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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[1], where pneumonia and diarrhea are two of the leading causes[2,3]. In addition to deaths, several diarrheal episodes lead to long-term nutritional deficits, whereas, childhood respiratory infections cause increased risk of reduced lung capacity[4,5]. 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[6,7].

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[7-9]. Due to differentials in food intake, standard of living and availability of health care facilities, urban-rural variations are also evident in childhood morbidity[10,11]. 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[12-14]. In addition to formal education, access to mass media helps to create awareness and form knowledge of communicable diseases[15-17]. 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[18-20]. A review of published articles[21] 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[22-24].

Investigating 171 Demographic and Health Surveys (DHS) in 70 low- and middle-income countries over the period 1986–2007, researchers[25] concluded that access to improved sanitation and water was associated with lower risk of childhood diarrhea. Similar relationships have been observed elsewhere[26-28]. 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[29]. As a part of Goal 3 of the Sustainable Development Goals (SDG), the UN is aiming to end epidemics of water-borne

and other communicable diseases by 2030. Goal 6 emphasizes ensuring the availability of water and sanitation for all[30].

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

Data and methods

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

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[33]. 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

living in houses with the floor made of mud or else. All information was extracted from the datasets mentioned in the previous section.

Statistical Analysis

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

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

Results

Distributions of respondents for various levels of selected predictors are presented in Table 1. Incidence of diarrhea was considerably lower for the children in Bangladesh (5.7%) with respect to Nepal (13.8%) and Pakistan (22.5%). A considerably higher percentage of children from Pakistan were suffering from ARI (15.9%) than Bangladesh (5.4%) and Nepal (4.6%). Percentages of children suffering from co-morbidity was highest in Pakistan and lowest in Bangladesh (Figure 1). Age distributions of children were consistent over the studied countries. Most of the children in the studied settings lived in rural areas, ranging from 70.3% in Pakistan to 90.6% in Nepal. The percentage of mothers with both lower (no or incomplete primary) and higher (completed secondary or higher) educational levels were highest in Pakistan (62.5% and 17.9%), whereas the percentage of mothers with no or incomplete primary level of education was lowest in Bangladesh (32.7%). The highest proportion of children whose mother had access to any of the mass media was from Nepal (84.4%). Among the studied countries, percentages of children from households using hygienic and unshared toilet facilities was lowest in Nepal (35.9%). Using solid fuel while cooking inside home was

rare in Bangladesh (9.6%) and common in Nepal (57.4%) and Pakistan (59.8%). Finally, a higher percentage (71.7%) of children of Pakistan were from household sharing more than two adults a room.

In the bivariate analyses, children suffering from ARI are were more likely to suffer from diarrhea and vice-versa (Table 2). Older children were significantly less likely to suffer from either episode than the younger. With the exception of episodes of ARI in Nepalese children, educational status of mother showed a significant impact on the incidence of episodes of both infections. Mother's access to mass media showed significant impact on both episodes in Bangladesh only. Except for the incidence of diarrhea in Bangladesh, wealth status of household showed significant impact on childhood morbidity. The impact of place of residence was statistically significant in the ARI for the children in Bangladesh and Pakistan. In all except one setting, the source of drinking water did not show any significant impact on any disease episode, whereas type of toilet facility showed a significant impact on the incidence of diarrhea in Nepal and Pakistan. The number of adults per living room showed a significant impact on the incidence of diarrhea in Bangladesh and Nepal. Children from households using solid cooking fuel inside the house were significantly more likely to suffer from ARI with respect to those from households not using solid fuel for cooking inside the home.

Adjusted ORs of suffering from diarrhea and their associated CI for the predictor variables are presented in Table 3. Once the effect of other variables was controlled for, in all the three countries, age of children and educational status of mother showed significant impact on incidence of diarrhea. In Bangladesh, Nepal and Pakistan, children below one year of age, 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, CI = 2.35 – 3.02) times more likely to suffer from diarrhea with respect to those aged above three years (the reference category). With respect to the reference category, children aged between one and three years were also significantly more likely to suffer from diarrhea. In Bangladesh, children from mothers with no or incomplete primary and incomplete secondary educational levels were 71% (OR 1.71, CI = 1.71 – 2.50) and 68% (OR 1.68, CI = 1.20 – 2.36) more likely to suffer from diarrhea with respect to those from mothers with secondary or higher level of education. In Pakistan, children from households categorized as poor and middle wealth status were significantly more likely to suffer from diarrhea with respect to those from well-off households. However, the impact of wealth on the incidence of diarrhea was not significant for the children from Bangladesh and Pakistan. Children from households

using shared and hygienic toilet facilities were more likely to suffer from diarrhea, however the impact is statistically significant for the children in Nepal only.

The ORs of suffering from ARI with associated CI for the studied variables were presented in Table 4. Like diarrhea, younger children were significantly more likely to suffer from ARI than older children. In Bangladesh and Pakistan, children from mothers with lower educational level were more likely to suffer from ARI than those from higher educational level. In Pakistan, with respect to the children from mothers with secondary or higher level of education, those from mothers with no or primary and incomplete secondary level of education were 32% (OR = 1.32, CI = 1.10 – 1.58) and 25% (OR = 1.25, CI = 1.04 – 1.50) more likely to suffer from ARI. However, the relationship of maternal education and ARI of children is not significant in Nepal. In Bangladesh and Nepal, children from households categorized as poor or middle were significantly more likely to suffer from ARI with respect to those from well-off households. However, the impact of wealth on ARI is not significant for Nepal. In Bangladesh, children from households using solid fuel and cooking inside the house were 62% (OR = 1.62, CI = 1.21 – 2.16) more likely to suffer from ARI, however, the effect is not significant in Nepal and Pakistan. Over the countries, neither the number of adults living per room nor the household floor material showed consistent impacts on either diarrhea or ARI.

Discussion

Incidence of two major infectious diseases, diarrhea and ARI, is relatively high among young children in the South Asian region. The study was conceived with a broad objective of comparing the impact of potential predictors, in particular sustainable household environment and maternal education, on disease episodes among preschoolers from three South Asian countries, Bangladesh, Nepal and Pakistan.

Data limitations: The study utilized one of the largest and most recent cross-sectional surveys conducted in each of Bangladesh (2014), Nepal (2011) and Pakistan (2012). The surveys have attractive features that make them appealing for quantitative analysis. For example, the DHS Program collects and processes reasonably accurate, nationally representative data on health and population in developing countries. The surveys collect information on morbidity status of children and covers a wide range of variables regarding the children, their parents and the households they live in. However, DHS are cross-section surveys which collect information regarding the disease episodes for a single point of time. The seasonal variations in the incidence of the disease episodes are not addressed in the data.

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[35,36]. 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[37-39]. 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[8,14]. 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[40]. 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

periods of time. Breastfeeding data is available in the DHS surveys, however it has not been included in the current analyses due to its high degree of confounding with age.

