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Original Research

ASSESSMENT OF RISK FACTORS ASSOCIATED WITH ACUTE RESPIRATORY INFECTIONS (ARIS) AMONG CHILDREN UNDER 5 YEARS OF AGE, PAKISTAN

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ABSTRACT

Introduction: Acute respiratory infections account for approximately 6% of the total global burden of disease; almost double the proportion compared with the other communicable diseases. **Aims:** To investigate the link between risk factors & ARIs in Pakistani pediatric population under 5 with different socio-demographic profiles. **Methods:** Research was conducted as a cross-sectional study, utilizing the Pakistan DHS 2017-18 data, after ethical approval for the utilization of the dataset. Study variables were defined as age and gender of the child, place of residence, maternal education, wealth index, breastfeeding, and the immunization status of the child. Sample size (n = 39,799) was determined as per the inclusion and exclusion criteria. Prevalence of ARIs was estimated and the association between ARIs and socio-demographic factor and child's immunization was examined. **Results:** Out of 39,799 children, 51.6% were males, 21.0 % were aged 36 – 47 months, 73.7% were the rural residents, 23% belonged to lowest wealth index quintiles. The mothers of 43.7% children were illiterate and 55.7% of the children were breastfed. ARIs proportion among the sample was 14.3%. Significant association was observed between ARIs and age (p=0.000), gender of the child (p=0.001), residence (p=0.000), economic deprivation (p=0.000), maternal education (p=0.000) and breastfeeding (p=0.000), vitamin A administration (p=0.021), BCG (p=0.008), pentavalent (p=0.008), measles (p=0.000), and pneumococcal vaccination (p=0.020). **Conclusion:** Socio-demographic characteristics, i.e., age and gender of the child, accommodation, economic deprivation, maternal education, breast-feeding and poor vaccination uptake were observed to be positively correlated with ARIs among children under 5 years of age in Pakistan.

Keywords: Acute respiratory infections (ARIs); Risk factors; Wealth index; Economic deprivation; Expanded Programme of Immunization (EPI)

INTRODUCTION

Acute respiratory infections (ARIs), as upper or lower respiratory tract infections, secondary to a viral or bacterial etiology, are comprised of a vast spectrum of clinical manifestations, varying from ordinary flu/cold to pharyngitis, laryngitis, tracheitis, pneumonia, and bronchopneumonia, or a fatal outcome such as respiratory failure and successive death (Liu et al., 2014).

Approximately one-third of the ARIs among the pediatric population has a viral origin; rhinovirus, flu virus, respiratory syncytial virus (RSV) and adenovirus act as the main infectious agents (Doan et al., 2014; Meskill and O'Bryant, 2020). Coronavirus accounts for only 10% of respiratory infections among the children (Mameli et al., 2022).

Approximately 6% of the disease burden worldwide is secondary to ARIs; almost double the percentage in comparison to the burden of other communicable diseases. e.g., diarrhea (3.8%), malaria (2.5%) or human immunodeficiency virus (HIV) infection (2.2%) (Our World in Data, 2021).

Globally, ARIs remain a crucial health challenge; the cardinal cause of not only mortalities but morbidities among children under 5 years of age. As an ARI, pneumonia is a prime under-five pediatric killer. Pneumonia leads to fourteen percent of all the casualties among the children aged less than 60 months, universally (World Health Organization, 2021).

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ARIs were reported as the most baleful group of communicable diseases in 2019 and were ranked as the 4th major cause of death worldwide. However, the burden of these infections disproportionately affects the residents of the low and low-middle income countries (LMIC's), specifically South Asia and Sub-Saharan Africa. Among the LMICs the morbidity burden of ARIs ranges from 22% to 40% (Shi et al., 2017). In accordance with the Global Burden of Disease study, 2017, mortality rate secondary to ARIs was 100 deaths per million European population juxtaposed to 1000 deaths per million population in LMICs (Global Burden of Disease, 2017). Various factors have been postulated to increase the likelihood of respiratory infections among children. These factors may differ significantly in developed countries and LMICs, depending upon the availability and access to the healthcare services, nutritional status of the high-risk population and quality of the living conditions.

Of the other demographic risk factors, age is reviewed as a strong predictor of ARIs. Although any age group is susceptible, the most vulnerable are children less than 12 months of age, owing to their weak immune system (Caballero et al., 2019). Ninety-nine percent of the global infants' mortalities occur in low-middle income countries and about one-third of these deaths are attributable to acute respiratory infections, particularly pneumonia (Solomon et al., 2018).

