison of prevalence:** The highest prevalence rates were in Pakistan for both diarrhea  
23 and ARI, and in Nepal, for diarrhea. Bangladesh is considered as a paradox in terms of good  
24 health outcomes despite economic poverty<sup>36,37</sup>. Even the disadvantaged children from  
25 Bangladesh (from households categorized as poor and using unimproved water and toilet  
26 facilities) possess lower risk of experiencing diarrhea with respect to economically  
27 advantaged children in Nepal and Pakistan. Similar outcomes have been reported<sup>38</sup>, where it  
28 is mentioned that Pakistan lags behind the MDG in many aspects including child health.  
29 Though the prevalence of ARI is low in Nepal, prevalence of diarrhea is higher in the  
30 country. This may be resulted from lack of sustainable household environment (defined as  
31 improved water source and hygienic sanitation) or knowledge of healthy practice of mother  
32 (measured by level of schooling).

33 **What didn't have a clear association with prevalence:** Rural-urban setting not found to  
34 have a significant effect on prevalence of either diarrhea or ARI. Source of drinking water,



1 number of adults sharing a living room and floor materials all showed inconsistent effects on  
2 the prevalence of childhood diarrhoea across the countries studied.

3 **What did have a clear effect on prevalence:** In all the three studied countries, bivariate  
4 analyses showed that the presence of diarrhoea significantly increases the likelihood of the  
5 prevalence of ARI, and vice-versa. However, it is important not to include diarrhoea in the  
6 multiple model of ARI prevalence, and vice versa, because there is a high degree of overlap  
7 in risk factors for diarrhoea and ARI e.g. age of child, crowding, poor housing. Furthermore,  
8 the short recall period employed in the DHS (two weeks) means that the data is clearly cross-  
9 sectional and the lag effect of one disease on another cannot be measured with the data at  
10 hand. Similar results were observed in previous studies where the epidemiology of diarrhoea  
11 and ARI overlapped. This is highly likely to be due to shared risk factors or compromised  
12 immune function<sup>39-41</sup>. Health policy needs to take a holistic approach to combatting  
13 childhood infections due to the clear presence of co-morbidity, at least in the case of diarrhoea  
14 and ARI shown in this paper.

15 Younger children possess significantly higher risks of experiencing morbidity than older; the  
16 result is consistent with previous studies in Bangladesh and elsewhere<sup>8,14</sup>. The immune  
17 system may not be developed at earlier ages, younger children may be infected from  
18 unhygienic feeding practices (water, bottles etc.) and unclean surroundings. Diarrhoea  
19 pathogens, like *E. coli*, are commonly transmitted via impure water, unhygienic utensils or  
20 poor food handling<sup>42</sup>. While crawling, children explore their immediate environment and may  
21 pick up infections. Inappropriate dietary supplementation may also hinder children's  
22 developing immune system, which can be overcome through exclusive breastfeeding for  
23 recommended periods of time. Breastfeeding data is available in the DHS surveys, however it  
24 has not been included in the current analyses due to its high degree of confounding with age.

25 Of most interest is the result that maternal educational status showed significant positive  
26 influence on reducing the prevalence of diarrhoea and ARI, and that the effects are more  
27 evident when the educational attainment is at least secondary or higher.

28 **Data limitations:** DHS are cross-sectional surveys which collect information regarding the  
29 disease episodes for a single point of time. Such studies can yield information on association  
30 but not impact. The seasonal variations in the prevalence of the disease episodes are not  
31 addressed in the data. Moreover, the disease episodes are determined on the basis of self-  
32 reporting of mother, and not followed by any clinical examination. To reduce the reporting  
33 bias due to memory lapse, a short recall period (two weeks) is considered while collecting  
34 morbidity related information. Children who were not de-jure resident at the time of the

1 survey were excluded from the analysis. The exclusion may lead a bias to the outcomes,  
2 however, the amount of bias is likely to be small. Finally, the datasets do not represent same  
3 time point for the studied countries, though the largest time difference is only three years.

4 **Conclusion:** This study focuses on three South Asian countries with relatively higher  
5 prevalence of childhood diarrhea and ARI on the worldwide scale. Sustainable household  
6 environment, as mentioned in the SDG, in terms of flooring, water, toilet and cooking  
7 facilities was not found to have the greatest association with morbidity. Nor was wealth a  
8 main driver, as its impact on childhood diarrhea and ARI was only statistically significant in  
9 half of the settings considered in this paper. Of far more importance was knowledge base of a  
10 child's primary caregiver (typically the mother) regarding the potential risks of infection and  
11 the impacts of infection on survival and well-being These results indicate that the SDG of  
12 good health and wellbeing needs to be tackled by incorporating quality health education  
13 along with the goals of clean water and sanitation for all, and no poverty. According to our  
14 findings, maternal education could be effective in reducing child morbidity only when it is at  
15 complete secondary level or higher. An effective basic knowledge base formed through  
16 policies that incorporate health education in school curricula at primary and secondary level  
17 has a good chance of making an impact, especially since the female primary  
18 school enrolment rate in Nepal and Bangladesh is already above 90%. Alternative ways to  
19 develop knowledge of healthy practices among the mass population could be delivered  
20 through mass media. Well-developed motivational programs incorporating mass media,  
21 health professionals, community health workers, community leaders, government and non-  
22 government organisations may help improve population awareness of the causes and  
23 consequences of infectious diseases. These programs may be more essential for the countries  
24 like Pakistan where the percentages of children suffering infectious diseases are relatively  
25 higher and female school enrolment rate is relatively lower.

26 Contributorship: MMH conceptualised the study. The methodology was developed by MMH  
27 and AR. Data interpretation and drafting of the paper were undertaken by MMH and AR.  
28 Both authors made contributions to the overall manuscript and are responsible for the drafting  
29 of the manuscript.

30 Competing interests: None declared.

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32 Survey Program (<https://dhsprogram.com/>).

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14 Table 3 The Adjusted ORs (confidence interval) for the studied covariates from binary  
15 multivariable logistic regression models for children experiencing diarrhea for Bangladesh,  
16 Nepal and Pakistan

17 Table 4 The Adjusted ORs (confidence interval) for the studied covariates from binary  
18 multivariable logistic regression models for children experiencing ARI for Bangladesh, Nepal  
19 and Pakistan

1 Table 1 Percentages of respondents for various levels of the selected predictor variables in  
 2 Bangladesh, Nepal and Pakistan  
 3

Background Characteristics	Percentages of respondents			4
	Bangladesh (N = 7760)	Nepal (N = 5140)	Pakistan (N= 11040)	
<i>Age of child</i>				
0-11 months	19.5	19.9	19.8	6
12-35 months	41.2	39.2	39.4	
36-59 months	39.3	40.9	40.8	7
<i>Type of Place of Residence</i>				
Rural	74.4	90.6	70.3	8
Urban	25.6	9.4	29.7	
<i>Mother's education</i>				9
Incomplete Primary	32.7	61.0	62.5	
Incomplete Secondary	51.5	25.3	19.6	10
Secondary or Higher	15.8	13.7	17.9	
<i>Access to electronic media</i>				11
No access	38.7	15.2	29.8	
Have access	61.3	84.8	70.2	12
<i>Age of mother at the time of survey</i>				
15 –19 years	14.6	7.0	2.2	13
20 –29 years	61.7	65.5	52.4	
30 –49 years	23.7	27.5	45.4	14
<i>Source of drinking water</i>				
Not improved/not in premises	21.1	36.1	22.9	15
Improved in premises	78.9	63.9	77.1	
<i>Toilet facility</i>				16
Worst	10.4	49.0	25.4	
Moderate	26.7	15.0	11.5	17
Ideal	62.9	35.9	63.2	
<i>Number of adults per room</i>				18
More than 2 adults	40.9	43.2	71.7	
Up to 2 adults	59.1	56.8	28.3	19
<i>Household cooking facility</i>				
Not ideal	9.6	57.4	59.8	20
Ideal	90.4	42.6	40.2	
<i>Household floor material</i>				21
Mud	68.9	75.4	47.3	
Not Mud	31.1	24.6	52.7	22

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1 Table 2 Associations between childhood morbidity (diarrhea or ARI) in two weeks preceding  
 2 the survey and background characteristics of children. The figures for various levels of  
 3 predictors represent the percentage of children experiencing disease.

