Journal of Public Health and Development
Vol.19 No.2 May-August 2021

ORIGINAL ARTICLE

Spatial-Temporal Patterns and Determinants of Diarrhea and Acute Respiratory Infection among Children under five years in Nepal

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Received: 15 January 2021
Revised: 9 March 2021
Accepted: 15 March 2021
Available online: May 2021

ABSTRACT

Diarrhea and acute respiratory infection (ARI) remain the leading cause of mortality and morbidity among children in Nepal. The aim of this study was to investigate the spatial and temporal patterns of diarrhea and ARI and its determinants among children from 2015 to 2018. The study used the data of diarrhea and ARI from District Health Information System 2 published by Integrated Health Information Management Section and district characteristics data from Central Bureau of Statistics. Statistical model was used for assessing diarrhea and ARI and its determinants were performed using multiple linear regression. The model provided good fit as indicated r-squared statistic (0.68) for diarrhea and r-squared statistic (0.56) for ARI. The proportion for diarrhea and ARI were 51% and 68% respectively. The multivariate analysis found that mother education and number of children was associated with diarrhea; human development index was associated with ARI and poverty gap, malnutrition and low birth weight were associated with both diarrhea and ARI. This study showed steady decreasing trend in diarrhea and ARI from 2015 to 2018; however, the cases are large and evenly distributed in Nepal. These findings provide insight to establish prevention programs based on socio economic barriers and high risky areas.

Key words: spatial, temporal, diarrhea, ARI, determinants, Nepal

INTRODUCTION

Globally, pneumonia, diarrhea and malaria remain among the leading causes of death among children under age of five accounting for almost a third of global under-five deaths.[1] Diarrheal disease kills 525,000 children worldwide annually, making diarrhea the second leading cause of death in children under five years.[2] Acute respiratory infections (ARIs) killed 808,694 children under five years in 2017, accounting for 15% of all deaths of children under five years old.[3]

Diarrhea and ARI fall under the top ten leading cause of mortality and morbidity among under five years in Nepal.[4-6] Despite the fact that the diarrhea

and ARI are both preventable and treatable many children are affected and died every year in Nepal.[2] In Nepal, the demographic health survey reported that the under-five mortality rate was 39 per 1000 live births in 2016, and symptoms of ARI and diarrhea were present among 8% and 2%, respectively, of the under five children in the 2 weeks prior to the survey interview.[5]The recent multi indicator cluster survey showed that the under-five mortality rate was 28 per live births in 2019.[7] The under-five mortality rate still remains higher than the Sustainable Development Goal (SDG) target of 20 per 1000 live births.[8]

Nepal has implemented the Community Based Integrated Management of Neonatal and Childhood Illness (CB-IMNCI) program to tackle the neonatal and under five-year mortality rate. The CB-IMNCI program incorporates community components, especially mobilization of Female Community Health Volunteers (FCHV) to identify and treat diarrhea and pneumonia cases among under five children, and regarded as the most efficient strategy for reducing the burden of disease and disability among the children under five years of Nepal.[4,6] With the implementation of CB IMNCI program the prevalence of pneumonia and diarrhea are in decreasing trend, however the numbers of cases and are still high among children [4]. Numerous studies had identified the factors associated with diarrhea and ARI in lower income countries including Nepal.[9-13] Factors associated with diarrhea among children under five years comprise of male child,[9] younger child,[10-13]birth order of the child,[14,15] having more than two under five children,[14] larger family size,[14,16] mother's occupation,[12] father's occupation,[15] low maternal education,[9,10,12,17] maternal depression,[16] low household socioeconomic status,[6,10,11,12] food insecurity[16] and rural area.[12,15] Furthermore poor sanitation [10,13,14], improper waste disposal, [14,15] improper drainage system,[15,18] unsafe drinking water,[10,11,13,118] and improper hand washing behavior[10,12,15] were also associated with diarrhea. Nutritional factors such as suboptimal breastfeeding practices,[12] malnutrition[10] and wasting[13] were among the leading risks for diarrhea among children younger than five years.

Similarly, determinants of ARI were child age, mother's occupation, socio economic status, exclusive breastfeeding,[12] maternal depression, food insecurity, sanitation,[16] male child, rural residency, overcrowding, history of ARI in any family member[19] and child's nutritional status (malnutrition).[12,19] Besides this, use of biomass fuel for cooking,[11] education level of father, type of house, presence of moisture and coldness in room [20] were also associated with ARI. Furthermore, human development index (HDI) was also associated with diarrhea and ARI mortality.[21,22]

Likewise, in Nepal, disparities exist in childhood morbidity and mortality, which are higher in marginalized community, among the poor and uneducated and those from rural areas.[5,12] Although studies have been conducted to identify the factors associated with diarrhea and ARI in lower income countries including Nepal, [9-11,18-20,232-25] the use of Integrated Health Management Information System (IHMIS) data to determine the disease and its determinants is limited in Nepal. However, these statistics show the burden of diarrhea and ARI in causing child mortality and therefore underscore the need to understand the factors fueling their occurrence. Determining the causes of diarrhea and ARI prevalence is imperative for policy formulation and advocacy and for a general assessment of resource requirements and prioritization. Besides this, investigating the regional and temporal

pattern of diarrhea and ARI can indicate areas with problems and possibly predict periods of likely disease epidemics. It can also help the concerned public health authorities to design an effective intervention program among children of under five years in Nepal. Thus, the objective of the study was to determine the spatial and temporal pattern of diarrhea and ARI and determinants associated with diarrhea and ARI among children under five years using IHMIS data from 2015 to 2018.