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

Conclusion: For these countries with relatively higher incidence of infectious diseases on the worldwide scale, our study shows that sustainable household environment in terms of flooring, water, toilet and cooking facilities was not found to have the greatest impact on childhood diseases. Nor was wealth a main driver, as its impact on childhood morbidity was only statistically significant in half of the settings considered in this paper. Of far more importance was knowledge base of a child's primary caregiver (typically the mother) regarding the potential risks of infection, and the impacts of infection on survival and well-being These results indicate that the Sustainable Development Goal of good health and wellbeing needs to be tackled not just through the goals of clean water and sanitation for all, and the ending of poverty, but also through the goal of quality education. According to our findings, maternal education is effective in reducing child morbidity only when it is at complete secondary level or higher. However, it is highly ambitious to upgrade the educational level of all women to at least secondary. An effective basic knowledge base formed through policies that incorporate health education in school curricula at primary and secondary level has a higher chance of making an impact, especially since the female primary school enrolment rate in Nepal and Bangladesh is already above 90%. Well-developed motivational programs incorporating mass media, health professionals, community health workers, community leaders, government and non-government organisations may help improve population awareness of the causes and consequences of infectious diseases. These programs may be more essential for the countries like Pakistan where the percentages of children suffering infectious diseases are relatively higher and female school enrolment rate is relatively lower.

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

Competing interests: None declared.

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References

1. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, Cousens S, Mathers C, Black RE (2015): Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015; 385: 430 – 440.
2. Bhutta, ZA, et al. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? Lancet 2013; 381: 1417-1429.
3. UNICEF. *Pneumonia and diarrhea: tackling the deadliest diseases for the world's poorest children*. New York: UNICEF, 2012.
4. Checkley W, Buckley G, Gilman RH, Assis AMO, Guerrant RL, Morris SS, Molbak K, Valentiner-Branth P, Lanata CF, Black RE, Childhood Malnutrition and Infection Network. Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol 2008; 37: 816–30.
5. Edmond K, Scott S, Korczak V, Ward C, Sanderson C, Theodoratou E, Clark A, Griffiths U, Rudan I, Campbell H. Long term sequelae from childhood pneumonia; systematic review and meta-analysis. PLoS One 2012; 7: e31239.
6. Qazi S, Aboubaker S, Maclean R, Fontaine O, Mantel C, Goodman T, Young M, Henderson P, Cherian T. Ending preventable child deaths from pneumonia and diarrhoea by 2025: development of the Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhoea. Archives of Disease in Childhood 2015; 100: S23-S28.
7. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, O'Brien KL, Campbell H, Black RE. Global burden of childhood pneumonia and diarrhea. Lancet 2013; 381: 1405 – 1416.
8. Bbaale E. Determinants of diarrhea and acute respiratory infection among under-fives in Uganda. Australasian Med J 2011; 4: 400 – 409.
9. Budge PJ, Griffin MR, Edwards KM, et al. Acute viral respiratory illnesses in Andean children: a household-based cohort study. Ped Inf Dis J, 2014; 33: 443.
10. Dostal M, Pastorkova A, Rychlik S, et al. Comparison of child morbidity in regions of Ostrava, Czech Republic, with different degrees of pollution: a retrospective cohort study. Env Health 2013; 12: 74.
11. Tumwine JK, et al. Diarrhoea and effects of different water sources, sanitation and hygiene behaviour in East Africa. Trop Med Int Health 2002; 7: 750-756.
12. Mukhtar A, Mohamed Izham MI, Pathiyil RS. 2011. A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. The Australasian Med J 2011; 4: 474-479.
13. Ghasemi, AA, Talebian A, Masoudi AN, Mousavi GA. Knowledge of mothers in management of diarrhea in under-five children, in Kashan, Iran. Nurs Midwifery Stud 2013; 1: 158—162.
14. Kamal MM, Hasan MM, Davey R. 2015. Determinants of childhood morbidity in Bangladesh: Evident from Demographic and Health Survey 2011. Brit Med J (BMJ) Open, 2015; 5.
15. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. Lancet 2010; 376: 1261-1271.
16. Asakitikpi, AE. 2010. Acute diarrhoea: Mothers' knowledge of ORT and its usage in Ibadan metropolis, Nigeria. Ethno-Med 4: 125-130.
17. Singh A, Singh MN. (2014) Diarrhoea and acute respiratory infections among under-five children in slums: Evidence from India. PeerJ PrePrints 2: e208v1.

18. Nundy S, et al. "Wealth and its associations with enteric parasitic infections in a low-income community in Peru: use of principal component analysis." Amer J Trop Med Hygiene 2001; 84: 38-42.
19. Hatt, LE, Waters HR. Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status. Soc Sci Med 2006; 62: 375-386.
20. Giasuddin MS, Kabir M, Hasan MM. Economic disparity and child nutrition in Bangladesh. Ind J Paed, 2005; 72: 481-487.
21. Colosia, AD., et al. Residential crowding and severe respiratory syncytial virus disease among infants and young children: a systematic literature review. BMC Inf Dis 2012; 12: 1.
22. Lim SS, Vos T, Flaxman AD et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2013; 380: 2224-2260.
23. Fatmi Z, White F. A comparison of 'cough and cold' and pneumonia: risk factors for pneumonia in children under 5 years revisited. Int J Inf Dis 2002; 6: 294-301.
24. Chafe, ZA, et al. Household cooking with solid fuels contributes to ambient PM2.5 air pollution and the burden of disease. Diss. University of British Columbia, 2015.
25. Fink G, Günther I, Hill K. The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007. Int J Epidemiol 2011; 40: 1196-1204.
26. Speich, B, et al. "Effect of sanitation and water treatment on intestinal protozoa infection: a systematic review and meta-analysis. Lancet Inf Dis 2016; 16: 87-99.
27. Fuller, JA., et al. The joint effects of water and sanitation on diarrhoeal disease: a multicountry analysis of the Demographic and Health Surveys. Trop Med Int Health 2015; 20: 284-292.
28. Shahnawaz K, Kumar M, Singh S, Kumar L. Incidence of diarrheal diseases among children in Kishanganj district of Bihar. J Evol Med Dental Sci, 2014; 3: 3040-3047.
29. Dora C, et al. Indicators linking health and sustainability in the post-2015 development agenda. Lancet 2015; 385: 380-391.
30. Sustainable Development Knowledge Platform, 2015. Available at: https://sustainabledevelopment.un.org/. Accessed 1 September 2016.
31. Central Intelligence Agency. The World Factbook. Available at https://www.cia.gov/library/publications/the-world-factbook/. Accessed 28 October 2016.
32. World GDP (Nominal) Ranking, 2015. Available at: http://statisticstimes.com/economy/world-gdp-ranking.php. Accessed 28 October, 2016.
33. National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ICF International. *Bangladesh Demographic and Health Survey 2014*. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International, 2016.
34. IBM Corp. *IBM SPSS Statistics for Windows, Version 22.0.* Armonk, NY: IBM Corp, 2013.
35. Chowdhury AMR, Bhuiya A, Chowdhury ME, Rasheed S, Hussain Z, Chen LC. The Bangladesh paradox: exceptional health achievement despite economic poverty. Lancet 2013; 382: 1734 – 1745.
36. Nasrin D, Wu Y, Blackwelder WC, et al. Health care seeking for childhood diarrhea in developing countries: evidence from seven sites in Africa and Asia. Amer J Trop Med Hygiene 2013; 89(1): 3 – 12.

37. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet 2003; 361: 2226–34.
38. Walker CLF, Perin J, Katz J, Tielsch JM, Black RE. Diarrhea as a risk factor for acute lower respiratory tract infections among young children in low income settings. J Glob Health 2013; 3: 60–67.
39. Schmidt WP, Cairncross S, Barreto ML, Clasen T, Genser B. Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years. Int J Epidemiol 2009; 38: 766 –772.
40. Black RE. Diarrheal diseases and child morbidity and mortality. Pop Devel Review 1984:141–61.

