Tesema et al. BMC Public Health (2022) 22:2013
https://doi.org/10.1186/s12889-022-14421-0

BMC Public Health

RESEARCH

Open Access

Understanding the rural–urban disparity in acute respiratory infection symptoms among under-five children in Sub-Saharan Africa: a multivariate decomposition analysis

Getayeneh Antehunegn Tesema[1*], Misganaw Gebrie Worku[2], Tesfa Sewunet Alamneh[1], Achamyeleh Birhanu Teshale[1], Yigizie Yeshaw[1,3], Adugnaw Zeleke Alem[1], Hiwotie Getaneh Ayalew[4], Alemneh Mekuriaw Liyew[1] and Zemenu Tadesse Tessema[1]

Abstract

Background: Acute Respiratory Infections (ARIs) account for more than 6% of the worldwide disease burden in children under the age of five, with the majority occurring in Sub-Saharan Africa. Rural children are more vulnerable to and disproportionately affected by ARIs. As a result, we examined the rural–urban disparity in the prevalence of ARI symptoms and associated factors among children under the age of five in Sub-Saharan Africa.

Methods: We used the most recent Demographic and Health Survey (DHS) data from 36 countries in Sub-Saharan Africa. The study included 199,130 weighted samples in total. To identify variables associated with ARIs symptoms, a multilevel binary logistic regression model was fitted. The Adjusted Odds Ratio (AOR) with a 95% CI was used to determine the statistical significance and strength of the association. To explain the rural–urban disparity in ARI prevalence, a logit-based multivariate decomposition analysis was used.

Results: Being female, ever breastfeeding, belonging to a poorer, better wealth status, and having better maternal educational status were significantly associated with lower odds of ARIs among under-five children. Whereas, small size or large size at birth, not taking vitamin A supplementation, being severely underweight, having diarrhea, didn't have media exposure, never had the vaccination, being aged 36–47 months, and being aged 48–59 months were significantly associated with higher odds of ARIs among under-five children. The multivariate decomposition analysis revealed that the difference in characteristics (endowment) across residences explained 64.7% of the overall rural–urban difference in the prevalence of ARIs, while the difference in the effect of characteristics (change in coefficient) explained 35.3%.

Conclusion: This study found that rural children were highly affected by ARIs in SSA. To reduce the excess ARIs in rural children, public health interventions aimed at impoverished households, home births, and unvaccinated and malnourished children are crucial.

*Correspondence: getayenehantehunegn@gmail.com

[1] Department of Epidemiology and Biostatistics, Institute of Public Health, College of Medicine and Health Sciences and Comprehensive Specialized Hospital, University of Gondar, Gondar, Ethiopia
Full list of author information is available at the end of the article

© The Author(s) 2022. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/. The Creative Commons Public Domain Dedication waiver (http://creativecommons.org/publicdomain/zero/1.0/) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Keywords: Acute respiratory infection symptoms, Under-five children, Sub-Saharan Africa

Background

Acute Respiratory Infections (ARIs) are a group of diseases caused by a wide range of pathogens such as Streptococcus pneumonia, Haemophilus influenza, Staphylococcus aureus, etc. [1]. ARIs are the major cause of illness and mortality in children under the age of five [2, 3]. They account for 6% of the global disease burden, which is greater than the burden of diarrheal illnesses and malaria combined [4–6]. Globally, ARIs are responsible for 12 million morbidities and 1.3 million fatalities in children under the age of five [7, 8], with three-fourths occurring in Sub-Saharan Africa (SSA) [9–18]. ARIs are responsible for the huge burden of infant and under-five mortality in rural areas [19].

According to studies, ARIs in children under the age of five are directly related to the population's environmental, cultural, and socioeconomic variables [20–23]. The prevalence of ARIs varied by residence, according to research undertaken in various Sub-Saharan African countries [24, 25], with rural households being the most afflicted due to the majority of people in rural areas relying predominantly on biomass for home energy [26]. Previous research found that maternal age, maternal education, place of delivery, Antenatal Care (ANC) visits, vitamin A supplementation, diarrhoea history, maternal age, household wealth status, child nutritional status, and other maternal-related factors have all been associated with ARIs symptoms in children under the age of five [22, 25, 27, 28].

Even though tremendous success in decreasing under-five mortality, there is significant variation among residents due to differences in susceptibility to common infectious diseases such as ARIs [29–31]. Even though various local studies on the prevalence and factors associated with ARIs among children under the age of five have been conducted in Sub-Saharan African countries [25, 32, 33], there is limited evidence on the rural–urban difference and factors that contributed to the change in ARIs across the residence. As a result, it's critical to investigate rural–urban disparity in ARIs among under-five children in SSA using multivariate decomposition analysis.