METHODS

Data for this study were extracted through various studies that have been conducted in national level. The diarrhea and ARI related data of last four years (2015 to 2018), malnutrition and low birth weight (LBW) data were taken from the District Health Information System 2 published by IHIMS. The data of IHIMS included the district wise information about the total registered cases (Health facility, primary health care-outreach clinics and FCHV reported cases) about the diarrhea and ARI cases among the children under five years. This IHMIS is a tool, used to collect the information on disease surveillance, vital registration, sentinel reporting, and surveys from grass root (FCHVs, maternal and child health worker [MCHWs]) to central level. Every month, the information obtained from health management information were entered into the electronic database of HMIS by MIS section at the central level. Afterward, a retrospective study was utilized the diarrhea, ARI and malnutrition data for 2015 to 2018, retrieved from annual reports of Department of Health Service of Nepal. Data of wealth quantile and average number of children related data was taken from the NDHS report 2016. District wise data for male and female literacy, human development index and poverty gap were obtained from 'Population Atlas of Nepal 2014' published by Central Bureau of Statistics. Ethical approval for this study was obtained from Institutional Review Committee of Nobel College.

Statistical Models

The conventional model for handling data where the outcome is continuous is linear regression. The multiple linear regression model with normally distributed errors for modeling is defined as

$$y_{ijt} = \mu + \alpha_i + \beta_j + \eta_q + \gamma_t .$$

The parameter μ is a constant encapsulating the overall mean, α_i , β_j η_q …are the main effect corresponding to determinants. Sum contrasts were used to obtain confidence intervals for comparing the adjusted proportion rates within each factor with the overall proportion rate [25]. The confidence intervals for factor-specific proportion rates obtained from the model divide naturally into three groups according to their location entirely above the mean, around the mean, or entirely below the mean, this trichotomy was used to classify schematic maps of high risk districts according to their estimated proportion of diarrhea and ARI cases. The R program was used for all statistical analysis, graphs and maps. The statistical analysis was explained elsewhere.[27,28]

RESULTS

The mean and standard deviation (SD) of different variables is shown in Table 1. The mean and standard deviation of male literacy rate was 75 and 8.34 whereas the mean and standard deviation of female literacy rate was 56 and 11. The

mean of HDI was 0.47 and the mean of poverty gap was 6.7. The mean for the total number of children was 1.7 with standard deviation of 0.29. However, the mean for malnutrition was 5 and the mean value for LBW was 5.9. The overall prevalence of diarrhea and ARI among children under **five** years was 51% and 68% respectively.

Table 1 Descriptive Statistics of Variables

Variable	**Mean±SD**
Male Literacy Rate	75.03 ±8.34
Female Literacy Rate	56.11±11.03
Human Development Index	46.83±5.52
Poverty Gap	6.71±4.1
Total Number of children	1.71±0.29
Malnutrition	5.18±6.28
Low birth weight	5.96±3.31
Prevalence of Diarrhea	50. 5±18.87
Prevalence of ARI	68.1±20.5

Figure 1 show 95% confidence intervals for the proportion of diarrhea and ARI by year. The horizontal line denotes the mean proportion of diarrhea (51%) and ARI (68%). There was an overall decrease in proportion of diarrhea and ARI from 2015 to 2018. There was drop in diarrhea from 60% in 2015 to 45.5% in 2018. Likewise, there was drop in ARI from 77% in 2015 to 62% in 2018.