Background Characteristics	Bangladesh		Nepal		Pakistan	
	% Diarrhea	% ARI	% Diarrhea	% ARI	% Diarrhea	% ARI
<i>Childhood ARI/ Diarrhea in last two weeks</i>						
Experienced	9.8	9.3	30.1	10.1	30.2	23.7
Not experienced	5.4	5.1	13.1	3.8	20.4	13.6
Chi-square	14.27 <sup>a</sup>	14.27 <sup>a</sup>	55.65 <sup>a</sup>	55.65 <sup>a</sup>	145.59 <sup>a</sup>	145.59 <sup>a</sup>
<i>Age of child</i>						
0-11 months	6.4	7.7	18.3	5.6	30.2	18.1
12-35 months	6.8	6.0	19.0	6.0	27.2	17.9
36-59 months	4.1	3.5	6.7	2.9	14.2	12.8
Chi-square	21.89 <sup>a</sup>	41.15 <sup>a</sup>	150.24 <sup>a</sup>	24.46 <sup>a</sup>	308.76 <sup>a</sup>	52.81 <sup>a</sup>
<i>Place of residence</i>						
Rural	5.7	5.7	13.9	4.6	22.7	16.4
Urban	5.6	4.3	13.4	5.0	21.9	14.6
Chi-square	0.01	5.66 <sup>b</sup>	0.07	0.12	0.89	5.84 <sup>b</sup>
<i>Mother's educational status</i>						
Incomplete primary	6.1	5.2	14.2	4.6	23.5	16.4
Incomplete secondary	6.0	6.1	14.8	5.1	23.0	16.3
Secondary or higher	3.8	3.3	10.5	4.1	18.5	13.4
Chi-square	9.93 <sup>a</sup>	15.37 <sup>a</sup>	7.75 <sup>c</sup>	1.04	22.26 <sup>a</sup>	10.84 <sup>a</sup>
<i>Wealth status of household</i>						
Low	6.3	6.5	13.5	4.7	23.5	15.6
Middle	5.3	5.2	15.0	5.5	23.6	17.0
High	5.2	3.3	11.8	2.2	17.1	13.7
Chi-square	3.66	19.76 <sup>a</sup>	5.03	12.92 <sup>a</sup>	36.23 <sup>a</sup>	10.58 <sup>a</sup>
<i>Access to electronic media</i>						
No access	6.4	6.0	15.8	4.7	23.2	15.9
Have access	5.2	5.0	13.5	4.6	22.2	15.8
Chi-square	4.87 <sup>c</sup>	3.39	2.83	0.03	1.42	0.03
<i>Age of mother at the time of survey</i>						
15 –19 years	6.3	7.9	16.2	5.6	32.6	21.1
20 –29 years	5.6	5.3	14.0	4.7	24.3	16.2
30 –49 years	5.6	4.1	12.9	4.2	19.9	15.2
Chi-square	0.86	20.72 <sup>a</sup>	2.64	1.47	43.87 <sup>a</sup>	7.09 <sup>b</sup>
<i>Source of drinking water</i>						
Unimproved/not in premises	6.8	6.1	14.1	4.7	21.7	15.5
Improved in premises	5.4	5.2	13.7	4.6	22.7	16.0
Chi-square	5.25 <sup>c</sup>	2.33	0.13	0.02	1.22	0.39
<i>Toilet facility</i>						
Worst	6.1	7.3	15.5	4.8	24.2	15.5
Moderate	5.8	6.4	12.0	5.6	23.5	15.8
Ideal	5.6	4.6	12.3	4.1	21.8	16.0
Chi-square	0.41	15.55 <sup>a</sup>	11.28 <sup>a</sup>	2.73	8.14 <sup>b</sup>	0.47
<i>Number of adults per room</i>						
More than 2 adults	5.0	5.3	14.8	4.8	22.7	15.7
Up to 2 adults	6.1	5.4	13.1	4.6	21.9	16.2
Chi-square	3.93 <sup>c</sup>	0.07	3.18	0.13	0.78	0.49
<i>Household cooking fuel</i>						
Not ideal	7.8	8.1	12.9	5.2	23.7	16.4
Ideal	5.4	5.1	15.1	3.8	20.6	15.1
Chi-square	6.89 <sup>a</sup>	11.85 <sup>a</sup>	5.53 <sup>b</sup>	5.50 <sup>b</sup>	14.65 <sup>a</sup>	3.00 <sup>c</sup>
<i>Household floor material</i>						
Mud	6.0	5.8	14.3	5.0	23.3	15.8
Not mud	4.9	4.4	12.5	3.6	21.7	15.9
Chi-square	3.57	7.19 <sup>a</sup>	2.50	4.35 <sup>c</sup>	3.83 <sup>b</sup>	0.03
Overall	5.7	5.4	13.8	4.6	22.5	15.9

a:  $p < 0.01$ ; b:  $0.01 \leq p < 0.05$ ; c:  $0.05 \leq p < 0.1$



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5 Table 3 The Adjusted ORs (confidence interval) for the studied covariates from binary  
 6 multivariable logistic regression models for children experiencing diarrhea for Bangladesh,  
 7 Nepal and Pakistan

Variables (Reference category) levels	Odds ratio of Diarrhea (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36-59 months)</i>			
0-11 months	1.63 <sup>a</sup> (1.23 – 2.16)	3.19 <sup>a</sup> (2.51 – 4.05)	2.56 <sup>a</sup> (2.26 – 2.91)
12-35 months	1.71 <sup>a</sup> (1.36 – 2.14)	3.29 <sup>a</sup> (2.68 – 4.04)	2.24 <sup>a</sup> (2.01 – 2.50)
<i>Place of residence (Urban)</i>			
Rural	0.87 (0.69 – 1.12)	0.92 (0.68 – 1.25)	0.83 <sup>a</sup> (0.73 – 0.94)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.70 <sup>a</sup> (1.16 – 2.49)	1.41 <sup>b</sup> (1.03 – 1.93)	1.27 <sup>a</sup> (1.08 – 1.48)
Incomplete Secondary	1.69 <sup>a</sup> (1.20 – 2.38)	1.55 <sup>a</sup> (1.14 – 2.10)	1.19 <sup>b</sup> (1.01 – 1.40)
<i>Mother's access to mass media (Have access)</i>			
No access	1.16 (0.91 – 1.48)	1.07 (0.85 – 1.35)	1.01 (0.90 – 1.13)
<i>Age of mother at the time of survey (30 – 49 years)</i>			
15 – 19 years	0.94 (0.67 – 1.30)	0.83 (0.59 – 1.17)	1.40 <sup>b</sup> (1.05 – 1.86)
20 – 29 years	0.94 (0.74 – 1.21)	0.99 (0.81 – 1.20)	1.17 <sup>a</sup> (1.07 – 1.29)
<i>Wealth Status (High)</i>			
Low	0.79 (0.48 – 1.30)	0.71 <sup>c</sup> (0.47 – 1.06)	1.53 <sup>a</sup> (1.23 – 1.91)
Middle	0.78 (0.53 – 1.16)	0.94 (0.66 – 1.33)	1.49 <sup>a</sup> (1.26 – 1.77)
<i>Source of drinking water (Hygienic in premises)</i>			
Unimproved or not in premises	1.21 (0.96 – 1.53)	1.10 (0.91 – 1.31)	0.93 (0.83 – 1.04)
<i>Toilet facility (Ideal)</i>			
Worst	1.06 (0.76 – 1.46)	1.29 <sup>b</sup> (1.04 – 1.59)	1.10 (0.97 – 1.25)
Moderate	1.03 (0.82 – 1.29)	0.92 (0.70 – 1.20)	1.01 (0.88 – 1.17)
<i>Number of adults per room (up to two adults per room)</i>			
More than two adults	0.76 <sup>a</sup> (0.62 – 0.93)	1.12 (0.95 – 1.33)	1.06 (0.95 – 1.17)
<i>Household floor material (Not mud)</i>			
Floor made of mud	1.27 (0.89 – 1.81)	1.11 (0.83 – 1.48)	0.94 (0.82 – 1.08)