The skewness of pediatric pneumonia is strongly linked to the quality of life and financial stability of a community, as economic deprivation is reported as one of the most robust factors for pneumonia associated burden of disease (Nirmolia et al., 2018).

Literature has also highlighted the crucial role of maternal age, family size and maternal formal education, in the background of the thrust of ARIs in a society (Merera, 2021; Gebrerufael and Hagos, 2023). Moreover, risk factors such as premature birth, low birth weight, non-exclusive breastfeeding during the first six months of life, poor weaning and under-nutrition have been observed to increase the incidence of ARIs in children, aged between 2 months to 5 years (Arpitha et al., 2014; Ullah et al., 2019).

High rates of acute respiratory infections have also been observed among children with incomplete immunization status, as per the Expanded Programme of Immunization (EPI) schedule (Jackson et al., 2013). Further, environmental factors, e.g., polluted indoor environment, also increase the risk of ARIs among the vulnerable pediatric population under five years of age (Kamal et al., 2015).

An investigation of the risk factors associated with acute respiratory infections among Pakistani children, with varying socio-demographic and immunization profiles, under five years of age was conducted in this study.

METHODS

The research opted for a cross-sectional study protocol. The study utilized the Pakistan 2017-18 Demography & Health Survey (PDHS) data. A written ethical approval for the utilization of this PDHS data was taken from the DHS program prior to commencement of the study (DHS authorization ref # 164128).

The Pakistan Demography & Health Survey 2017-18 was conducted by Pakistan Institute of Population studies with the objective of assessment of basic demographics and health and nutrition indicators of the Pakistani population. A list of enumeration blocks (EBs), based on the Pakistan Population and Housing Census 2017 was used as sampling frame for the PDHS 2017-18. Data were collected between Nov 2017 - Apr 2018, from four provinces, i.e., Punjab, Sindh, Khyber Pakhtunkhwa, Baluchistan and four regions, i.e., Azad Jammu and Kashmir, Gilgit Baltistan, Islamabad capital territory, and Federally Administered Tribal Areas (FATA), of Pakistan.

Two-staged stratified sampling design was used. Firstly, the four provinces and four regions were ordered into urban and rural areas (total 16 strata). From each stratum, clusters were chosen via the probability sampling technique. A total 580 clusters were selected, out of which 19 were excluded secondary to the security risks. From the remaining 561 clusters, a specified number of 28 households per cluster (total 16240 households) were selected via systematic random sampling.

The selected households were surveyed using six different questionnaires: Household's, Woman's, Man's, Fieldworker, Biomarker, and the Community Questionnaire. Sections related to childhood immunization, breast feeding practices and childhood illnesses were included in the woman's questionnaire.

In PDHS 2017-18 dataset, a sample (n = 42,408) from mothers with children aged less than five years was available; however, for the current analysis cases were included and excluded depending upon the completeness of the information (related to ARIs diagnosis) provided by the mothers. Cases with incomplete/missing information were excluded from the data set to attain the final sample (n = 39,799).

The **dependent variable or outcome variable** was "acute respiratory infection" (as cough along with difficult breathing within the last two weeks of data collection) and taken as binominal, i.e., yes/no. **Independent variables** were selected, based on the evidence from literature and available PDHS 2017-18 data. These variables were divided into two groups, Group 1 was socio-demographic profile which included: age and gender of the child, place of residence (rural/ urban), maternal education, family's wealth index, and breastfeeding. Group 2 was about vitamin A administration and the immunization status of the child as per the EPI schedule.

Data were extracted, recoded, and analyzed using SPSS (statistical package for social sciences) version 27. For **descriptive epidemiology**, mean and standard deviation (S.D) were calculated for the numeric variables like age. For categorical variables, like the gender of the child, place of t== residence (rural/ urban), maternal education, family's wealth index, breastfeeding, vitamin A administration and the immunization status of the child, frequency and percentages were calculated and illustrated as frequency tables, bar charts and pie charts.

For **analytical epidemiology,** association of ARIs with individual factors (age, gender of the child), social factors (area of residence, maternal education, breast-feeding), economic factors (wealth index) and immunization of the child were investigated. For the binomial socio-demographic and immunization variables, the binary logistic regression test was applied as a test of significance (with a confidence interval of 95%). p-value ≤ 0.05 was considered significant. For multinomial variables, e.g., age categories, maternal education and wealth-index quintiles, multinomial logistic regression test were applied as a test of significance.

RESULTS

Children aged 0 to 59 months (n = 39,799) were selected for the study. Data about BCG, pentavalent, measles and pneumococcal vaccination were missing in 86.8 % (34,555) each, and about polio in 88.4% (35,174) of the children. Data were mainly missing for the children aged 36 - 59 months, rural regions, and mothers with no formal education.