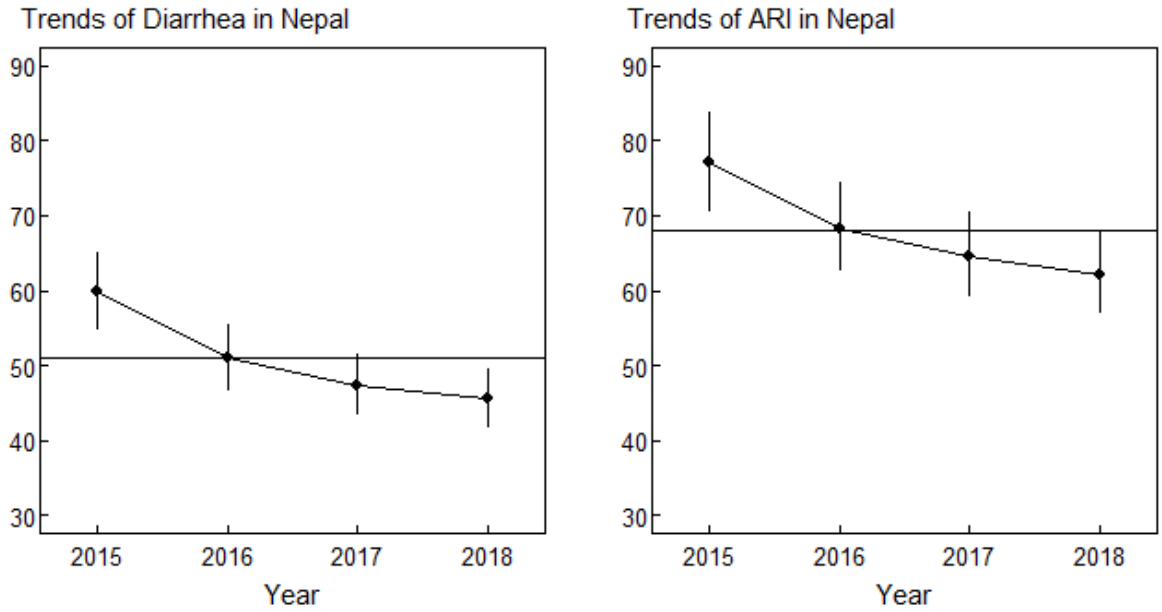
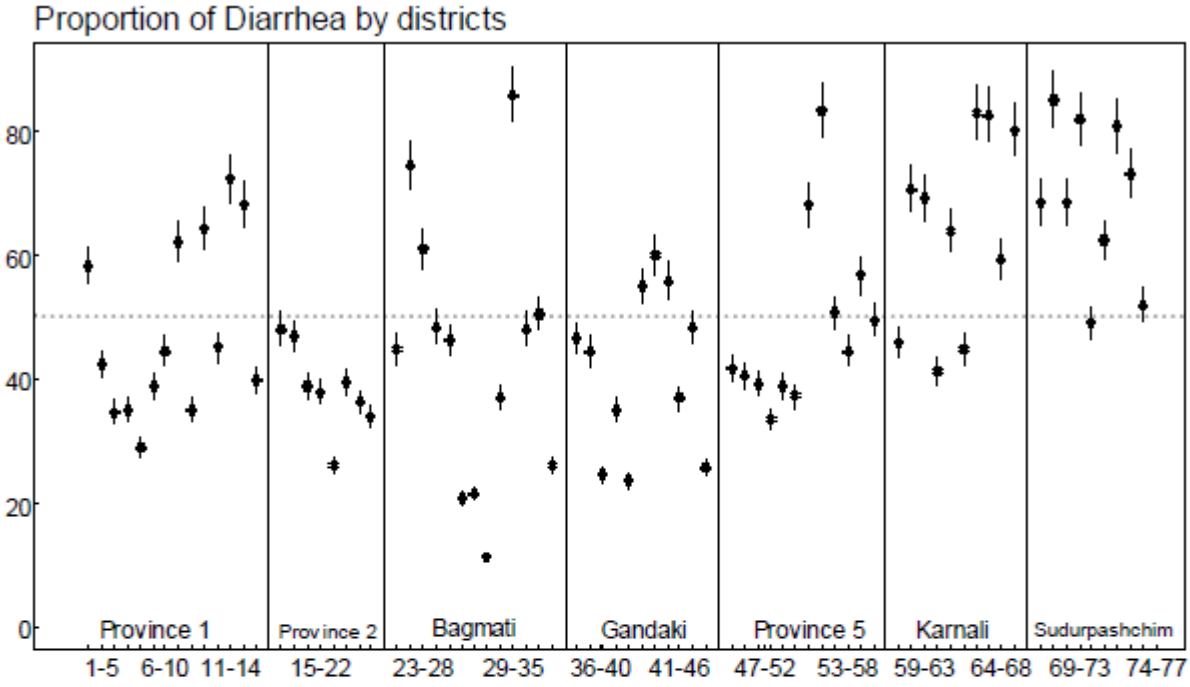


Figure 1: Proportion of Trends of Diarrhea and ARI by year

Figure 2 shows 95% confidence intervals for proportion of diarrhea by districts. Districts with 95% confidence intervals above the mean are categorized as having a higher than average value, while districts with 95% confidence intervals

below the mean are categorized as having a lower than average value and districts with confidence intervals not evidently different from the mean are categorized as average. About 28 districts were categorized as having a higher than average proportion, nine districts were categorized as average and 40 districts were categorized as having a lower than average value. In between the year 2015 to 2018, the proportion of diarrhea was highest in most of the districts of Karnali and Sudurpashim Province and lowest in most of the district of Province 2.