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 9 a:  $p < 0.01$ ; b:  $0.01 \leq p < 0.05$ ; c:  $0.05 \leq p < 0.1$

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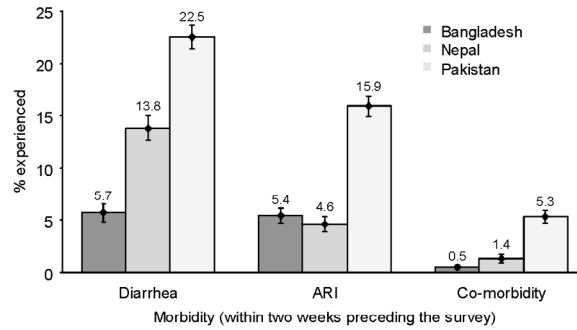
11 Table 4 The Adjusted ORs (confidence interval) for the studied covariates from binary  
 12 multivariable logistic regression models for children experiencing ARI for Bangladesh, Nepal  
 13 and Pakistan  
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Variables (Reference category) levels	Odds ratio of ARI (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36+ months)</i>			
0-11 months	2.21 <sup>a</sup> (1.66 – 2.92)	1.99 <sup>a</sup> (1.23 – 2.79)	1.49 <sup>a</sup> (1.30 – 1.72)
12-35 months	1.74 <sup>a</sup> (1.36 – 2.22)	2.12 <sup>a</sup> (1.54 – 2.91)	1.49 <sup>a</sup> (1.32 – 1.68)
<i>Place of residence (Urban)</i>			
Rural	1.10 (0.83 – 1.45)	0.66 <sup>c</sup> (0.41 – 1.07)	1.14 <sup>c</sup> (0.98 – 1.34)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.31 (0.88 – 1.96)	0.86 (0.54 – 1.38)	1.35 <sup>a</sup> (1.13 – 1.62)
Incomplete Secondary	1.63 <sup>a</sup> (1.14 – 2.33)	1.02 (0.64 – 1.63)	1.24 <sup>b</sup> (1.04 – 1.49)
<i>Mother's access to mass media (Have access)</i>			
No access	0.96 (0.75 – 1.22)	1.02 (0.69 – 1.49)	0.99 (0.87 – 1.12)
<i>Age of mother at the time of survey (30–49 years)</i>			
15–19 years	1.47 <sup>b</sup> (1.05 – 2.06)	0.95 (0.55 – 1.64)	1.29 (0.93 – 1.78)
20–29 years	1.20 (0.91 – 1.57)	1.01 (0.74 – 1.38)	1.02 (0.91 – 1.13)
<i>Wealth Status (High)</i>			
Low	2.25 <sup>a</sup> (1.36 – 3.70)	2.25 <sup>b</sup> (1.08 – 4.69)	0.94 (0.74 – 1.20)
Middle	1.61 <sup>b</sup> (1.08 – 2.41)	2.68 <sup>a</sup> (1.41 – 5.10)	1.09 (0.90 – 1.31)
<i>Household cooking fuel (Ideal)</i>			
Not ideal	1.62 <sup>a</sup> (1.22 – 2.16)	1.31 <sup>c</sup> (0.96 – 1.79)	1.01 (0.88 – 1.16)
<i>Number of adults per room (up to two adults per room)</i>			
More than two adults	0.95 (0.77 – 1.17)	1.03 (0.79 – 1.36)	0.96 (0.86 – 1.08)
<i>Household floor material (Not mud)</i>			
Floor made of mud	0.77 (0.55 – 1.08)	1.04 (0.67 – 1.31)	0.92 (0.79 – 1.07)

a:  $p < 0.01$ ; b:  $0.01 \leq p < 0.05$ ; c:  $0.05 \leq p < 0.1$

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Percentage (with 95% confidence interval) of children in Bangladesh, Nepal and Pakistan experiencing diarrhea, ARI and co-morbidity within two weeks preceding the survey

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# BMJ Open

## How sustainable household environment and knowledge of healthy practices relate to childhood morbidity in South Asia: Analysis of survey data from Bangladesh, Nepal and Pakistan

Journal:	<i>BMJ Open</i>
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Complete List of Authors:	Hasan, Masud; University of Canberra, Faculty of Education, Science, Technology, and Mathematics Richardson, Alice ; Australian National University, NCEPH
<b>Primary Subject Heading</b>:	Public health
Secondary Subject Heading:	Paediatrics
Keywords:	Public health < INFECTIOUS DISEASES, Community child health < PAEDIATRICS, PUBLIC HEALTH, STATISTICS & RESEARCH METHODS

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Manuscripts

1                   1                   **How sustainable household environment and knowledge of healthy**  
2                   2                   **practices relate to childhood morbidity in South Asia: Analysis of survey**  
3                   3                   **data from Bangladesh, Nepal and Pakistan**

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8                   5                   Md Masud Hasan and Alice Richardson  
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28                  21                  **Keywords:** Public health < Infectious Diseases; Community child health < Paediatrics;

29                  22                  Public Health; Statistics and Research Methods  
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1 **Abstract:**

2 **Objectives:** Prevalence of diarrhea and acute respiratory infection (ARI) is considerably high  
3 among South Asian children. The objective of this study is to compare the associations of  
4 sustainable household environment and knowledge of healthy practices with episodes of  
5 these diseases among the children in the region.

6 **Design:** The study analyzed the latest, nationally representative and cross sectional  
7 Demographic and Health Survey data.

8 **Setting:** Data from three countries were analyzed: Bangladesh, Nepal and Pakistan.

9 **Participants:** Women aged between 12 and 49 years living in selected households provided  
10 information on 23,940 of their children under age of five years.

11 **Primary outcomes measures:** The morbidity status of the children was recorded with  
12 respect to episodes of diarrhea and/or ARI in the two weeks preceding data collection.

13 **Results:** Consuming unhygienic drinking water increased the risks of childhood diarrhea, and  
14 use of solid fuel for indoor cooking increased the risk of ARI, across all three countries  
15 investigated. However far more significant were the effects of mother's education, with  
16 incomplete primary education leading to an odds of diarrhea approaching twice that of a  
17 mother with secondary education or higher (OR = 1.70 in Bangladesh, 95% CI 1.16 to 2.49).