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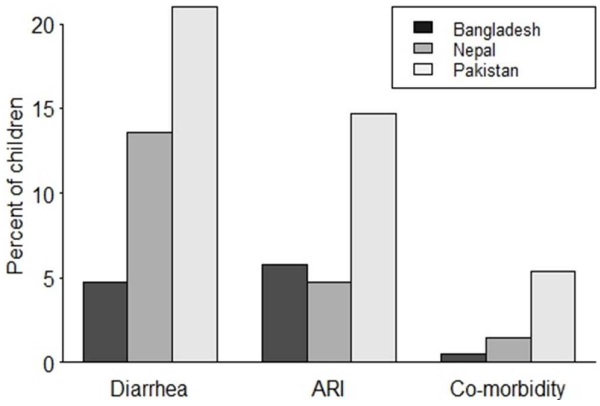

Figure 1 Percentage of children suffering from diarrhea, ARI and co-morbidity

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)
Prevalence of Diarrhea	**5.7**	**13.8**	**22.5**
Prevalence of ARI	**5.4**	**4.6**	**15.9**
Age of child			
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
Type of Place of Residence			
Rural	74.4	90.6	70.3
Urban	25.6	9.4	29.7
Mother's education			
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
Access to elect media			
No access	38.7	15.2	29.8
Have access	61.3	84.8	70.2
Source of drinking water			
Unhygienic/not in premises	21.1	36.1	22.9
Hygienic	78.9	63.9	77.1
Toilet facility			
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
Number of adults per room			
More than 2 persons	40.9	43.2	71.7
Up to 2 persons	59.1	56.8	28.3
Household cooking fuel			
In home-solid fuel	9.6	57.4	59.8
Not solid fuel inside	90.4	42.6	40.2
Household floor material			
Mud	68.9	75.4	47.3
Not Mud	31.1	24.6	527

	Diarrhea	ARI	Diarrhea	ARI	Diarrhea	ARI
Childhood ARI/ Diarrhea						
Suffered	9.8***	9.3***	30.1***	10.1***	30.2***	23.7***
Not suffered	5.4	5.1	13.1	3.8	20.4	13.6
Age of child						
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+ months	4.1	3.5	6.7	2.9	14.2	12.8
Place of residence						
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
Mother's educational status						
Inco primary	6.1***	5.2***	14.2**	4.6	23.5***	16.4***
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
Wealth status of household						
Poor	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
Rich	5.2	3.3	11.8	2.2	17.1	13.7
Access to electronic media						
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
Source of drinking water						
Unhygienic	6.8**	6.1	14.1	4.7	21.7	15.5
Hygienic	5.4	5.2	13.7	4.6	22.7	16.0
Toilet facility						
Unhygienic Shared	6.1	7.3***	15.5***	4.8	24.2**	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
Number of adults per room						
More than 2 persons	5.0*	5.3	14.8*	4.8	22.7	15.7
Up to 2 persons	6.1	5.4	13.1	4.6	21.9	16.2
Household cooking fuel						
In home-solid fuel	7.8***	8.1***	12.9**	5.2**	23.7***	16.4*
Not solid fuel inside	5.4	5.1	15.1	3.8	20.6	15.1
Household floor material						
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
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
Age of child (36+ months)			
0-11 months	1.61*** (1.23 – 2.12)	3.11*** (2.46 – 3.93)	2.67*** (2.35 – 3.02)
12-35 months	1.70*** (1.36 – 2.13)	3.26*** (2.65 – 3.99)	2.29*** (2.06 – 2.55)
Place of residence (Urban)			
Rural	0.87 (0.67 – 1.13)	0.92 (0.68 – 1.25)	0.84*** (0.74 –0.95)
Mother's education (Secondary or higher)			
Incomplete Primary	1.71*** (1.17 – 2.50)	1.41** (1.03 – 1.93)	1.25*** (1.07 – 1.47)
Incomplete Secondary	1.68*** (1.20 – 2.36)	1.53*** (1.23 – 2.07)	1.21** (1.03 – 1.42)
Mother's access to mass media (Have access)			
No access	1.16 (0.91 – 1.48)	1.08 (0.86 – 1.36)	0.99 (0.88 – 1.11)
Wealth Status (Rich)			
Poor	0.79 (0.48 – 1.29)	0.70 (0.47 – 1.06)	1.53*** (1.23 – 1.91)
Middle	0.78 (0.53 – 1.15)	0.93 (0.66 – 1.32)	1.50*** (1.27 – 1.78)
Source of drinking water (Hygienic in premises)			
Unhygienic or not in premises	1.21 (0.96 – 1.53)	1.09 (0.91 – 1.31)	0.93 (0.83 – 1.04)
Toilet facility (Hygienic unshared)			
Unhygienic Shared	1.05 (0.76 – 1.44)	1.27** (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)
Number of adults per room (up to two persons per room)			
More than two persons	0.76*** (0.62 – 0.94)	1.12 (0.95 – 1.33)	1.03 (0.93 – 1.14)
Household floor material (Not mud)			
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 logistic regression models for Bangladesh, Nepal and Pakistan

Variables (Reference category) levels	Odds ratio of *ARI* (95% CI)		
	Bangladesh	Nepal	Pakistan
Age of child (36+ months)			
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)
Place of residence (Urban)			
Rural	1.09 (0.82 – 1.43)	0.66 (0.41 – 1.06)	1.14 (0.98 – 1.33)
Mother's education (Secondary or higher)			
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)
Mother's access to mass media (Have access)			
No access	0.94 (0.74 – 1.20)	1.04 (0.71 – 1.52)	0.97 (0.86 – 1.11)
Wealth Status (Rich)			
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)
Household cooking fuel (Not solid fuel is used and cooked outside)			
Solid fuel cooked inside	1.62*** (1.21 – 2.16)	1.30 (0.95 – 1.77)	1.03 (0.90 – 1.31)
Number of adults per room			
More than two persons	0.93 (0.75 – 1.14)	1.05 (0.80 – 1.37)	0.95 (0.85 – 1.07)
Household floor material			
Mud	0.78 (0.55 – 1.08)	1.02 (0.66 – 1.57)	0.94 (0.81 – 1.09)

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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

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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

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Abstract:

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

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

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

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

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 = 1.70 in Bangladesh, 95% CI 1.16 to 2.49).

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 prevalence of childhood diarrhea. Replacing indoor solid fuel cooking arrangements with cleaner fuel or more airy conditions can help reduce the prevalence of ARI. However, 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 prevalence 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 child deaths worldwide[1], where pneumonia and diarrhea are two of the leading causes[2,3]. In addition to deaths, several diarrheal episodes lead to long-term nutritional deficits, whereas childhood respiratory infections cause increased risk of reduced lung capacity[4,5]. The greatest proportions of severe episodes of these infections are experienced in the south Asian and African regions and within these regions, the prevalence of these diseases is even higher for poorer countries and among disadvantaged children[6,7].