Methods

Data source and sampling procedure

This study used the Demographic and Health Surveys (DHSs) data of 36 sub-Saharan African countries conducted from 2005 to 2019, which was conducted using nationally representative samples to estimate core demographic and health indicators of the whole country. To recruit the samples, a multistage stratified cluster sampling technique was used, with Enumeration Areas (EAs) serving as primary sampling units and households serving as secondary sampling units [34]. The Kids Record dataset (KR file) was used for this study after we obtained an authorization letter from the measure DHS program for data access.

Measurement of variables

Dependent variable

The outcome variable was ARI symptoms among under-five children. The presence of ARIs is defined as children having a history of cough within two weeks accompanied by short, rapid breathing or difficulty of breathing and fever within two weeks preceding the survey. In DHS, mothers of under-five children were asked whether their children had a history of cough within two weeks preceding the survey. For children who had a cough, the mother was asked whether the child's cough was accompanied by short, rapid breathing or difficulty of breathing and fever within two weeks preceding the survey. It was obtained from the question "did he/she breathe faster than usual with short, rapid breaths or have difficulty breathing in the 2 weeks preceding the survey?". Then categorized as "Yes" if a child meets all the above-mentioned criteria and "No" otherwise [35].

Independent variables

The independent variables were categorized into child characteristics, mother characteristics, household characteristics, and contextual factors. Child characteristics include child age, sex of the child, breastfeeding, vitamin A supplementation, diarrhea in the last two weeks, ever had vaccinated, type of birth, child size at birth, and child nutritional status (stunting, wasting, and underweight); mothers-related characteristics include maternal age, media exposure, and maternal education, and household characteristics and contextual characteristics include household wealth status, residence, and country.

To assess a child's nutritional status DHS used anthropometric measures (height, age, and weight), height for age measures stunting, weight for height measured wasting, and weight for age measured for underweight. Stunting is defined as the height for age z-score less than 2 standard deviations below the median of the reference population, wasting is defined as the weight for height z-score less than 2 standard deviations below the median of the reference population, and underweight is defined as weight for age z-score less than 2 standard deviations below the median of reference population [36].

Data analysis

To adjust for the non-response and sampling design, the data were weighted using the primary sampling unit, strata, and weighting variable. STATA version 16 statistical software was used for analysis. Since the DHS data has a hierarchical nature, under-five children within the same cluster might share similar characteristics to children from different clusters. This could violate the assumptions of the traditional logistic regression model; these are the independence of observations and equal variance assumptions. Therefore, a multilevel binary logistic regression model was fitted to identify factors associated with ARIs using EAs as a random variable. The presence of the clustering effect was assessed using the Intra-class Correlation Coefficient (ICC) and Likelihood Ratio (LR) test. ICC quantifies the degree of heterogeneity of ARIs between clusters (the proportion of the total observed individual-level variation in ARIs that is attributable to cluster variations)

$$\text{ICC} = \sigma^2 / \left(\sigma^2 + \pi 2/3 \right),$$

Six models were fitted and model comparison was made using deviance as the models were nested models. Null model (empty model), Model I (residence), Model II (Model I + child characteristics), Model III (Model II + mothers characteristics), Model IV (Model III + household characteristics), Model V (Model IV + country-level characteristics (sub-Saharan African region)) were fitted and a model with lowest deviance value was chosen as the best-fitted model for the data. We identified the independent variables based on previous literature conducted on determinants of ARIs. Variables with a p-value less than 0.2 in the bi-variable analysis were considered for multivariable analysis. The Adjusted Odds Ratio (AOR) with a 95% Confidence Interval (CI) and p-value < 0.05 in the multivariable model were used to declare significant determinants of ARIs.

Logit-based Multivariate Decomposition analysis was used to identify factors that contributed to the rural–urban difference in ARIs. The analysis was based on the logit link function which uses the output from the binary logistic regression model by dividing the difference in ARIs among under-five children into components. The overall rural–urban difference in the prevalence of ARIs among under-five children can be explained by the difference in composition between residences (i.e., differences in characteristics or endowment) and/or the difference in effects of the explanatory variables across residences (i.e., differences in coefficients). The mvdcmp STATA command was used to generate the overall and detailed multivariate decomposition analysis results [37]. Variables with a p-value < 0.2 in the bi-variable Logit-based multivariate decomposition analysis were considered for the multivariable Logit-based multivariate decomposition analysis. Finally, p-value < 0.05 and the corresponding coefficient (B) with a 95% confidence interval were used to declare significant factors that contributed to the rural–urban difference in ARIs.