18 **Conclusions:** Results from the current research underline the importance of developing and  
19 implementing integrated strategic plans for mothers and children in the countries  
20 investigated. Promoting hygienic water and sanitation facilities can help reduce the  
21 prevalence of childhood diarrhea. Replacing indoor solid fuel cooking arrangements with  
22 cleaner fuel or more airy conditions can help reduce the prevalence of ARI. However, these  
23 strategies need to be integrated with education for women to raise the likelihood that reduced  
24 risks are actually realised.

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## 1 Strengths and limitations of this study

- 2 • The study utilized some of the largest and most recent cross-sectional surveys  
3 conducted in the countries analyzed
- 4 • Three countries were compared: Bangladesh (2014), Nepal (2011) and Pakistan  
5 (2012).
- 6 • Information regarding the disease episodes is limited by its provision at a single point  
7 of time so that the seasonal variations in the prevalence of the disease episodes are not  
8 addressed in the data.
- 9 • The disease episodes are limited by their determination on the basis of self-reporting  
10 of mothers over a short recall period (two weeks)
- 11 • The datasets do not represent same time point for the studied countries, though the  
12 largest time difference is only three years.



## 1 Introduction

2 Infectious diseases are responsible for approximately half of child deaths worldwide<sup>1</sup>, where  
3 pneumonia and diarrhea are two of the leading causes<sup>2,3</sup>. Apart from deaths, several diarrheal  
4 episodes lead to long-term nutritional deficits, whereas childhood respiratory infections cause  
5 increased risk of reduced lung capacity<sup>4,5</sup>. The greatest proportions of severe episodes of  
6 these infections are experienced in the south Asian and African regions and within these  
7 regions, the prevalence of these diseases is even higher for poorer countries and among  
8 disadvantaged children<sup>6,7</sup>.

9 Considering the consequences of diarrhea and ARI episodes on mortality and long-term  
10 adverse health outcomes, numerous studies have been conducted to identify associated risk  
11 factors. Existing literature suggests that younger children are more likely to experience  
12 infectious diseases than older cohorts, and consequently, a higher proportion of diarrhea and  
13 pneumonia related deaths happen in the first two years of life<sup>7-9</sup>. Due to differentials in food  
14 intake, standard of living and availability of health care facilities, urban-rural variations are  
15 also evident in childhood morbidity<sup>10,11</sup>. Educated mothers are knowledgeable about healthy  
16 environments and possible risks of their children being exposed to infectious diseases, and  
17 hence, occurrence of infectious diseases is significantly associated with the educational status  
18 of mother<sup>12-14</sup>. In addition to formal education, access to mass media helps to create  
19 awareness around communicable diseases<sup>15-17</sup>. Furthermore, poorer individuals within  
20 impoverished settings face a relatively higher burden of infectious diseases, and children in  
21 wealthy families are more protected from diarrhea and ARI<sup>18-20</sup>.

22 At the end of the Millennium Development Goals (MDG) in 2015, the development policies  
23 emphasized reducing the percentage of people living in households lacking a sustainable  
24 environment in terms of durable housing structure, sufficient living area, access to safe water  
25 and access to improved sanitation. These policies were developed considering the fact that a  
26 large proportion of diarrhea-related mortality is attributable to either unsafe drinking water,  
27 inadequate sanitation, or insufficient hygiene<sup>21</sup>. Investigating 171 Demographic and Health  
28 Surveys (DHS) in 70 low- and middle-income countries over the period 1986–2007,  
29 researchers<sup>22</sup> concluded that access to improved sanitation and water was associated with  
30 lower risk of childhood diarrhea. Similar relationships have been observed elsewhere<sup>23-25</sup>. As  
31 a part of Goal 3 of the Sustainable Development Goals (SDG), the UN is aiming to end  
32 epidemics of water-borne and other communicable diseases by 2030. Goal 6 emphasizes  
33 ensuring the availability of water and sanitation for all<sup>26</sup>. A review of published articles<sup>27</sup>  
34 concluded that residential crowding significantly increased the risk of severe respiratory

1 disease. Using solid fuel for cooking is a major source of household air pollution and  
2 responsible for a variety of respiratory diseases<sup>28-30</sup>.

3 The main aim of this study was to advise on the relative importance of the SDG, in the light  
4 of evidence around the prevalence of diarrhea and ARI among preschoolers from three south  
5 Asian countries; Bangladesh, Nepal and Pakistan. The first objective was to compare the  
6 prevalence of diarrhea and ARI across the three countries. The second objective was to  
7 identify characteristics of children with relatively higher risks of diarrhea and ARI. The third  
8 was to compare the association of potential predictors with the prevalence of diarrhea and  
9 ARI. Of particular interest in the light of the SDG is the relative importance of sustainable  
10 household environment, in terms of safe drinking water and toilet facilities, compared to  
11 other predictors such as maternal education and household wealth. A second aim was to  
12 provide suggestions regarding the development of feasible and effective plans that fit with the  
13 SDG and are likely to reduce childhood diarrhea and ARI in the region.

## 14 **Data and methods**

15 This study achieved the objectives by utilizing the latest releases of nationally representative  
16 and cross-sectional DHS datasets from three south Asian countries – Bangladesh (2014),  
17 Nepal (2011) and Pakistan (2012). These developing countries are home to 400 million  
18 people (Bangladesh 169 million, Nepal 32 million and Pakistan 199 million)<sup>31</sup> and share  
19 common historical, social and cultural background. In terms of per capita GDP, they trail the  
20 world (Pakistan 152<sup>nd</sup>, Bangladesh 156<sup>th</sup> and Nepal 172<sup>nd</sup>)<sup>32</sup>. Significant variations also exist  
21 among the countries in terms of child morbidity outcomes, as well as, a range of exposures to  
22 poverty and unhygienic household environment.

23 The DHS consists of a nationally representative sample of households obtained through a  
24 two-stage stratified sampling procedure. First, sample sizes in terms of number of households  
25 (for Bangladesh 18,000 households, for Nepal 10,826 households, for Pakistan 14,000  
26 households) were calculated to provide reasonable precision for the survey indicators. In the  
27 first stage, each of the countries were divided into strata and a sample of Enumeration Areas  
28 (EAs) were selected independently from each stratum using probability proportional to size.  
29 The EAs were considered as the Primary Sampling Units. In the second stage, a systematic  
30 sampling technique was employed to select a fixed number of households from each of these  
31 EAs. Finally, ever-married women aged between 12 and 49 years living in the selected  
32 households were approached for interview to collect necessary information. The DHS  
33 surveys enjoy high response rates and provide cleaned data for secondary analysis. The

1 present study excluded children from women who were not de-jure resident at the time of  
2 interview. Episodes of diarrhea and ARI in 23 940 children (7 760 from Bangladesh, 5 140  
3 from Nepal and 11 040 from Pakistan) under age of five years and born to the selected  
4 women were analyzed. To ensure the representativeness of the sample at various levels,  
5 sampling weights are included in the data for each sampling stage and cluster based on  
6 sampling probabilities. The sample weights were incorporated into the current analyses.

7 The surveys have attractive features that make them appealing for quantitative analysis: they  
8 collect information on the morbidity status of children and cover a wide range of variables  
9 regarding the children, their parents and the households they live in. The variables used in the  
10 current study will be described in the next section.

### 11 **Dependent and independent variables**

12 The dependent variables in the study come from mother's responses to questions on recent  
13 (within two weeks preceding the survey) episodes of diarrhea and ARI of their children aged  
14 below five years. The DHS identify a child experiencing ARI by asking the mother whether  
15 the child has been ill in the two weeks preceding the survey with a cough accompanied by  
16 short, rapid breathing or by difficulty in breathing that the mother considered to be chest-  
17 related<sup>14</sup>. The children were categorized as those suffering or not experiencing these episodes  
18 within two weeks before the survey. Similarly, the DHS identify a child experiencing  
19 diarrhea by asking the mother whether the child had diarrhea in the last two weeks preceding  
20 the survey.