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 experience infectious diseases than older cohorts, and consequently, a higher proportion of diarrhea and pneumonia related deaths happen in the first two years of life[7-9]. Due to differentials in food intake, standard of living and availability of health care facilities, urban-rural variations are also evident in childhood morbidity[10,11]. Educated mothers are knowledgeable about healthy environments and possible risks of their children being exposed to infectious diseases, and hence, occurrence of infectious diseases is significantly associated with the educational status of mother[12-14]. In addition to formal education, access to mass media helps to create awareness and form knowledge of communicable diseases[15-17]. Furthermore, poorer individuals within impoverished settings face a relatively higher burden of infectious diseases, and children in wealthy families are more protected from diarrhea and ARI[18-20].

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

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

Data and methods

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

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

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

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

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 DHS identify a child experiencing ARI by asking the mother whether the child has been ill in the two weeks preceding the survey with a cough accompanied by short, rapid breathing or by difficulty in breathing that the mother considered to be chest-related[14]. The children were categorized as those suffering or not experiencing these episodes within two weeks before the survey. Similarly, the DHS identify a child experiencing diarrhea by asking the mother whether the child had diarrhea in the last two weeks preceding the survey.

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 diarrhea and ARI across age groups, children were categorized as those aged less than one year, between one and three years and from three to five years. A similar categorization is used by other researchers[17]. Households were also categorized as being in either an urban or rural setting. Educational attainment, and access to mass media have been considered as a proxy of knowledge and understanding of mother regarding exposure to infectious diseases and their

consequences on their children[15-16]. 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 radio, television or newspapers.

Significant positive associations between household economic status and prevalence of infectious diseases were observed in previous studies[14, 20]. As a proxy of household economic status, this study used the wealth score created by the DHS and 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). Details about the calculation of the wealth scores is available[33]. On the basis of wealth score, children were classified as those coming from a household classified as low (lower 40%), middle (middle 40%) and high (upper 20%) wealth categories.

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. Pipe, borehole, protected dug well, spring, or rainwater are considered as improved sources of drinking water[33]. Households were categorized as those having or not having an improved water source located on the premises. Sanitation using technologies such as flush toilet, ventilated pit latrine, traditional pit latrine with a slab, or composting toilet were considered as improved. Households were categorized as those with ideal (improved unshared), moderate (unimproved unshared or improved shared) or worst (unimproved shared or no facility) toilet facilities. 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 existence of cooking practice, the households were categorized as ideal (cooking outside the house or not using solid fuel while cooking inside) or not ideal (using solid fuel while cooking inside the house). Finally, houses were categorized as having the floor made of mud or else. All information was extracted from the datasets mentioned in the previous section.

Statistical Analysis

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

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

Results

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

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

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

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

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

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

Discussion

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

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

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

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

What did have a clear effect on prevalence: In all the three studied countries, bivariate analyses showed that the presence of diarrhea significantly increases the likelihood of the prevalence of ARI, and vice-versa. However, it is important not to include diarrhea in the multiple model of ARI prevalence, and vice versa, because there is a high degree of overlap in risk factors for diarrhea and ARI e.g. age of child, crowding, poor housing. Furthermore, the short recall period employed in the DHS (two weeks) means that the data is clearly cross-sectional and the lag effect of one disease on another cannot be measured with the data at hand. Similar results were observed in previous studies where the epidemiology of diarrhea and ARI overlapped. This is highly likely to be due to shared risk factors or compromised immune function[39-41]. 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 experiencing morbidity than older; the result is consistent with previous studies in Bangladesh and elsewhere[8,14]. The immune system may not be developed at earlier ages, 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 poor food handling[42]. 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 periods of time. Breastfeeding data is available in the DHS surveys, however it has not been included in the current analyses due to its high degree of confounding with age.

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

Data limitations: DHS are cross-sectional surveys which collect information regarding the disease episodes for a single point of time. Such studies can yield information on association but not impact. The seasonal variations in the prevalence of the disease episodes are not addressed in the data. 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. Children who were not de-jure resident at the time of the

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

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

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

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References

1. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, Cousens S, Mathers C, Black RE (2015): Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015; 385: 430 – 440.
2. Bhutta, ZA, et al. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? Lancet 2013; 381: 1417-1429.
3. UNICEF. *Pneumonia and diarrhea: tackling the deadliest diseases for the world's poorest children*. New York: UNICEF, 2012.
4. Checkley W, Buckley G, Gilman RH, Assis AMO, Guerrant RL, Morris SS, Molbak K, Valentiner-Branth P, Lanata CF, Black RE, Childhood Malnutrition and Infection Network. Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol 2008; 37: 816–30.
5. Edmond K, Scott S, Korczak V, Ward C, Sanderson C, Theodoratou E, Clark A, Griffiths U, Rudan I, Campbell H. Long term sequelae from childhood pneumonia; systematic review and meta-analysis. PLoS One 2012; 7: e31239.
6. Qazi S, Aboubaker S, Maclean R, Fontaine O, Mantel C, Goodman T, Young M, Henderson P, Cherian T. Ending preventable child deaths from pneumonia and diarrhoea by 2025: development of the Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhoea. Archives of Disease in Childhood 2015; 100: S23-S28.
7. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, O'Brien KL, Campbell H, Black RE. Global burden of childhood pneumonia and diarrhea. Lancet 2013; 381: 1405 – 1416.
8. Bbaale E. Determinants of diarrhea and acute respiratory infection among under-fives in Uganda. Australasian Med J 2011; 4: 400 – 409.
9. Budge PJ, Griffin MR, Edwards KM, et al. Acute viral respiratory illnesses in Andean children: a household-based cohort study. Ped Inf Dis J, 2014; 33: 443.
10. Dostal M, Pastorkova A, Rychlik S, et al. Comparison of child morbidity in regions of Ostrava, Czech Republic, with different degrees of pollution: a retrospective cohort study. Env Health 2013; 12: 74.
11. Tumwine JK, et al. Diarrhoea and effects of different water sources, sanitation and hygiene behaviour in East Africa. Trop Med Int Health 2002; 7: 750-756.
12. Mukhtar A, Mohamed Izham MI, Pathiyil RS. 2011. A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. The Australasian Med J 2011; 4: 474-479.
13. Ghasemi, AA, Talebian A, Masoudi AN, Mousavi GA. Knowledge of mothers in management of diarrhea in under-five children, in Kashan, Iran. Nurs Midwifery Stud 2013; 1: 158—162.
14. Kamal MM, Hasan MM, Davey R. 2015. Determinants of childhood morbidity in Bangladesh: Evident from Demographic and Health Survey 2011. Brit Med J (BMJ) Open, 2015; 5.
15. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. Lancet 2010; 376: 1261-1271.
16. Asakitikpi, AE. 2010. Acute diarrhoea: Mothers' knowledge of ORT and its usage in Ibadan metropolis, Nigeria. Ethno-Med 4: 125-130.
17. Singh A, Singh MN. (2014) Diarrhoea and acute respiratory infections among under-five children in slums: Evidence from India. PeerJ PrePrints 2: e208v1.