The mean age of children (n = 39,799) was 30 months ± 18.4 S.D, 21.0 % (8322) were aged 36 - 47 months, the most of any age group, 51.6% (20523) were males, 73.7% (29,323) were the residents of the rural communities, and 23.8% (9483) children belonged to the poorest household. The mothers of the 43.7% (17,402) children were illiterate, and 55.7% (22,176) of the children were breastfed.

Within the last six months of the data collection vitamin A was administered to 61.2% of the children. From the available immunization data, only 82.5% (4327) and 87.1% (4027) of the children were vaccinated with BCG vaccine given at birth and OPV within the first two weeks of birth, respectively. Also, 73.2% (3839), 59.8% (3138) and 68.7% (3602) of the children had been vaccinated at-least once with pentavalent, measles and pneumococcal vaccine, respectively.

Within the last two weeks of the data collection, the proportion of ARIs among the children was 14.3% (5703). The prevalence of acute respiratory infections was highest among boys, i.e., 15% (3057) and the age group 0 to 11 months, i.e., 17.2% (1392). Also, ARIs were 1.5% more prevalent among the children of rural areas compared to the urban communities and among the children of illiterate mothers by 5.5% in contrast to the children whose mothers had a higher educational qualification, i.e., 15.6% vs 11.1%.

The prevalence of ARIs was observed to be highest (18.6%) among the poorest group, among the breastfed children (15.8%) and those who had received vitamin A drops (14.7%). Further, ARIs were more prevalent among the unvaccinated groups as compared to the vaccinated cohorts. Moreover, among the unvaccinated children, the percentage of respiratory infections was highest (17.8%) for those who were not vaccinated with BCG or measles vaccine.

ARIs were observed to be strongly linked to the age (p = 0.000) and gender (p = 0.001) of the child, risk was highest among the children 0 – 11 months of age (OR = 1.5, 95% CI 1.370 – 1.639) and male child (OR = 1.1, 95% CI 1.040 – 1.164). A significant association was also observed between acute respiratory tract infections and the rurality of the dwelling (p = 0.000), children from an urban residence were less likely to have respiratory infections compared to a rural community (OR = 0.88, 95% CI 0.827 – 0.942) (Table 1a).

Poverty (OR = 1.8, 95% CI 1.629 - 1.970) and maternal illiteracy (OR = 1.8, 95% CI 1.629 - 1.970) increased the likelihood of ARIs among the children less than five years of age and were observed as strong predictors for ARIs (p = 0.000) (Table 1a).

A significant relationship was also observed between ARIs and breastfeeding practices (p = 0.000), and vitamin A oral drops administration (p = 0.021), higher risk of ARIs among children who are not breastfed (OR = 1.3, 95% CI 1.235 – 1. 386) and to whom vitamin A was not administered (OR = 1.1, 95% CI 1.010 – 1.134) was observed (Table 1a).

Immunization with BCG (p = 0.008), pentavalent (p = 0.008), measles (p = 0.000), and pneumococcal vaccine (p = 0.02), was observed to be strongly linked to ARIs among children less than 60 months of age. Higher odds of ARIs among children who were not vaccinated with BCG (OR = 1.3, 95% CI 1.069 – 1.562), pentavalent (OR = 1.3, 95% CI 1.059 – 1.476), measles (OR = 1.4, 95% CI 1.237 – 1.678) and pneumococcal vaccine (OR = 1.2, 95% CI 1.030 – 1.419) was noted (Table 1b).

Table 1. Relationship between ARIs and socio-demographic factors

Variable		n (39,799)	ARIs (%)	Odds ratio (OR: 95% CI)	p-value
Age in Months	**0 – 11**	8110	17.2	1.5 (1.370 – 1.639)	**0.000***