21 The set of independent variables considered as potential predictors were decided upon using  
22 the existing literature, availability of information in the survey datasets, and the knowledge of  
23 the researchers of the study region. To compare the prevalence of diarrhea and ARI across  
24 age groups, children were categorized as those aged less than one year, between one and  
25 three years and from three to five years. A similar categorization is used by other  
26 researchers<sup>17</sup>. Households were also categorized as being in either an urban or rural setting.  
27 Educational attainment, and access to mass media have been considered as a proxy of  
28 knowledge and understanding of mother regarding exposure to infectious diseases and their  
29 consequences on their children<sup>15-16</sup>. Mothers were categorized as those with no or incomplete  
30 primary level, complete primary to incomplete secondary level and complete secondary or  
31 above level of education. Mothers were also classified on the basis of having or not having  
32 access to any of radio, television or newspapers.

1 Significant positive associations between household economic status and prevalence of  
2 infectious diseases were observed in previous studies<sup>14, 20</sup>. As a proxy of household economic  
3 status, this study used the wealth score created by the DHS and calculated using principal  
4 components analysis from variables comprising household construction materials (roof,  
5 ceiling and floor), possessions (televisions and bicycles) and dwelling characteristics (source  
6 of drinking water, sanitation facilities). Details about the calculation of the wealth scores is  
7 available<sup>33</sup>. On the basis of wealth score, children were classified as those coming from a  
8 household classified as low (lower 40%), middle (middle 40%) and high (upper 20%) wealth  
9 categories.

10 Source of drinking water, type of toilet facility, crowding, type of cooking fuel and type of  
11 floor material were considered as indicators of sustainable household environment. Pipe,  
12 borehole, protected dug well, spring, or rainwater are considered as improved sources of  
13 drinking water<sup>33</sup>. Households were categorized as those having or not having an improved  
14 water source located on the premises. Sanitation using technologies such as flush toilet,  
15 ventilated pit latrine, traditional pit latrine with a slab, or composting toilet were considered  
16 as improved. Households were categorized as those with ideal (improved unshared),  
17 moderate (unimproved unshared or improved shared) or worst (unimproved shared or no  
18 facility) toilet facilities. The number of adults per living room indicates crowding, and  
19 households were categorized as those with up to two adults per living room, and two or more  
20 adults per living room. On the basis of existence of cooking practice, the households were  
21 categorized as ideal (cooking outside the house or not using solid fuel while cooking inside)  
22 or not ideal (using solid fuel while cooking inside the house). Finally, houses were  
23 categorized as having the floor made of mud or else. All information was extracted from the  
24 datasets mentioned in the previous section.

### 25 **Statistical Analysis**

26 The dependent variables (prevalence of diarrhea and ARI), as well as the predictor variables  
27 considered in the study, are categorical. Bivariate chi-square analyses were carried out to  
28 compare the prevalence of the diseases among the levels of the selected predictors.

29 Given the dichotomous nature of the dependent variables, multiple binary logistic regression  
30 models were fitted to assess the association between selected predictors on childhood  
31 morbidity. The model considers logarithm of odds (ratio of the probability of occurring to not  
32 occurring) as a linear additive function of the predictors. Exponentials of the estimated  
33 parameters referred as the odds ratio (OR), estimate the changes in the odds with unit change

1 in the predictors (for continuous predictor) or changes in the level of predictors compared to  
2 baseline (for categorical predictor)<sup>34</sup>. Separate multiple logistic regression models were fitted  
3 to the data from individual countries. To focus the models for each disease, the model for  
4 diarrhea excluded the variable cooking fuel as predictor, whereas the model for ARI excluded  
5 source of drinking water and type of toilet facility as predictors. Statistical analysis was  
6 conducted in SPSS 21.0<sup>35</sup> using a weighted analysis to account for the survey weights and  
7 clustered structure of the sample.

## 8 **Results**

9 Prevalence of diarrhea was considerably lower for the children in Bangladesh (5.7%) with  
10 respect to Nepal (13.8%) and Pakistan (22.5%). A considerably higher percentage of children  
11 from Pakistan were experiencing ARI (15.9%) than Bangladesh (5.4%) and Nepal (4.6%).  
12 Percentages of children experiencing co-morbidity (defined in this study as presence of both  
13 diarrhea and ARI) were highest in Pakistan and lowest in Bangladesh (Figure 1).  
14 Distributions of respondents for various levels of selected predictors are presented in Table 1.  
15 Age distributions of children were consistent over the studied countries. Most of the children  
16 in the studied settings lived in rural areas, ranging from 70.3% in Pakistan to 90.6% in Nepal.  
17 The percentage of mothers with both lower (no or incomplete primary) and higher  
18 (completed secondary or higher) educational levels were highest in Pakistan (62.5% and  
19 17.9%), whereas the percentage of mothers with no or incomplete primary level of education  
20 was lowest in Bangladesh (32.7%). The highest proportion of children whose mother had  
21 access to any mass media was from Nepal (84.4%). Among the studied countries, percentages  
22 of children from households using improved and unshared toilet facilities was lowest in  
23 Nepal (35.9%). Using solid fuel while cooking inside home was rare in Bangladesh (9.6%)  
24 and common in Nepal (57.4%) and Pakistan (59.8%). Among the studied settings, the  
25 percentage of children from household sharing more than two adults a room was highest  
26 (71.7%) in Pakistan.

27 In the bivariate analyses, children experiencing episodes of ARI (within two weeks before the  
28 survey) were more likely to experience diarrhea and vice-versa (Table 2). Older children  
29 were significantly less likely to experience either episode than the younger. With the  
30 exception of episodes of ARI in Nepalese children, educational status of mother showed a  
31 significant association with the prevalence of the episodes of both infections. A mother's  
32 access to mass media showed significant association with both episodes in Bangladesh only.  
33 Except for the prevalence of diarrhea in Bangladesh, the wealth status of a household showed  
34 significant association with childhood diarrhea and ARI. Significant associations between

1 place of residence and prevalence of ARI were also observed for children in Bangladesh and  
2 Pakistan ( $p < 0.05$ ). In all except one setting, the source of drinking water did not show any  
3 significant association with diarrhea or ARI, whereas type of toilet facility showed a  
4 significant association with the prevalence of diarrhea in Nepal and Pakistan. The number of  
5 adults per living room showed a significant association with the prevalence of diarrhea in  
6 Bangladesh and Nepal. Children from households using solid cooking fuel inside the house  
7 were significantly more likely to experience ARI with respect to those from households not  
8 using solid fuel for cooking inside the home.

9 Adjusted ORs for experiencing diarrhea and their associated confidence interval (CI) for the  
10 predictor variables are presented in Table 3. Once the effect of other variables was controlled  
11 for, in all the three countries, age of children and educational status of mother showed  
12 significant association with prevalence of diarrhea. In Bangladesh, Nepal and Pakistan,  
13 children below one year of age, were 63% (OR 1.63, CI = 1.23 – 2.16), 219% (OR 3.19, CI =  
14 2.51 – 4.05) and 156% (OR 2.56, CI = 2.26 – 2.91) more likely to experience diarrhea with  
15 respect to those aged above three years (the reference category). With respect to the reference  
16 category, children aged between one and three years were also significantly more likely to  
17 experience diarrhea. In Bangladesh, children from mothers with no or incomplete primary  
18 and incomplete secondary educational levels were 70% (OR 1.70, CI = 1.16 – 2.49) and 69%  
19 (OR 1.69, CI = 1.20 – 2.38) more likely to experience diarrhea with respect to those from  
20 mothers with secondary or higher level of education. In Pakistan, children from households  
21 categorized as low and middle wealth status were significantly more likely to experience  
22 diarrhea with respect to those with high economic status. However, for the children from  
23 Bangladesh and Pakistan, the wealth status of household was not significantly associated with  
24 the prevalence of diarrhea ( $p > 0.05$ ). Children from households using worst toilet facilities  
25 (in terms of improvement and sharing status) were more likely to experience diarrhea,  
26 however, the association is statistically significant for the children in Nepal only.