id	District	id	District	id	District	id	District	id	District	id	District
1	Taplejung	14	Udayapur	27	Kavre	40	Kaski	53	Pyuthan	66	Kalikot
2	Panchthar	15	Saptari	28	Lalitpur	41	Manang	54	Rolpa	67	Mugu
3	Ilam	16	Siraha	29	Bhaktapur	42	Mustang	55	Rukum East	68	Humla
4	Jhapa	17	Dhanusa	30	Kathmandu	43	Myagdi	56	Dang	69	Bajura
5	Morang	18	Mahottari	31	Nuwakot	44	Parbat	57	Banke	70	Bajhang
6	Sunsari	19	Sarlahi	32	Rasuwa	45	Baglung	58	Bardiya	71	Achham
7	Dhankuta	20	Rautahat	33	Dhading	46	Nawalparasi East	59	Rukum West	72	Doti
8	Terhathum	21	Bara	34	Makwanpur	47	Gulmi	60	Salyan	73	Kailali
9	Sankhuwasabha	22	Parsa	35	Chitwan	48	Palpa	61	Surkhet	74	Kanchanpur
10	Bhojpur	23	Sindhuli	36	Gorkha	49	Nawalparasi West	62	Dailekh	75	Dadeldhura
11	Solukhumbu	24	Ramechhap	37	Lamjung	50	Rupandehi	63	Jajarkot	76	Baitadi
12	Okhaldhunga	25	Dolakha	38	Tanahu	51	Kapilbastu	64	Dolpa	77	Darchaula
13	Khotang	26	Sindhupalchok	39	Syangja	52	Arghakhanchi	65	Jumla		

Figure 2 Proportion of Diarrhea by District

Map in figure 3 represents the categorization of the district based on morbidity due to diarrhea. Districts with 95% confidence intervals above the mean are categorized as having a higher than average value (darkest shade), while

districts with 95% confidence intervals below the mean are categorized as having a lower than average coverage value (lightest shade) and districts with confidence intervals not evidently different from the mean are categorized as average coverage value (intermediate shade).

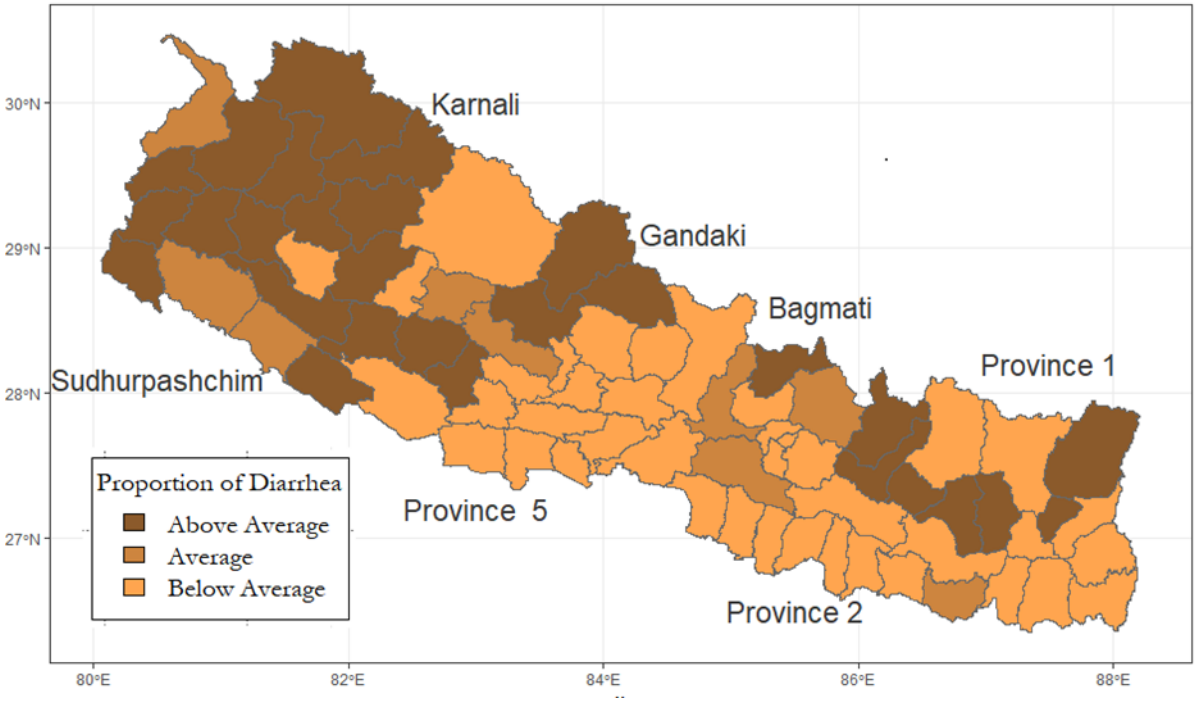
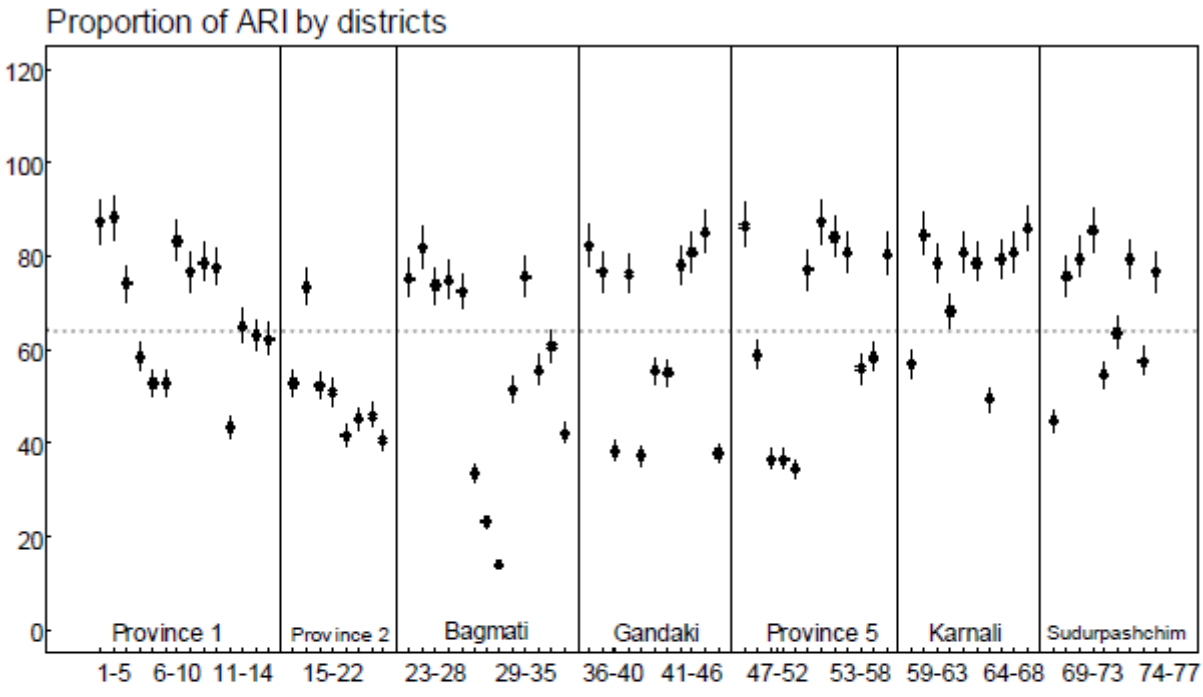