18. Nundy S, et al. "Wealth and its associations with enteric parasitic infections in a low-income community in Peru: use of principal component analysis." Amer J Trop Med Hygiene 2001; 84: 38-42.
19. Hatt, LE, Waters HR. Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status. Soc Sci Med 2006; 62: 375-386.
20. Giasuddin MS, Kabir M, Hasan MM. Economic disparity and child nutrition in Bangladesh. Ind J Paed, 2005; 72: 481-487.
21. Dora C, et al. Indicators linking health and sustainability in the post-2015 development agenda. Lancet 2015; 385: 380-391.
22. Fink G, Günther I, Hill K. The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007. Int J Epidemiol 2011; 40: 1196-1204.
23. Speich, B, et al. "Effect of sanitation and water treatment on intestinal protozoa infection: a systematic review and meta-analysis. Lancet Inf Dis 2016; 16: 87-99.
24. Fuller, JA., et al. The joint effects of water and sanitation on diarrhoeal disease: a multicountry analysis of the Demographic and Health Surveys. Trop Med Int Health 2015; 20: 284-292.
25. Shahnawaz K, Kumar M, Singh S, Kumar L. Incidence of diarrheal diseases among children in Kishanganj district of Bihar. J Evol Med Dental Sci, 2014; 3: 3040-3047.
26. Sustainable Development Knowledge Platform, 2015. Available at: https://sustainabledevelopment.un.org/. Accessed 1 September 2016.
27. Colosia, AD., et al. Residential crowding and severe respiratory syncytial virus disease among infants and young children: a systematic literature review. BMC Inf Dis 2012; 12: 1.
28. Lim SS, Vos T, Flaxman AD et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2013; 380: 2224-2260.
29. Fatmi Z, White F. A comparison of 'cough and cold' and pneumonia: risk factors for pneumonia in children under 5 years revisited. Int J Inf Dis 2002; 6: 294-301.
30. Chafe, ZA, et al. Household cooking with solid fuels contributes to ambient PM2.5 air pollution and the burden of disease. Diss. University of British Columbia, 2015.
31. Central Intelligence Agency. The World Factbook. Available at https://www.cia.gov/library/publications/the-world-factbook/. Accessed 28 October 2016.
32. World GDP (Nominal) Ranking, 2015. Available at: http://statisticstimes.com/economy/world-gdp-ranking.php. Accessed 28 October, 2016.
33. National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ICF International. *Bangladesh Demographic and Health Survey 2014*. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International, 2016.
34. Hosmer Jr DW, Lemeshow S. *Applied logistic regression*. John Wiley & Sons. 2004.
35. IBM Corp. *IBM SPSS Statistics for Windows, Version 22.0.* Armonk, NY: IBM Corp, 2013.
36. Chowdhury AMR, Bhuiya A, Chowdhury ME, Rasheed S, Hussain Z, Chen LC. The Bangladesh paradox: exceptional health achievement despite economic poverty. Lancet 2013; 382: 1734 – 1745.

37. Nasrin D, Wu Y, Blackwelder WC, et al. Health care seeking for childhood diarrhea in developing countries: evidence from seven sites in Africa and Asia. Amer J Trop Med Hygiene 2013; 89(1): 3 – 12.
38. Rizvi A, Bhatti Z, Das JK, Bhutta ZA. Pakistan and the millennium development goals for maternal and child health: progress and the way forward. Paediatrics and international child health, 2015; 35(4), 287-297.
39. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet 2003; 361: 2226–34.
40. Walker CLF, Perin J, Katz J, Tielsch JM, Black RE. Diarrhea as a risk factor for acute lower respiratory tract infections among young children in low income settings. J Glob Health 2013; 3: 60–67.
41. Schmidt WP, Cairncross S, Barreto ML, Clasen T, Genser B. Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years. Int J Epidemiol 2009; 38: 766 –772.
42. Black RE. Diarrheal diseases and child morbidity and mortality. Pop Devel Review 1984:141–61.

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

Background Characteristics	Percentages of respondents		
	Bangladesh (N = 7760)	Nepal (N = 5140)	Pakistan (N= 11040)
Age of child			
0-11 months	19.5	19.9	19.8
12-35 months	41.2	39.2	39.4
36-59 months	39.3	40.9	40.8
Type of Place of Residence			
Rural	74.4	90.6	70.3
Urban	25.6	9.4	29.7
Mother's education			
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
Access to electronic media			
No access	38.7	15.2	29.8
Have access	61.3	84.8	70.2
Age of mother at the time of survey			
15 –19 years	14.6	7.0	2.2
20 –29 years	61.7	65.5	52.4
30 –49 years	23.7	27.5	45.4
Source of drinking water			
Not improved/not in premises	21.1	36.1	22.9
Improved in premises	78.9	63.9	77.1
Toilet facility			
Worst	10.4	49.0	25.4
Moderate	26.7	15.0	11.5
Ideal	62.9	35.9	63.2
Number of adults per room			
More than 2 adults	40.9	43.2	71.7
Up to 2 adults	59.1	56.8	28.3
Household cooking facility			
Not ideal	9.6	57.4	59.8
Ideal	90.4	42.6	40.2
Household floor material			
Mud	68.9	75.4	47.3
Not Mud	31.1	24.6	527

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

Background Characteristics	Bangladesh		Nepal		Pakistan	
	% Diarrhea	% ARI	% Diarrhea	% ARI	% Diarrhea	% ARI
Childhood ARI/ Diarrhea in last two weeks						
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[a]	14.27[a]	55.65[a]	55.65[a]	145.59[a]	145.59[a]
Age of child						
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[a]	41.15[a]	150.24[a]	24.46[a]	308.76[a]	52.81[a]
Place of residence						
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[b]	0.07	0.12	0.89	5.84[b]
Mother's educational status						
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[a]	15.37[a]	7.75[c]	1.04	22.26[a]	10.84[a]
Wealth status of household						
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[a]	5.03	12.92[a]	36.23[a]	10.58[a]
Access to electronic media						
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[c]	3.39	2.83	0.03	1.42	0.03
Age of mother at the time of survey						
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[a]	2.64	1.47	43.87[a]	7.09[b]
Source of drinking water						
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[c]	2.33	0.13	0.02	1.22	0.39
Toilet facility						
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[a]	11.28[a]	2.73	8.14[b]	0.47
Number of adults per room						
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[c]	0.07	3.18	0.13	0.78	0.49
Household cooking fuel						
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[a]	11.85[a]	5.53[b]	5.50[b]	14.65[a]	3.00[c]
Household floor material						
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
	3.57	7.19[a]	2.50	4.35[c]	3.83[b]	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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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