27 Adjusted ORs for experiencing ARI with associated CI for the studied variables were  
28 presented in Table 4. Like diarrhea, younger children were significantly more likely to  
29 experience ARI than older children. In Bangladesh and Pakistan, children of mothers with  
30 incomplete primary or incomplete secondary level of education were more likely to  
31 experience ARI than those from secondary or higher level of education. In Pakistan, with  
32 respect to the children of mothers with secondary or higher level of education, those of  
33 mothers with incomplete primary and incomplete secondary level of education were 35%  
34 (OR = 1.35, CI = 1.13 – 1.62) and 24% (OR = 1.24, CI = 1.04 – 1.49) more likely to

1 experience ARI. However, the relationship of maternal education and ARI of children is not  
2 significant in Nepal. In Bangladesh and Nepal, children from households categorized as low  
3 or middle wealth status were significantly more likely to experience ARI with respect to  
4 those with high status. However, the association of wealth with ARI was not significant for  
5 Nepal. In Bangladesh, children from households not using ideal cooking facilities (using solid  
6 fuel while cooking inside house) were 62% (OR = 1.62, CI = 1.22 – 2.16) more likely to  
7 experience ARI, however, the association was not statistically significant in Nepal and  
8 Pakistan ( $p > 0.05$ ). Over the countries, neither the degree of crowding nor the household  
9 floor material showed consistent association with either diarrhea or ARI.

## 11 Discussion

12 Prevalence of two major infectious diseases, diarrhea and ARI, is relatively high among  
13 young children in the South Asian region. The study was conceived with objectives of  
14 comparing the association of potential predictors, in particular sustainable household  
15 environment and maternal education, on disease episodes among preschoolers from three  
16 South Asian countries, Bangladesh, Nepal and Pakistan.

17 The highest prevalence rates were in Pakistan for both diarrhea and ARI, and in Nepal, for  
18 diarrhea. Bangladesh is considered as a paradox in terms of good health outcomes despite  
19 economic poverty<sup>36,37</sup>. Even the disadvantaged children from Bangladesh (from households  
20 categorized as poor and using unimproved water and toilet facilities) possess lower risk of  
21 experiencing diarrhea with respect to economically advantaged children in Nepal and  
22 Pakistan. Similar outcomes have been reported<sup>38</sup>, where it is mentioned that Pakistan lags  
23 behind the MDG in many aspects including child health. Though the prevalence of ARI is  
24 low in Nepal, prevalence of diarrhea is higher in the country. This may be resulted from lack  
25 of sustainable household environment (defined as improved water source and hygienic  
26 sanitation) or knowledge of healthy practice of mother (measured by level of schooling).

27 Rural-urban setting not found to have a significant effect on prevalence of either diarrhea or  
28 ARI. Source of drinking water, number of adults sharing a living room and floor materials all  
29 showed inconsistent effects on the prevalence of childhood diarrhea across the countries  
30 studied.

31 In all the three studied countries, bivariate analyses showed that the presence of diarrhea  
32 significantly increases the likelihood of the prevalence of ARI, and vice-versa. However, it is  
33 important not to include diarrhea in the multiple model of ARI prevalence, and vice versa,  
34 because there is a high degree of overlap in risk factors for diarrhea and ARI e.g. age of child,

1 crowding, poor housing. Furthermore, the short recall period employed in the DHS (two  
2 weeks) means that the data is clearly cross-sectional and the lag effect of one disease on  
3 another cannot be measured with the data at hand. Similar results were observed in previous  
4 studies where the epidemiology of diarrhea and ARI overlapped. This is highly likely to be  
5 due to shared risk factors or compromised immune function<sup>39-41</sup>. Health policy needs to take a  
6 holistic approach to combatting childhood infections due to the clear presence of co-  
7 morbidity, at least in the case of diarrhea and ARI shown in this paper.

8 Younger children possess significantly higher risks of experiencing morbidity than older; the  
9 result is consistent with previous studies in Bangladesh and elsewhere<sup>8,14</sup>. The immune  
10 system may not be developed at earlier ages, younger children may be infected from  
11 unhygienic feeding practices (water, bottles etc.) and unclean surroundings. Diarrhea  
12 pathogens, like *E. coli*, are commonly transmitted via impure water, unhygienic utensils or  
13 poor food handling<sup>42</sup>. While crawling, children explore their immediate environment and may  
14 pick up infections. Inappropriate dietary supplementation may also hinder children's  
15 developing immune system, which can be overcome through exclusive breastfeeding for  
16 recommended periods of time. Breastfeeding data is available in the DHS surveys, however it  
17 has not been included in the current analyses due to its high degree of confounding with age.

18 Of most interest is the result that maternal educational status showed significant positive  
19 influence on reducing the prevalence of diarrhea and ARI, and that the effects are more  
20 evident when the educational attainment is at least secondary or higher.

21 **Data limitations:** Though the DHS adopted appropriate survey methodology to obtain a  
22 representative sample, the final sample does not guarantee complete representativeness at  
23 national and regional levels. DHS are cross-sectional surveys which collect information  
24 regarding the disease episodes for a single point of time. Such studies can yield information  
25 on association but not impact. The seasonal variations in the prevalence of the disease  
26 episodes are not addressed in the data. Moreover, the disease episodes are determined on the  
27 basis of self-reporting of mothers, and not followed by any clinical examination. To reduce  
28 the reporting bias due to memory lapse, a short recall period (two weeks) is considered while  
29 collecting morbidity related information. Children who were not de-jure resident at the time  
30 of the survey were excluded from the analysis. The exclusion may lead a bias to the  
31 outcomes, however, the amount of bias is likely to be small. Finally, the datasets do not  
32 represent same time point for the studied countries, though the largest time difference is only  
33 three years.



1 **Conclusion:** This study focuses on three South Asian countries with relatively higher  
2 prevalence of childhood diarrhea and ARI on the worldwide scale. Sustainable household  
3 environment, as mentioned in the SDG, in terms of flooring, water, toilet and cooking  
4 facilities was not found to have the greatest association with morbidity. Nor was wealth a  
5 main driver, as its association with childhood diarrhea and ARI was only statistically  
6 significant in half of the settings considered in this paper. Of far more importance was the  
7 knowledge base of a child's primary caregiver (typically the mother) regarding the potential  
8 risks of infection and the impacts of infection on survival and well-being. These results  
9 indicate that the SDG of good health and wellbeing needs to be tackled by incorporating  
10 quality health education along with the goals of clean water and sanitation for all, and no  
11 poverty. According to our findings, maternal education could be effective in reducing child  
12 morbidity only when it is at complete secondary level or higher. An effective basic  
13 knowledge base formed through policies that incorporate health education in school curricula  
14 at primary and secondary level has a good chance of making an impact, especially since the  
15 female primary school enrolment rate in Nepal and Bangladesh is already above 90%.  
16 Alternative ways to develop knowledge of healthy practices among the mass population  
17 could be delivered through mass media. Well-developed motivational programs incorporating  
18 mass media, health professionals, community health workers, community leaders,  
19 government and non-government organisations may help improve population awareness of  
20 the causes and consequences of infectious diseases. These programs may be more essential  
21 for the countries like Pakistan where the percentages of children suffering infectious diseases  
22 are relatively higher and female school enrolment rate is relatively lower.