Figure 3 Map of Nepal with proportion of Diarrhea

Figure 4, shows 95% confidence intervals for proportion of ARI by districts. Districts with 95% confidence intervals above the mean are categorized as having a higher than average value, while districts with 95% confidence intervals below the mean are categorized as having a lower than average value and districts with confidence intervals not evidently different from the mean are categorized as average. About 38 districts were categorized as having a higher than average proportion, six districts were categorized as average and 33 districts were categorized as having a lower than average value. In between 2015 to 2018, the proportion of ARI was highest in most of the districts of Province 1 and Karnali province.



id	District	id	District	id	District	id	District	id	District	id	District
1	Taplejung	14	Udayapur	27	Kavre	40	Kaski	53	Pyuthan	66	Kalikot
2	Panchthar	15	Saptari	28	Lalitpur	41	Manang	54	Rolpa	67	Mugu
3	Ilam	16	Siraha	29	Bhaktapur	42	Mustang	55	Rukum East	68	Humla
4	Jhapa	17	Dhanusa	30	Kathmandu	43	Myagdi	56	Dang	69	Bajura
5	Morang	18	Mahottari	31	Nuwakot	44	Parbat	57	Banke	70	Bajhang
6	Sunsari	19	Sarlahi	32	Rasuwa	45	Baglung	58	Bardiya	71	Achham
7	Dhankuta	20	Rautahat	33	Dhading	46	Nawalparasi East	59	Rukum West	72	Doti
8	Terhathum	21	Bara	34	Makwanpur	47	Gulmi	60	Salyan	73	Kailali
9	Sankhuwasabha	22	Parsa	35	Chitwan	48	Palpa	61	Surkhet	74	Kanchanpur
10	Bhojpur	23	Sindhuli	36	Gorkha	49	Nawalparasi West	62	Dailekh	75	Dadeldhura
11	Solukhumbu	24	Ramechhap	37	Lamjung	50	Rupandehi	63	Jajarkot	76	Baitadi
12	Okhaldhunga	25	Dolakha	38	Tanahu	51	Kapilbastu	64	Dolpa	77	Darchaula
13	Khotang	26	Sindhupalchok	39	Syangja	52	Arghakhanchi	65	Jumla		

Figure 4 Proportion of ARI by district

Map in figure 5 represents the categorization of the district based on morbidity of ARI. Districts with 95% confidence intervals above the mean are categorized as having a higher than average coverage value (darkest shade), while districts with 95% confidence intervals below the mean are categorized as having a lower than average coverage value (lightest shade) and districts with confidence intervals not evidently different from the mean are categorized as average coverage value (intermediate shade).