Variable		**n (39,799)**	**ARIs (%)**	**Odds ratio (OR: 95% CI)**	**p-value**
	12 – 23	7824	16.1	1.4 (1.263 – 1.516)	
	24 – 35	7827	13.6	1.1 (1.038 – 1.253)	
	36 – 47	8322	12.6	1.04 (0.952 – 1.50)	
	48 – 59	7674	12.2	1.0	
Gender	**Female**	19276	13.7	1.0	**0.001***
	Male	20523	14.9	1.1 (1.040 – 1.164)	
Area of residence	**Rural**	29323	14.7	1.0	**0.000***
	Urban	10476	13.2	0.88 (0.827 – 0.942)	
Wealth index quintiles	**Poorest/ Lowest**	9483	18.6	1.8 (1.629 - 1.970)	**0.000***
	Second Lowest	8474	15.1	1.4 (1.265 – 1.544)	
	Middle	8310	13	1.2 (1.060 – 1.300)	
	Second Highest	7499	11.9	1.1 (0.948 – 1.171)	
	Richest/ Highest	6033	11.3	1.0	
Maternal Education	**Illiterate**	17402	15.6	1.5 (1.339 – 1.626)	**0.000***
	Primary	8039	15.3	1.4 (1.301 – 1.612)	
	Secondary	9358	12.9	1.2 (1.609 – 1.329)	
	Higher Education	5000	11.1	1.0	
Breastfed	**Yes**	22176	15.8	1.0	**0.000***
	No	17623	12.5	1.3 (1.235 – 1. 386)	
Vitamin A administration	**Yes**	24344	14.7	1.0	**0.021***
	No	15455	13.8	1.1 (1.010 – 1.134)	

*p < 0.05 was considered as significant

Table 2. Relationship between ARIs and immunization status of the child

Variable		n	ARIs (%)	Odds ratio (OR: 95% CI)	p-value
BCG (n = 5244)	**Yes**	4327	14.3	1.0	**0.008***
	No	917	17.8	1.3 (1.069 – 1.562)	
Oral Polio drops (OPV) (n = 4625)	**Yes**	4027	13.6	1.0	**0.349**
	No	598	15.1	1.1 (0.882 – 1.429),	
Pentavalent (n = 5244)	**Yes**	3839	14.1	1.0	**0.008***
	No	1405	17.1	1.3 (1.059 – 1.476)	
Measles (n = 5244)	**Yes**	3138	13.0	1.0	**0.000***
	No	2106	17.8	1.4 (1.237 – 1.678)	
Pneumococcal (n = 5244)	**Yes**	3602	14.2	1.0	**0.020***
	No	1642	16.6	1.2 (1.030 – 1.419)	

*p < 0.05 was considered as significant

DISCUSSION

Multiple risk factors have been linked with acute respiratory infections among children less than five years of age, globally. The study aimed to evaluate the interrelation of the risk factors with ARIs among children in Pakistan under 60 months of aged with varying socio-demographic profiles and immunization statuses, , utilizing the data from Pakistan Demography & Health survey, 2017-18.

As per analysis of the data, the prevalence of ARIs among children less than five years of age was 14.3%. However, very high (app. 55%) ARIs prevalence among children under five years of age was observed in a hospital0based cross-sectional study (n = 512) in Bamenda Cameroon (Tazinya et al., 2018). Also, in a community-based cross-sectional study in south India (n = 500), 27% ARIs prevalence rate was reported among children under five years of age (Sharma et al., 2013). Further, Bangladesh Demography and Health Surveys, 1997 – 2014 data analysis revealed 43% ARIs prevalence rate among children 0 to 59 months of age (Yaya and Bishwajit, 2019). The contrast in the ARIs proportion of the current study and literature could be secondary to the non-identical sampling frame and study settings.

The current study has highlighted a significant association of ARIs and age of the child. Opposite to the current analysis, DHS data, 2011-16, of 28 Sub-Saharan African countries revealed a directly proportional relationship between ARIs and age of the child; the risk of ARIs was almost one and half times higher among children aged 12 to 59 months in comparison to age group 0 to 11 months (Seidu et al., 2019). The greater risk of infections among the older children could be due to the exposure to smoky cooking fuel in the house or poor personal hygiene (Seidu et al., 2019).

Bangladesh DHS, 2014 data analysis showed a significant but inversely proportional association of respiratory infections and the chronological age of the child; the odds of ARIs among 0 to 11 months old children was 2.87 times higher juxtaposed to children 48 to 59 months of age (Imran et al., 2019).

The current study has revealed a significant link between acute respiratory infections and gender of the child. Similar findings were observed in a cross-sectional analysis of Bangladesh DHS data 2014 (n = 6566), i.e., the proportion of ARIs among boys was 1.6% more in comparison to the girls, also the boys were observed to have 1.25 times higher risk of ARIs compared to the girls of the same age group (Sultana et al., 2019). A cohort study, conducted in the urban slums of India, among children under 60 months of age (n =400) reflects the current analysis, i.e., a significant association between ARIs and gender of the child and has reported a 2.41 times higher risk of ARIs among the male child compared to their female counterparts (Ramani, 2016).

Further, a hospital-based cross-sectional study in Pakistan among children less than 24 months of age (n = 200) revealed twice a high prevalence rate of acute respiratory infections among boys compared to girls, i.e., 65% vs 35% (Musa et al., 2016). The high proportion of ARIs among boys could be due to high susceptibility secondary to genetics or the result of gender-based discrimination in reporting of the ailment by the caretakers.