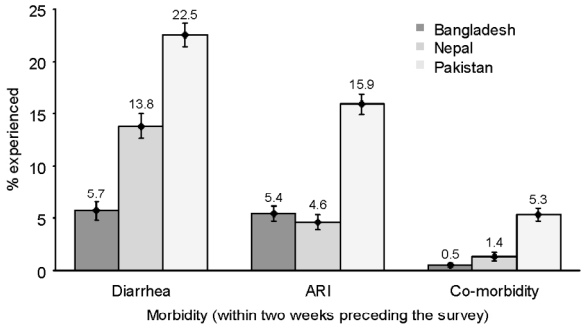
Variables (Reference category) levels	Odds ratio of Diarrhea (95% CI)		
	Bangladesh	Nepal	Pakistan
Age of child (36-59 months)			
0-11 months	1.63[a] (1.23 – 2.16)	3.19[a] (2.51 – 4.05)	2.56[a] (2.26 – 2.91)
12-35 months	1.71[a] (1.36 – 2.14)	3.29[a] (2.68 – 4.04)	2.24[a] (2.01 – 2.50)
Place of residence (Urban)			
Rural	0.87 (0.69 – 1.12)	0.92 (0.68 – 1.25)	0.83[a] (0.73 –0.94)
Mother's education (Secondary or higher)			
Incomplete Primary	1.70[a] (1.16 – 2.49)	1.41[b] (1.03 – 1.93)	1.27[a] (1.08– 1.48)
Incomplete Secondary	1.69[a] (1.20 – 2.38)	1.55[a] (1.14 – 2.10)	1.19[b] (1.0 1– 1.40)
Mother's access to mass media (Have access)			
No access	1.16 (0.91 – 1.48)	1.07 (0.85 – 1.35)	1.01 (0.90 – 1.13)
Age of mother at the time of survey (30 –49 years)			
15 –19 years	0.94 (0.67 –1.30)	0.83 (0.59 – 1.17)	1.40[b] (1.05 –1.86)
20 –29 years	0.94 (0.74 –1.21)	0.99 (0.81 – 1.20)	1.17[a] (1.07 –1.29)
Wealth Status (High)			
Low	0.79 (0.48 – 1.30)	0.71[c] (0.47 – 1.06)	1.53[a] (1.23 – 1.91)
Middle	0.78 (0.53 – 1.16)	0.94 (0.66 – 1.33)	1.49[a] (1.26 – 1.77)
Source of drinking water (Hygienic in premises)			
Unimproved or not in premises	1.21 (0.96 – 1.53)	1.10 (0.91 – 1.31)	0.93 (0.83 – 1.04)
Toilet facility (Ideal)			
Worst	1.06 (0.76 – 1.46)	1.29[b] (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)
Number of adults per room (up to two adults per room)			
More than two adults	0.76[a] (0.62 – 0.93)	1.12 (0.95 – 1.33)	1.06 (0.95 – 1.17)
Household floor material (Not mud)			
Floor made of mud	1.27 (0.89 – 1.81)	1.11 (0.83 – 1.48)	0.94 (0.82 – 1.08)

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

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

Variables (Reference category) levels	Odds ratio of *ARI* (95% CI)		
	Bangladesh	Nepal	Pakistan
Age of child (36+ months)			
0-11 months	2.21[a] (1.66 – 2.92)	1.99[a] (1.23 – 2.79)	1.49 [a] (1.30 – 1.72)
12-35 months	1.74[a] (1.36 – 2.22)	2.12[a] (1.54 – 2.91)	1.49[a] (1.32 – 1.68)
Place of residence (Urban)			
Rural	1.10 (0.83 – 1.45)	0.66[c] (0.41 – 1.07)	1.14[c] (0.98 – 1.34)
Mother's education (Secondary or higher)			
Incomplete Primary	1.31 (0.88 – 1.96)	0.86 (0.54 – 1.38)	1.35[a] (1.13 – 1.62)
Incomplete Secondary	1.63[a] (1.14 – 2.33)	1.02 (0.64 – 1.63)	1.24[b] (1.04 – 1.49)
Mother's access to mass media (Have access)			
No access	0.96 (0.75 – 1.22)	1.02 (0.69 – 1.49)	0.99 (0.87 – 1.12)
Age of mother at the time of survey (30 –49 years)			
15 –19 years	1.47[b] (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)
Wealth Status (High)			
Low	2.25[a] (1.36 – 3.70)	2.25[b] (1.08 – 4.69)	0.94 (0.74 –1.20)
Middle	1.61[b] (1.08 – 2.41)	2.68[a] (1.41 – 5.10)	1.09 (0.90 – 1.31)
Household cooking fuel (Ideal)			
Not ideal	1.62[a] (1.22 –2.16)	1.31[c] (0.96 – 1.79)	1.01 (0.88 – 1.16)
Number of adults per room (up to two adults per room)			
More than two adults	0.95 (0.77 – 1.17)	1.03 (0.79 – 1.36)	0.96 (0.86 – 1.08)
Household floor material (Not mud)			
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: $0.05 \leq p < 0.1$



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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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

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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

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Abstract:

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

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

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

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

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 = 1.70 in Bangladesh, 95% CI 1.16 to 2.49).

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 prevalence of childhood diarrhea. Replacing indoor solid fuel cooking arrangements with cleaner fuel or more airy conditions can help reduce the prevalence of ARI. However, 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 is limited by its provision at a single point of time so that the seasonal variations in the prevalence of the disease episodes are not addressed in the data.
- The disease episodes are limited by their determination 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 child deaths worldwide[1], where pneumonia and diarrhea are two of the leading causes[2,3]. Apart from deaths, several diarrheal episodes lead to long-term nutritional deficits, whereas childhood respiratory infections cause increased risk of reduced lung capacity[4,5]. The greatest proportions of severe episodes of these infections are experienced in the south Asian and African regions and within these regions, the prevalence of these diseases is even higher for poorer countries and among disadvantaged children[6,7].

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 experience infectious diseases than older cohorts, and consequently, a higher proportion of diarrhea and pneumonia related deaths happen in the first two years of life[7-9]. Due to differentials in food intake, standard of living and availability of health care facilities, urban-rural variations are also evident in childhood morbidity[10,11]. Educated mothers are knowledgeable about healthy environments and possible risks of their children being exposed to infectious diseases, and hence, occurrence of infectious diseases is significantly associated with the educational status of mother[12-14]. In addition to formal education, access to mass media helps to create awareness around communicable diseases[15-17]. Furthermore, poorer individuals within impoverished settings face a relatively higher burden of infectious diseases, and children in wealthy families are more protected from diarrhea and ARI[18-20].

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

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

Data and methods

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

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

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

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

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 DHS identify a child experiencing ARI by asking the mother whether the child has been ill in the two weeks preceding the survey with a cough accompanied by short, rapid breathing or by difficulty in breathing that the mother considered to be chest-related[14]. The children were categorized as those suffering or not experiencing these episodes within two weeks before the survey. Similarly, the DHS identify a child experiencing diarrhea by asking the mother whether the child had diarrhea in the last two weeks preceding the survey.

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 diarrhea and ARI across age groups, children were categorized as those aged less than one year, between one and three years and from three to five years. A similar categorization is used by other researchers[17]. Households were also categorized as being in either an urban or rural setting. Educational attainment, and access to mass media have been considered as a proxy of knowledge and understanding of mother regarding exposure to infectious diseases and their consequences on their children[15-16]. 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 radio, television or newspapers.

Significant positive associations between household economic status and prevalence of infectious diseases were observed in previous studies[14, 20]. As a proxy of household economic status, this study used the wealth score created by the DHS and 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). Details about the calculation of the wealth scores is available[33]. On the basis of wealth score, children were classified as those coming from a household classified as low (lower 40%), middle (middle 40%) and high (upper 20%) wealth categories.

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. Pipe, borehole, protected dug well, spring, or rainwater are considered as improved sources of drinking water[33]. Households were categorized as those having or not having an improved water source located on the premises. Sanitation using technologies such as flush toilet, ventilated pit latrine, traditional pit latrine with a slab, or composting toilet were considered as improved. Households were categorized as those with ideal (improved unshared), moderate (unimproved unshared or improved shared) or worst (unimproved shared or no facility) toilet facilities. 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 existence of cooking practice, the households were categorized as ideal (cooking outside the house or not using solid fuel while cooking inside) or not ideal (using solid fuel while cooking inside the house). Finally, houses were categorized as having the floor made of mud or else. All information was extracted from the datasets mentioned in the previous section.