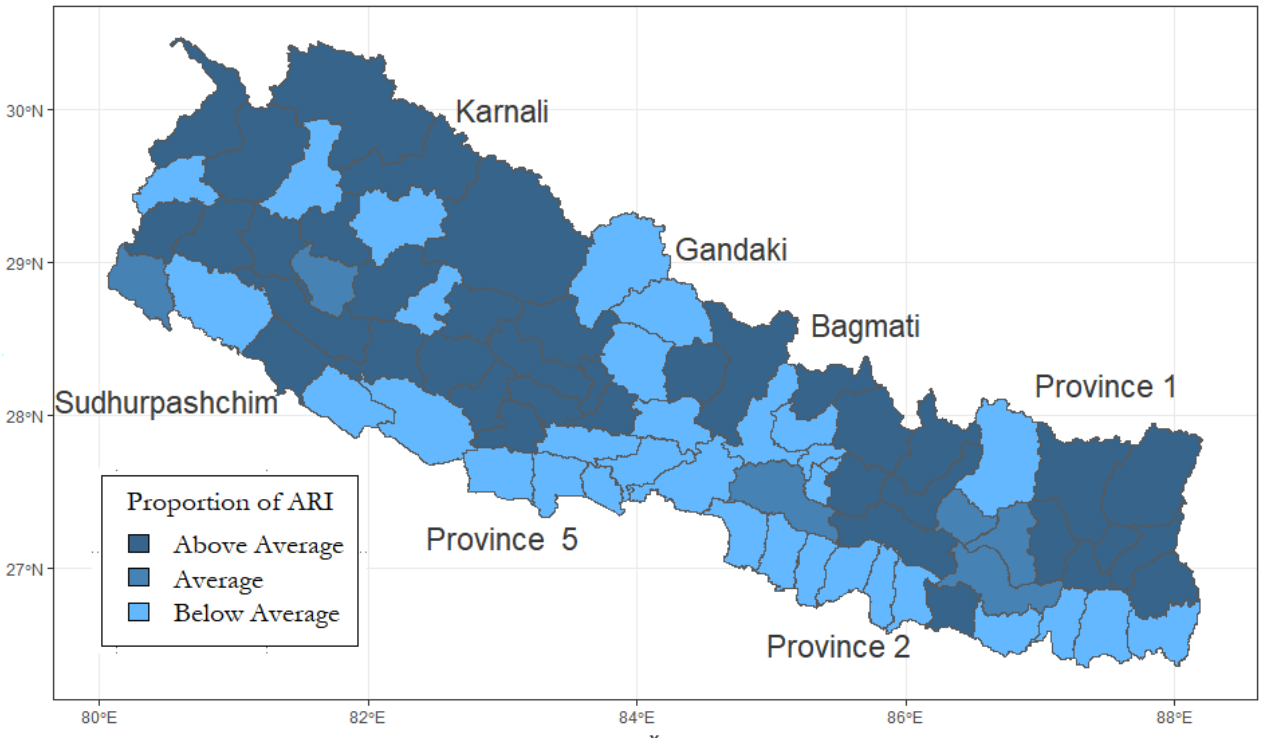


Figure 5 Map of Nepal with proportion of ARI

Determinants of Diarrhea Morbidity

Table 2 shows the findings of the multiple linear regression of determinants of diarrhea morbidity. A multiple linear regression was carried out to find the association between geographical and administrative factors, socio demographic factors, development and economic indicators with diarrhea. The result of regression indicated that the model explained 68% of variance and that the model was a significant predicator of diarrhoea, F (15,292) =36.3, p-value<0.0001. The Province, female literacy rate, number of children, poverty gap, malnutrition and LBW contributed significantly in diarrhea(p value<0.05). Compared to Province 1, Province 2, Bagmati Province, Gandaki Province and Province 5 have low proportion of diarrhea by 21%, 8%, 6% and 8% respectively. However, both Karnali and Sudurpaschim Province had high proportion of diarrhea ie.11% and 9% respectively. Similarly, for one unit increase in the female literacy rate the proportion of diarrhea decreases by 0.5%. Likewise, for a one unit increase in the average number of children the proportion of diarrhea cases decreases by nearly 1%. On the contrary, for one unit increase in the poverty gap, malnutrition and LBW the proportion of diarrhea morbidity increase by 1.2%,1% and 1.1% respectively.