23 **Contributorship:** MMH conceptualised the study. The methodology was developed by MMH  
24 and AR. Data interpretation and drafting of the paper were undertaken by MMH and AR.  
25 Both authors made contributions to the overall manuscript and are responsible for the drafting  
26 of the manuscript.

27 **Competing interests:** None declared.

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29 **Data sharing:** Data are available upon request from the Demographic and Health Survey  
30 Program (<https://dhsprogram.com/>).

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16 Nepal and Pakistan

17 Table 4 The Adjusted ORs (confidence interval) for the studied covariates from binary  
18 multivariable logistic regression models for children experiencing ARI for Bangladesh, Nepal  
19 and Pakistan

1 Table 1 Percentages of respondents for various levels of the selected predictor variables in  
 2 Bangladesh, Nepal and Pakistan  
 3

Background Characteristics	Percentages of respondents			4
	Bangladesh (N = 7760)	Nepal (N = 5140)	Pakistan (N= 11040)	
<i>Age of child</i>				
0-11 months	19.5	19.9	19.8	6
12-35 months	41.2	39.2	39.4	
36-59 months	39.3	40.9	40.8	7
<i>Type of Place of Residence</i>				
Rural	74.4	90.6	70.3	8
Urban	25.6	9.4	29.7	
<i>Mother's education</i>				9
Incomplete Primary	32.7	61.0	62.5	
Incomplete Secondary	51.5	25.3	19.6	10
Secondary or Higher	15.8	13.7	17.9	
<i>Access to electronic media</i>				11
No access	38.7	15.2	29.8	
Have access	61.3	84.8	70.2	12
<i>Age of mother at the time of survey</i>				
15 –19 years	14.6	7.0	2.2	13
20 –29 years	61.7	65.5	52.4	
30 –49 years	23.7	27.5	45.4	14
<i>Source of drinking water</i>				
Not improved/not in premises	21.1	36.1	22.9	15
Improved in premises	78.9	63.9	77.1	
<i>Toilet facility</i>				16
Worst	10.4	49.0	25.4	
Moderate	26.7	15.0	11.5	17
Ideal	62.9	35.9	63.2	
<i>Number of adults per room</i>				18
More than 2 adults	40.9	43.2	71.7	
Up to 2 adults	59.1	56.8	28.3	19
<i>Household cooking facility</i>				
Not ideal	9.6	57.4	59.8	20
Ideal	90.4	42.6	40.2	
<i>Household floor material</i>				21
Mud	68.9	75.4	47.3	
Not Mud	31.1	24.6	52.7	22

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1 Table 2 Associations between childhood morbidity (diarrhea or ARI) in two weeks preceding  
 2 the survey and background characteristics of children. The figures for various levels of  
 3 predictors represent the percentage of children experiencing disease.

Background Characteristics	Bangladesh		Nepal		Pakistan	
	% Diarrhea	% ARI	% Diarrhea	% ARI	% Diarrhea	% ARI
<i>Childhood ARI/ Diarrhea in last two weeks</i>						
Experienced	9.8	9.3	30.1	10.1	30.2	23.7
Not experienced	5.4	5.1	13.1	3.8	20.4	13.6
Chi-square	14.27 <sup>a</sup>	14.27 <sup>a</sup>	55.65 <sup>a</sup>	55.65 <sup>a</sup>	145.59 <sup>a</sup>	145.59 <sup>a</sup>
<i>Age of child</i>						
0-11 months	6.4	7.7	18.3	5.6	30.2	18.1
12-35 months	6.8	6.0	19.0	6.0	27.2	17.9
36-59 months	4.1	3.5	6.7	2.9	14.2	12.8
Chi-square	21.89 <sup>a</sup>	41.15 <sup>a</sup>	150.24 <sup>a</sup>	24.46 <sup>a</sup>	308.76 <sup>a</sup>	52.81 <sup>a</sup>
<i>Place of residence</i>						
Rural	5.7	5.7	13.9	4.6	22.7	16.4
Urban	5.6	4.3	13.4	5.0	21.9	14.6
Chi-square	0.01	5.66 <sup>b</sup>	0.07	0.12	0.89	5.84 <sup>b</sup>
<i>Mother's educational status</i>						
Incomplete primary	6.1	5.2	14.2	4.6	23.5	16.4
Incomplete secondary	6.0	6.1	14.8	5.1	23.0	16.3
Secondary or higher	3.8	3.3	10.5	4.1	18.5	13.4
Chi-square	9.93 <sup>a</sup>	15.37 <sup>a</sup>	7.75 <sup>c</sup>	1.04	22.26 <sup>a</sup>	10.84 <sup>a</sup>
<i>Wealth status of household</i>						
Low	6.3	6.5	13.5	4.7	23.5	15.6
Middle	5.3	5.2	15.0	5.5	23.6	17.0
High	5.2	3.3	11.8	2.2	17.1	13.7
Chi-square	3.66	19.76 <sup>a</sup>	5.03	12.92 <sup>a</sup>	36.23 <sup>a</sup>	10.58 <sup>a</sup>
<i>Access to electronic media</i>						
No access	6.4	6.0	15.8	4.7	23.2	15.9
Have access	5.2	5.0	13.5	4.6	22.2	15.8
Chi-square	4.87 <sup>c</sup>	3.39	2.83	0.03	1.42	0.03
<i>Age of mother at the time of survey</i>						
15–19 years	6.3	7.9	16.2	5.6	32.6	21.1
20–29 years	5.6	5.3	14.0	4.7	24.3	16.2
30–49 years	5.6	4.1	12.9	4.2	19.9	15.2
Chi-square	0.86	20.72 <sup>a</sup>	2.64	1.47	43.87 <sup>a</sup>	7.09 <sup>b</sup>
<i>Source of drinking water</i>						
Unimproved/not in premises	6.8	6.1	14.1	4.7	21.7	15.5
Improved in premises	5.4	5.2	13.7	4.6	22.7	16.0
Chi-square	5.25 <sup>c</sup>	2.33	0.13	0.02	1.22	0.39
<i>Toilet facility</i>						
Worst	6.1	7.3	15.5	4.8	24.2	15.5
Moderate	5.8	6.4	12.0	5.6	23.5	15.8
Ideal	5.6	4.6	12.3	4.1	21.8	16.0
Chi-square	0.41	15.55 <sup>a</sup>	11.28 <sup>a</sup>	2.73	8.14 <sup>b</sup>	0.47
<i>Number of adults per room</i>						
More than 2 adults	5.0	5.3	14.8	4.8	22.7	15.7
Up to 2 adults	6.1	5.4	13.1	4.6	21.9	16.2
Chi-square	3.93 <sup>c</sup>	0.07	3.18	0.13	0.78	0.49
<i>Household cooking fuel</i>						
Not ideal	7.8	8.1	12.9	5.2	23.7	16.4
Ideal	5.4	5.1	15.1	3.8	20.6	15.1
Chi-square	6.89 <sup>a</sup>	11.85 <sup>a</sup>	5.53 <sup>b</sup>	5.50 <sup>b</sup>	14.65 <sup>a</sup>	3.00 <sup>c</sup>
<i>Household floor material</i>						
Mud	6.0	5.8	14.3	5.0	23.3	15.8
Not mud	4.9	4.4	12.5	3.6	21.7	15.9
Chi-square	3.57	7.19 <sup>a</sup>	2.50	4.35 <sup>c</sup>	3.83 <sup>b</sup>	0.03
Overall	5.7	5.4	13.8	4.6	22.5	15.9