Statistical Analysis

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

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

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

Results

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

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

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

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

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

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

Discussion

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

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

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

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

crowding, poor housing. Furthermore, the short recall period employed in the DHS (two weeks) means that the data is clearly cross-sectional and the lag effect of one disease on another cannot be measured with the data at hand. Similar results were observed in previous studies where the epidemiology of diarrhea and ARI overlapped. This is highly likely to be due to shared risk factors or compromised immune function[39-41]. 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 experiencing morbidity than older; the result is consistent with previous studies in Bangladesh and elsewhere[8,14]. The immune system may not be developed at earlier ages, 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 poor food handling[42]. 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 periods of time. Breastfeeding data is available in the DHS surveys, however it has not been included in the current analyses due to its high degree of confounding with age.

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

Data limitations: Though the DHS adopted appropriate survey methodology to obtain a representative sample, the final sample does not guarantee complete representativeness at national and regional levels. DHS are cross-sectional surveys which collect information regarding the disease episodes for a single point of time. Such studies can yield information on association but not impact. The seasonal variations in the prevalence of the disease episodes are not addressed in the data. Moreover, the disease episodes are determined on the basis of self-reporting of mothers, 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. Children who were not de-jure resident at the time of the survey were excluded from the analysis. The exclusion may lead a bias to the outcomes, however, the amount of bias is likely to be small. Finally, the datasets do not represent same time point for the studied countries, though the largest time difference is only three years.

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

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

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References

1. Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, Cousens S, Mathers C, Black RE (2015): Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet 2015; 385: 430 – 440.
2. Bhutta, ZA, et al. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? Lancet 2013; 381: 1417-1429.
3. UNICEF. *Pneumonia and diarrhea: tackling the deadliest diseases for the world's poorest children*. New York: UNICEF, 2012.
4. Checkley W, Buckley G, Gilman RH, Assis AMO, Guerrant RL, Morris SS, Molbak K, Valentiner-Branth P, Lanata CF, Black RE, Childhood Malnutrition and Infection Network. Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol 2008; 37: 816–30.
5. Edmond K, Scott S, Korczak V, Ward C, Sanderson C, Theodoratou E, Clark A, Griffiths U, Rudan I, Campbell H. Long term sequelae from childhood pneumonia; systematic review and meta-analysis. PLoS One 2012; 7: e31239.
6. Qazi S, Aboubaker S, Maclean R, Fontaine O, Mantel C, Goodman T, Young M, Henderson P, Cherian T. Ending preventable child deaths from pneumonia and diarrhoea by 2025: development of the Integrated Global Action Plan for the Prevention and Control of Pneumonia and Diarrhoea. Archives of Disease in Childhood 2015; 100: S23-S28.
7. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, O'Brien KL, Campbell H, Black RE. Global burden of childhood pneumonia and diarrhea. Lancet 2013; 381: 1405 – 1416.
8. Bbaale E. Determinants of diarrhea and acute respiratory infection among under-fives in Uganda. Australasian Med J 2011; 4: 400 – 409.
9. Budge PJ, Griffin MR, Edwards KM, et al. Acute viral respiratory illnesses in Andean children: a household-based cohort study. Ped Inf Dis J, 2014; 33: 443.
10. Dostal M, Pastorkova A, Rychlik S, et al. Comparison of child morbidity in regions of Ostrava, Czech Republic, with different degrees of pollution: a retrospective cohort study. Env Health 2013; 12: 74.
11. Tumwine JK, et al. Diarrhoea and effects of different water sources, sanitation and hygiene behaviour in East Africa. Trop Med Int Health 2002; 7: 750-756.
12. Mukhtar A, Mohamed Izham MI, Pathiyil RS. 2011. A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. The Australasian Med J 2011; 4: 474-479.
13. Ghasemi, AA, Talebian A, Masoudi AN, Mousavi GA. Knowledge of mothers in management of diarrhea in under-five children, in Kashan, Iran. Nurs Midwifery Stud 2013; 1: 158—162.
14. Kamal MM, Hasan MM, Davey R. 2015. Determinants of childhood morbidity in Bangladesh: Evident from Demographic and Health Survey 2011. Brit Med J (BMJ) Open, 2015; 5.
15. Wakefield MA, Loken B, Hornik RC. Use of mass media campaigns to change health behaviour. Lancet 2010; 376: 1261-1271.
16. Asakitikpi, AE. 2010. Acute diarrhoea: Mothers' knowledge of ORT and its usage in Ibadan metropolis, Nigeria. Ethno-Med 4: 125-130.
17. Singh A, Singh MN. (2014) Diarrhoea and acute respiratory infections among under-five children in slums: Evidence from India. PeerJ PrePrints 2: e208v1.

18. Nundy S, et al. "Wealth and its associations with enteric parasitic infections in a low-income community in Peru: use of principal component analysis." Amer J Trop Med Hygiene 2001; 84: 38-42.
19. Hatt, LE, Waters HR. Determinants of child morbidity in Latin America: a pooled analysis of interactions between parental education and economic status. Soc Sci Med 2006; 62: 375-386.
20. Giasuddin MS, Kabir M, Hasan MM. Economic disparity and child nutrition in Bangladesh. Ind J Paed, 2005; 72: 481-487.
21. Dora C, et al. Indicators linking health and sustainability in the post-2015 development agenda. Lancet 2015; 385: 380-391.
22. Fink G, Günther I, Hill K. The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007. Int J Epidemiol 2011; 40: 1196-1204.
23. Speich, B, et al. "Effect of sanitation and water treatment on intestinal protozoa infection: a systematic review and meta-analysis. Lancet Inf Dis 2016; 16: 87-99.
24. Fuller, JA., et al. The joint effects of water and sanitation on diarrhoeal disease: a multicountry analysis of the Demographic and Health Surveys. Trop Med Int Health 2015; 20: 284-292.
25. Shahnawaz K, Kumar M, Singh S, Kumar L. Incidence of diarrheal diseases among children in Kishanganj district of Bihar. J Evol Med Dental Sci, 2014; 3: 3040-3047.
26. Sustainable Development Knowledge Platform, 2015. Available at: https://sustainabledevelopment.un.org/. Accessed 1 September 2016.
27. Colosia, AD., et al. Residential crowding and severe respiratory syncytial virus disease among infants and young children: a systematic literature review. BMC Inf Dis 2012; 12: 1.
28. Lim SS, Vos T, Flaxman AD et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2013; 380: 2224-2260.
29. Fatmi Z, White F. A comparison of 'cough and cold' and pneumonia: risk factors for pneumonia in children under 5 years revisited. Int J Inf Dis 2002; 6: 294-301.
30. Chafe, ZA, et al. Household cooking with solid fuels contributes to ambient PM2.5 air pollution and the burden of disease. Diss. University of British Columbia, 2015.
31. Central Intelligence Agency. The World Factbook. Available at https://www.cia.gov/library/publications/the-world-factbook/. Accessed 28 October 2016.
32. World GDP (Nominal) Ranking, 2015. Available at: http://statisticstimes.com/economy/world-gdp-ranking.php. Accessed 28 October, 2016.
33. National Institute of Population Research and Training (NIPORT), Mitra and Associates, and ICF International. *Bangladesh Demographic and Health Survey 2014*. Dhaka, Bangladesh, and Rockville, Maryland, USA: NIPORT, Mitra and Associates, and ICF International, 2016.
34. Hosmer Jr DW, Lemeshow S. *Applied logistic regression*. John Wiley & Sons. 2004.
35. IBM Corp. *IBM SPSS Statistics for Windows, Version 22.0.* Armonk, NY: IBM Corp, 2013.
36. Chowdhury AMR, Bhuiya A, Chowdhury ME, Rasheed S, Hussain Z, Chen LC. The Bangladesh paradox: exceptional health achievement despite economic poverty. Lancet 2013; 382: 1734 – 1745.