Table 2 Determinants of Diarrhea among under **five** year children of Nepal

Variables	Coeff	95% CI		P-value
		Lower	Upper	
Region(Ref=Mountain)				
Hill	4.285	-0.298	8.868	0.067
Terai	-1.487	-7.512	4.537	0.627
Region(Ref=Province 1)				
Province 2	-21.896	-30.325	-13.467	<0.001
Bagmati Province	-8.363	-13.137	-3.589	0.001
Gandaki Province	-6.299	-11.053	-1.545	0.010
Province 5	-8.092	-13.562	-2.622	0.004
Karnali Province	11.649	5.191	18.107	<0.001
Sudurpaschim Province	9.554	0.603	18.505	0.037
Male Literacy rate	0.229	-0.467	0.925	0.517
Female Literacy Rate	-0.515	-1.126	-0.096	0.009
Number of children	-1.157	-1.899	-3.415	0.002
Human Development Index	-0.695	-1.446	0.055	0.069
Poverty Gap	1.224	0.469	1.978	0.002
Malnutrition	0.931	0.625	1.236	<0.001
Low birth weight	1.167	0.741	1.592	<0.001

Adjusted R square=0.68, F-statistic: 36.3 on 15 and 292 DF, p-value: < 0.0000001

Determinants of ARI Morbidity

Table 3 displays the findings of multiple linear regression of determinants of ARI morbidity. The model predicts 56% of the variance and that the model was a significant predicator of ARI, F (16,291) =22.32, p-value <0.0000001. The ecological region, province, HDI, poverty gap, malnutrition, LBW and proportion of diarrhea contributed significantly in ARI disease (p value<0.05). Compared to the districts in the mountain region, the districts in the terai region had 13.2% low proportion of ARI morbidity. The districts of Bagmati Province had 5.8% of low proportion of ARI compared to the districts of Province 1. With one unit increase in HDI, the ARI cases decreases by 2.6%. Likewise, a unit change in the poverty gap result in decrease of the proportion of ARI by almost 1%. However, the proportion of ARI cases decrease by 0.5% with a unit change in malnutrition. Furthermore, the proportion of ARI cases increases by 0.6% and 0.5% with one unit increase in LBWand proportion of diarrhea respectively.

Table 3 Determinants of ARI among under **five** year children of Nepal

Variables	Coeff	95% CI		P-value
		Lower	Upper	
Region(Ref=Mountain)				
Hill	-3.103	-8.333	2.128	0.244
Terai	-13.268	-20.107	-6.429	<0.001
Region(Ref=Province 1)				
Province 2	-3.069	-13.053	6.915	0.546
Bagmati Province	-5.864	-11.391	-0.337	0.038
Gandaki Province	-0.465	-5.922	4.993	0.867
Province 5	-4.724	-11.021	1.572	0.141
Karnali Province	-6.519	-14.004	0.966	0.088
Sudurpaschim Province	-8.863	-19.097	1.371	0.089
Male Literacy rate	0.247	-0.543	1.037	0.539
Female Literacy Rate	0.588	-0.108	1.285	0.098
Number of children	-1.225	-7.849	5.400	0.716
Human Development Index	-2.666	-3.522	-1.809	<0.001
Poverty Gap	-0.940	-1.811	-0.069	0.034
Malnutrition	-0.590	-0.958	-0.223	0.002
Low birth weight	0.636	0.130	1.142	0.014
Proportion of diarrhea	0.481	0.351	0.612	<0.001

Adjusted R square=0.56, F-statistic: 22.32 on 16 and 291 DF, p-value: < 0.0000001

DISCUSSION

This retrospective analysis aimed to identify the determinants of morbidity of diarrhea and ARI linking HMIS data with characteristics of the district like literacy rates, HDI, poverty gap, malnutrition, LBW, year, province and ecological region. The study found that nearly half of the children had diarrhea and more than one third of the children had ARI. In Nepal, diarrhea and ARI are among the top ten leading cause of disease mortality and mobility among children.[5, 6] However, this study revealed that both diarrhea and ARI were found to be in decreasing trends in from 2015 to 2018. And this is possibly because of implementation of CB-IMCI program at community level which made significant impact in the health status of children. Studies had documented that as a result of CB-IMCI, Nepal made impressive progress in reducing under-five mortality in last ten years.[5,6] The nationwide implementation of CB-IMCI created an enabling environment for better control and treatment of children diarrhea and ARI. The CB-IMCI program, training of community level volunteers has enhanced the knowledge and skills in preventing and treating diarrhea and ARI cases at the community level.[4,5,8] Besides this, treatment or advice-seeking practices from the health facilities or providers for diarrhea, symptoms of ARI, and fever showed significant improvement in recent years.[5]

Childhood mortality was distributed unevenly in Nepal; diarrhea and ARI found to be higher among Karnali and Sudurpaschim compared to other provinces. In Nepal, disparities in public health interventions in the Karnali and Sudurpaschim compared to other provinces are evident.[6] Providing essential health services to these regions is difficult. In

these regions, geographic inaccessibility, low utilization of health services, traditional attitudes and practices, inequalities towards women and the lack of health knowledge are associated with high childhood morbidity.