Significance at a:  $p < 0.01$ ; b:  $p < 0.05$ ; c:  $p < 0.1$

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Table 3 The Adjusted ORs (confidence interval) for the studied covariates from binary multivariable logistic regression models for children experiencing diarrhea for Bangladesh, Nepal and Pakistan

Variables (Reference category) levels	Odds ratio of Diarrhea (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36-59 months)</i>			
0-11 months	1.63 <sup>a</sup> (1.23 – 2.16)	3.19 <sup>a</sup> (2.51 – 4.05)	2.56 <sup>a</sup> (2.26 – 2.91)
12-35 months	1.71 <sup>a</sup> (1.36 – 2.14)	3.29 <sup>a</sup> (2.68 – 4.04)	2.24 <sup>a</sup> (2.01 – 2.50)
<i>Place of residence (Urban)</i>			
Rural	0.87 (0.69 – 1.12)	0.92 (0.68 – 1.25)	0.83 <sup>a</sup> (0.73 – 0.94)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.70 <sup>a</sup> (1.16 – 2.49)	1.41 <sup>b</sup> (1.03 – 1.93)	1.27 <sup>a</sup> (1.08 – 1.48)
Incomplete Secondary	1.69 <sup>a</sup> (1.20 – 2.38)	1.55 <sup>a</sup> (1.14 – 2.10)	1.19 <sup>b</sup> (1.01 – 1.40)
<i>Mother's access to mass media (Have access)</i>			
No access	1.16 (0.91 – 1.48)	1.07 (0.85 – 1.35)	1.01 (0.90 – 1.13)
<i>Age of mother at the time of survey (30 – 49 years)</i>			
15 – 19 years	0.94 (0.67 – 1.30)	0.83 (0.59 – 1.17)	1.40 <sup>b</sup> (1.05 – 1.86)
20 – 29 years	0.94 (0.74 – 1.21)	0.99 (0.81 – 1.20)	1.17 <sup>a</sup> (1.07 – 1.29)
<i>Wealth Status (High)</i>			
Low	0.79 (0.48 – 1.30)	0.71 <sup>c</sup> (0.47 – 1.06)	1.53 <sup>a</sup> (1.23 – 1.91)
Middle	0.78 (0.53 – 1.16)	0.94 (0.66 – 1.33)	1.49 <sup>a</sup> (1.26 – 1.77)
<i>Source of drinking water (Hygienic in premises)</i>			
Unimproved or not in premises	1.21 (0.96 – 1.53)	1.10 (0.91 – 1.31)	0.93 (0.83 – 1.04)
<i>Toilet facility (Ideal)</i>			
Worst	1.06 (0.76 – 1.46)	1.29 <sup>b</sup> (1.04 – 1.59)	1.10 (0.97 – 1.25)
Moderate	1.03 (0.82 – 1.29)	0.92 (0.70 – 1.20)	1.01 (0.88 – 1.17)
<i>Number of adults per room (up to two adults per room)</i>			
More than two adults	0.76 <sup>a</sup> (0.62 – 0.93)	1.12 (0.95 – 1.33)	1.06 (0.95 – 1.17)
<i>Household floor material (Not mud)</i>			
Floor made of mud	1.27 (0.89 – 1.81)	1.11 (0.83 – 1.48)	0.94 (0.82 – 1.08)

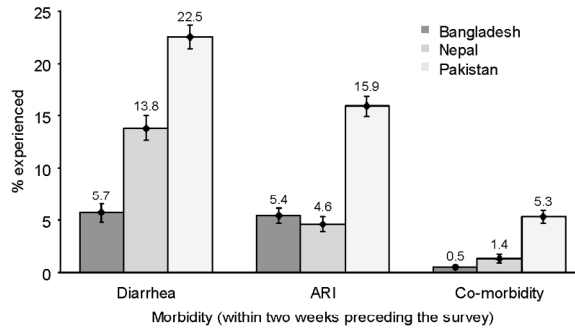
Significance at a:  $p < 0.01$ ; b:  $p < 0.05$ ; c:  $p < 0.1$

11 Table 4 The Adjusted ORs (confidence interval) for the studied covariates from binary  
 12 multivariable logistic regression models for children experiencing ARI for Bangladesh, Nepal  
 13 and Pakistan  
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Variables (Reference category) levels	Odds ratio of <i>ARI</i> (95% CI)		
	Bangladesh	Nepal	Pakistan
<i>Age of child (36+ months)</i>			
0-11 months	2.21 <sup>a</sup> (1.66 – 2.92)	1.99 <sup>a</sup> (1.23 – 2.79)	1.49 <sup>a</sup> (1.30 – 1.72)
12-35 months	1.74 <sup>a</sup> (1.36 – 2.22)	2.12 <sup>a</sup> (1.54 – 2.91)	1.49 <sup>a</sup> (1.32 – 1.68)
<i>Place of residence (Urban)</i>			
Rural	1.10 (0.83 – 1.45)	0.66 <sup>c</sup> (0.41 – 1.07)	1.14 <sup>c</sup> (0.98 – 1.34)
<i>Mother's education (Secondary or higher)</i>			
Incomplete Primary	1.31 (0.88 – 1.96)	0.86 (0.54 – 1.38)	1.35 <sup>a</sup> (1.13 – 1.62)
Incomplete Secondary	1.63 <sup>a</sup> (1.14 – 2.33)	1.02 (0.64 – 1.63)	1.24 <sup>b</sup> (1.04 – 1.49)
<i>Mother's access to mass media (Have access)</i>			
No access	0.96 (0.75 – 1.22)	1.02 (0.69 – 1.49)	0.99 (0.87 – 1.12)
<i>Age of mother at the time of survey (30–49 years)</i>			
15–19 years	1.47 <sup>b</sup> (1.05 – 2.06)	0.95 (0.55 – 1.64)	1.29 (0.93 – 1.78)
20–29 years	1.20 (0.91 – 1.57)	1.01 (0.74 – 1.38)	1.02 (0.91 – 1.13)
<i>Wealth Status (High)</i>			
Low	2.25 <sup>a</sup> (1.36 – 3.70)	2.25 <sup>b</sup> (1.08 – 4.69)	0.94 (0.74 – 1.20)
Middle	1.61 <sup>b</sup> (1.08 – 2.41)	2.68 <sup>a</sup> (1.41 – 5.10)	1.09 (0.90 – 1.31)
<i>Household cooking fuel (Ideal)</i>			
Not ideal	1.62 <sup>a</sup> (1.22 – 2.16)	1.31 <sup>c</sup> (0.96 – 1.79)	1.01 (0.88 – 1.16)
<i>Number of adults per room (up to two adults per room)</i>			
More than two adults	0.95 (0.77 – 1.17)	1.03 (0.79 – 1.36)	0.96 (0.86 – 1.08)
<i>Household floor material (Not mud)</i>			
Floor made of mud	0.77 (0.55 – 1.08)	1.04 (0.67 – 1.31)	0.92 (0.79 – 1.07)

15 Significance at a:  $p < 0.01$ ; b:  $p < 0.05$ ; c:  $p < 0.1$

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Percentage (with 95% confidence interval) of children in Bangladesh, Nepal and Pakistan experiencing diarrhea, ARI and co-morbidity within two weeks preceding the survey

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