Rurality of the dwelling turned out as a strong predictor for acute respiratory infections in the recent study. Ethiopia Demography and Health Survey, 2011 data analysis showed parallel observations. i.e., inordinate rate of ARIs among rural communities versus urban. i.e., 91% vs 9% (Astale and Chenault, 2015). Moreover, an analysis of the "Iraqi multiple indicator cluster survey" also mirrored the urban-rural difference in ARIs distribution (OR = 0.99) in the current study (Siziya et al., 2009).

The study revealed a strong relationship between maternal education and ARIs among children. An epidemiological study conducted in rural Northern Bangladesh has indicated maternal formal education as an independent factor of a child's health outcome, as it not only affects the healthcare knowledge (e.g., screening/ immunization schedules, nutritional requirement and guidelines) but also the health seeking attitude and practice of a mother (Ullah et al., 2019). Also, in a case-control study in India, the risk for ARIs was observed to be approximately three times higher among the children of uneducated mothers in comparison to the literate mothers (Kaware et al., 2017)

ARIs risk among non-breastfed is reported to be 107% higher in comparison to exclusively breastfed infants (Lamberti et al., 2013). In the current study a significant association was observed between breastfeeding and ARIs among the study population. Evidence from literature shows a similar fact, i.e., the risk of ARIs among children who are not breastfed is 1 - 3 times higher in comparison to those who are breastfed (Savitha and Gopalakrishnan, 2018).

This study highlighted economic deprivation as a determinant for respiratory infections among pediatric population. This observation mirrors an epidemiological study highlighting higher risk (OR = 1.27) of ARIs among the most economically deprived households compared to those at the top of the economic ladder (Harerimana et al., 2016). Analysis of the Nigeria Demography and Health Survey, 2013 dataset also indicated a significant link between poverty and ARIs; children from the lowest wealth index quintile have 1.42 times more risk of ARIs in comparison to the highest quintile (Adesanya and Chiao, 2017). Sonego et al.

(2015) conducted a meta-analysis and stated that economic stability of a household impacts health outcomes among children directly or indirectly via quality of housing, undernutrition, and lacking healthcare access.

The current study revealed a statistically significant link between vitamin A administration and acute respiratory infections among children less than 60 months of age. However, a neutral observation, i.e., vitamin A supplementation has no impact on ARIs distribution among children under five years of age, has been reported in a meta-analysis of 47 studies (Imdad et al., 2022).

Evidence-based literature supports a robust relationship between acute respiratory infections and vaccination profile of children under five years of age: the non-immunized cohort showed higher risk of ARIs. A statistically significant association was observed between respiratory infections and BCG vaccination, in the current analysis. Indicating the similar fact as the current study, a retrospective cohort study in , Norway has highlighted disproportionately high TB rates among unvaccinated study groups, i.e., 3.3 per million person-years vs 1.3 per million person-years of vaccinated individuals (Nguipdop-Djomo et al., 2016). BCG vaccination could lead to risk reduction of acute respiratory infections by 17% to 37% (Hollm-Delgado et al., 2014).

High prevalence of ARIs was observed among children not vaccinated with pentavalent vaccine, in the current analysis. Neutral relationship between respiratory infections rates and immunization status of the children less than five years of age has been reported in literature (Rahmadiena et al., 2021).

LRIs, particularly pneumonia, is the most frequent complication of measles among children less than five years of age. A directly proportional relationship was observed between measles vaccination and respiratory infections in this study. Analysis of Pakistan, India, Ethiopia, Republic of Congo, and Nigeria DHS has highlighted the shielding effect of measles immunization against ARIs; it reduces the susceptibility of respiratory infections among measles immunized children as compared to unimmunized groups in all the counties (except Nigeria) (Bawankule et al., 2017).

The most encountered community-acquired pneumonia among children less than five years of age is attributable to *Streptococcus pneumoniae infection*. Pneumococcal immunization and ARIs are significantly associated, according to recent research. Literature also suggests results reflective of the current study, i.e., pneumococcal vaccine has a protective effect against ARIs among the pediatric population (Fathima et al., 2018).

CONCLUSION

The study examined several risk factors associated with acute respiratory infections (ARIs) among Pakistani children under five years of age with different socio-demographic profiles and immunization statuses. A significant association ($p < 0.05$) of ARIs was observed with the age and male gender of the child, rural dwelling, low maternal qualification level, and a low household wealth index. Also, ARIs among the study population were observed to be strongly linked to poor vitamin A, BCG, polio, pentavalent, measles and pneumococcal vaccine uptake.

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