ARI was comparatively lower in Terai compared to Mountain Region. This finding was supported by recent demographic health survey which revealed that children living in the Terai (flat land) had lower risk of ARI symptoms than those living in the Mountain area.[6]

This study has shown a significant association between female literacy rate and the number of children with diarrhea, which was consistent with several studies in developing countries.[10,14] The education level of the women plays a vital role in diarrhea occurrence among children in Nepal.[6,7] Women with a higher level of education have better knowledge on prevention; they enhance women's attitude and better treatment practice during childhood illness.[17] There was significant association between the number of children and diarrhea. Children in larger families are more vulnerable to diarrhea, which may be related to the quality of care and hygiene.[14]

HDI was associated with ARI, as the association between HDI and its dimension with the health of communities has been confirmed.[21,22] In societies with low HDI, insufficient socioeconomic support is interrelated to a variety of adverse health outcomes including childhood morbidity and mortality.[21,29]

Poverty gap has a significant association with both diarrhea and ARI among the children. Numerous studies support the link between poverty and child health.[6,7,30] The children from poor families have inadequate access to health services compared to children from rich families. The inequality and inequity in health services demonstrate a significant impact on the health status of the child. The poor are more likely to suffer and exhibit higher morbidities.[31] Similar findings are supported by studies that explain the better affordability of nourishment and health care for the children in wealthier families.[6,10] Poor are likely to be living in unsanitary environment with increased exposure to the infectious agent. Furthermore, the poor families often have more children and live in crowded houses, which is conducive for disease transmission.[32]

The findings revealed that with increase in malnutrition cases both diarrhea and ARI cases increase. Studies have shown an increased likelihood of acquiring diarrhea among malnourished children.[10,33] The children with malnutrition experience more severe diarrhea that lasts for longer period, which also adds to the higher risk of mortality from diarrhea in developing countries.[34] This might be because malnutrition predisposes the immune system, which increases the risk of infections. Malnourished children often come from poor families.[32] The burden of childhood illness is often higher in resource poor setting, as poor living conditions with unhygienic practices aggravate the probabilities of disease transmission.[33] Although this study shows the negative correlation between ARI and malnutrition, this should be presented with caution as numerous studies have shown greater risk of ARI related with malnutrition.[19,23]

LBW had shown a significant relationship with diarrhea and ARI. Similar findings were presented in other studies where the proportion of morbidities was higher among the LBW babies compared to normal weight babies.[18,35,36]

There were strong comorbidities of diarrhea and ARI in our study. Studies showed that the occurrence of diarrhea leads to susceptibility of pneumonia in malnourished children [24,25,30] and malnourished children were higher susceptibility of developing diarrhea,

thereby creating a vicious cycle.[25] Diarrhea increases the likelihood of ARI[25] by causing significant loss of micronutrient and dehydration, and it weakens the immune system therefore predisposing the child to a substantial risk of infection. Comorbidity of diarrhea and ARI can either be simultaneous (both occurring at the same time) or sequential (where the occurrence of one leads to the occurrence of the other).[30] A study found that out that diarrhea and ARI in children under **five** years was present as simultaneous comorbidity and the relationship became stronger with the severity of the disease.[37]

The study findings suggest that interventions aiming to reduce the burden of ARI and diarrhea should consider context-specific and integrated interventions in both the community and health facility. The experience in Nepal has shown that community members with minimal prior education can be trained and engaged in their own communities to scale up safe and effective interventions. Engaging community members to implement strategies to manage cases of diarrhea and ARI, along with improved nutrition and immunization coverage, guide to the combat the burden of childhood illness.[38]

The study had few limitations in our study. It was based on secondary data; therefore, we could not include some risk factors for disease, such as breastfeeding, overcrowding, water and sanitation due to unavailability of the data.

CONCLUSION AND RECOMMENDATIONS

Diarrhea and ARI continue to contribute a high disease burden among under-five children in Nepal, however the disease is found to be in decreasing trends. The highest burden of disease was found in Karnali and Sudurpaschim provinces. From this study, mother education and number of children were found to be associated with diarrhea; HDI and comorbidity of diarrhea were associated with ARI and poverty gap and malnutrition and LBW were associated with both diarrhea and ARI. It is recommend that implementation of programs aimed at reducing combined diarrhea and ARI in children under **five** years should focus on addressing socioeconomic barriers that limit caregivers' access to wealth and education.

ACKNOWLEDGEMENTS

We would like to express our gratitude to the Department of Health Services, Ministry of Health and Population for permission to use their data. We are indebted to Sherry B. Olson for the English language review. The authors have no conflict of interests to declare

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