37. Nasrin D, Wu Y, Blackwelder WC, et al. Health care seeking for childhood diarrhea in developing countries: evidence from seven sites in Africa and Asia. Amer J Trop Med Hygiene 2013; 89(1): 3 – 12.
38. Rizvi A, Bhatti Z, Das JK, Bhutta ZA. Pakistan and the millennium development goals for maternal and child health: progress and the way forward. Paediatrics and international child health, 2015; 35(4), 287-297.
39. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet 2003; 361: 2226–34.
40. Walker CLF, Perin J, Katz J, Tielsch JM, Black RE. Diarrhea as a risk factor for acute lower respiratory tract infections among young children in low income settings. J Glob Health 2013; 3: 60–67.
41. Schmidt WP, Cairncross S, Barreto ML, Clasen T, Genser B. Recent diarrheal illness and risk of lower respiratory infections in children under the age of 5 years. Int J Epidemiol 2009; 38: 766 –772.
42. Black RE. Diarrheal diseases and child morbidity and mortality. Pop Devel Review 1984:141–61.

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

Background Characteristics	Percentages of respondents		
	Bangladesh (N = 7760)	Nepal (N = 5140)	Pakistan (N= 11040)
Age of child			
0-11 months	19.5	19.9	19.8
12-35 months	41.2	39.2	39.4
36-59 months	39.3	40.9	40.8
Type of Place of Residence			
Rural	74.4	90.6	70.3
Urban	25.6	9.4	29.7
Mother's education			
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
Access to electronic media			
No access	38.7	15.2	29.8
Have access	61.3	84.8	70.2
Age of mother at the time of survey			
15 –19 years	14.6	7.0	2.2
20 –29 years	61.7	65.5	52.4
30 –49 years	23.7	27.5	45.4
Source of drinking water			
Not improved/not in premises	21.1	36.1	22.9
Improved in premises	78.9	63.9	77.1
Toilet facility			
Worst	10.4	49.0	25.4
Moderate	26.7	15.0	11.5
Ideal	62.9	35.9	63.2
Number of adults per room			
More than 2 adults	40.9	43.2	71.7
Up to 2 adults	59.1	56.8	28.3
Household cooking facility			
Not ideal	9.6	57.4	59.8
Ideal	90.4	42.6	40.2
Household floor material			
Mud	68.9	75.4	47.3
Not Mud	31.1	24.6	527

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

Background Characteristics	Bangladesh		Nepal		Pakistan	
	% Diarrhea	% ARI	% Diarrhea	% ARI	% Diarrhea	% ARI
Childhood ARI/ Diarrhea in last two weeks						
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[a]	14.27[a]	55.65[a]	55.65[a]	145.59[a]	145.59[a]
Age of child						
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[a]	41.15[a]	150.24[a]	24.46[a]	308.76[a]	52.81[a]
Place of residence						
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[b]	0.07	0.12	0.89	5.84[b]
Mother's educational status						
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[a]	15.37[a]	7.75[c]	1.04	22.26[a]	10.84[a]
Wealth status of household						
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[a]	5.03	12.92[a]	36.23[a]	10.58[a]
Access to electronic media						
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[c]	3.39	2.83	0.03	1.42	0.03
Age of mother at the time of survey						
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[a]	2.64	1.47	43.87[a]	7.09[b]
Source of drinking water						
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[c]	2.33	0.13	0.02	1.22	0.39
Toilet facility						
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[a]	11.28[a]	2.73	8.14[b]	0.47
Number of adults per room						
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[c]	0.07	3.18	0.13	0.78	0.49
Household cooking fuel						
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[a]	11.85[a]	5.53[b]	5.50[b]	14.65[a]	3.00[c]
Household floor material						
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
	3.57	7.19[a]	2.50	4.35[c]	3.83[b]	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

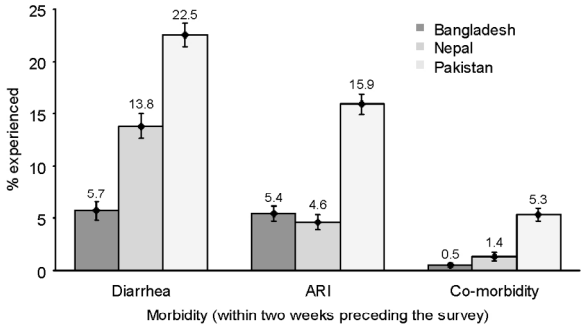
Variables (Reference category) levels	Odds ratio of Diarrhea (95% CI)		
	Bangladesh	Nepal	Pakistan
Age of child (36-59 months)			
0-11 months	1.63[a] (1.23 – 2.16)	3.19[a] (2.51 – 4.05)	2.56[a] (2.26 – 2.91)
12-35 months	1.71[a] (1.36 – 2.14)	3.29[a] (2.68 – 4.04)	2.24[a] (2.01 – 2.50)
Place of residence (Urban)			
Rural	0.87 (0.69 – 1.12)	0.92 (0.68 – 1.25)	0.83[a] (0.73 –0.94)
Mother's education (Secondary or higher)			
Incomplete Primary	1.70[a] (1.16 – 2.49)	1.41[b] (1.03 – 1.93)	1.27[a] (1.08– 1.48)
Incomplete Secondary	1.69[a] (1.20 – 2.38)	1.55[a] (1.14 – 2.10)	1.19[b] (1.0 1– 1.40)
Mother's access to mass media (Have access)			
No access	1.16 (0.91 – 1.48)	1.07 (0.85 – 1.35)	1.01 (0.90 – 1.13)
Age of mother at the time of survey (30 –49 years)			
15 –19 years	0.94 (0.67 –1.30)	0.83 (0.59 – 1.17)	1.40[b] (1.05 –1.86)
20 –29 years	0.94 (0.74 –1.21)	0.99 (0.81 – 1.20)	1.17[a] (1.07 –1.29)
Wealth Status (High)			
Low	0.79 (0.48 – 1.30)	0.71[c] (0.47 – 1.06)	1.53[a] (1.23 – 1.91)
Middle	0.78 (0.53 – 1.16)	0.94 (0.66 – 1.33)	1.49[a] (1.26 – 1.77)
Source of drinking water (Hygienic in premises)			
Unimproved or not in premises	1.21 (0.96 – 1.53)	1.10 (0.91 – 1.31)	0.93 (0.83 – 1.04)
Toilet facility (Ideal)			
Worst	1.06 (0.76 – 1.46)	1.29[b] (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)
Number of adults per room (up to two adults per room)			
More than two adults	0.76[a] (0.62 – 0.93)	1.12 (0.95 – 1.33)	1.06 (0.95 – 1.17)
Household floor material (Not mud)			
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: $p < 0.1$

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

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

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



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

210x297mm (200 x 200 DPI)