Ethical consideration

There was no need for ethical clearance as the researcher did not interact with respondents. The data used was obtained from the MEASURE DHS Program, and permission for data access was obtained from the measure DHS program through an online request from http://www.dhsprogram.com. The data used for this study were publicly available with no personal identifier. For details about the ethical considerations of the DHS, the program sees https://dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm.

Results

Background characteristics of respondents

The study included 199,130 children under the age of five. Around 135,832 (68.2%) of the under-fives were from rural areas. Nearly half (48.7%) of under-five children were of average birth weight, and about 96,264 (48.3%) were born to mothers aged 15–24 years (Table 1). Males composed more than half of under-five children in both rural (50.4%) and urban (50.31%) areas. About 19.47% of urban and 43.41% of rural under-five children were born to mothers with no formal education (Table 2).

Prevalence of ARIs across characteristics

In SSA, the overall prevalence of ARIs among children under the age of five was 8.6% (95% CI: 8.5%, 8.7%). The prevalence was 9.1% in rural areas and 7.5% in urban areas, respectively. ARIs were found in 9.7% of children aged less than 12 months and 10% of children aged 12 to 23 months. The chi-square test for the association of ARIs and independent variables showed a statistically significant association between residence, child sex, child age, child size at birth, maternal age, maternal education, stunting, underweight, wasting, media exposure, household wealth status, vitamin A supplementation, ever breastfeeding, ever had the vaccination had diarrhea in the last two weeks, and ARIs (p-value < 0.05) (Table 2).

Factors associated with ARIs

Model V was chosen since it had the lowest deviance value. Residence, sex of the child, age of the child, size of child at birth, underweight, wasting, breastfeeding status,

Table 1 Distributions of acute respiratory infection symptoms across residence in sub-Saharan African countries ($n = 199{,}330$)

Countries	Study year	Number of under five children	Prevalence of ARI (95% CI) Urban	Prevalence of ARI (95% CI) Rural
Angola	2015	12,528	3.3 (2.9, 3.7)	3.4 [2.9, 3.9]
Burkina Faso	2010	1407	18.9 [15.2, 23.2]	19.2 [16.9, 21.7]
Benin	2018	12,570	2.3 [1.9, 2.8]	3.2 [2.9, 3.7]
Burundi	2016/17	12,774	4.1 [3.1, 5.4]	7.4 [6.9, 7.9]
Dr Congo	2013/2014	5257	16.6 [15.0, 18.3]	24.4 [23.0, 25.9]
Congo	2011/2012	2129	16.5 [14.7, 18.6]	20.1 [17.4, 23.2]
Cote di vaire	2011/2012	1451	16.4 [13.6, 19.6]	17.2 [14.8, 19.9]
Cameroon	2011	3835	12.6 [11.2, 14.2]	17.3 [15.9, 19.1]
Ethiopia	2016	10,346	4.1 [3.1, 5.5]	7.0 [6.5, 7.5]
Gabon	2012	1860	21.1 [19.1, 23.2]	21.4 [17.0, 26.5]
Ghana	2014	748	17.4 [13.8, 21.7]	33.6 [29.0, 38.4]
Gambia	2013	1024	34.3 [30.3, 38.6]	33.7 [29.8, 37.9]
Guinea	2018	7152	1.9 [1.4, 2.6]	2.2 [1.9, 2.7]
Kenya	2014	6796	21.2 [19.6, 22.9]	24.3 [23.1, 25.6]
Comoros	2012/2013	545	14.3 [10.0, 20.1]	16.7 [13.2, 21.0]
Liberia	2019/2020	1508	24.8 [21.6, 28.2]	27.4 [24.5, 30.5]
Lesotho	2014	829	13.2 [9.5, 18.2]	17.5 [14.6, 20.7]
Madagascar	2008/09	1315	24.7 [19.3, 31.0]	26.5 [24.0, 29.2]
Mali	2018	9477	1.2 [0.8, 1.8]	2.2 [1.9, 2.6]
Malawi	2015/16	16,338	3.7 [3.0, 4.6]	5.7 [5.4, 6.1]
Mozambique	2011	1016	12.4 [9.5, 16.0]	18.9 [16.0, 22.2]
Nigeria	2018	30,779	2.0 [1.7, 2.2]	3.1 [2.8, 3.3]
Niger	2012	1735	24.7 [20.3, 30.0]	32.3 [29.9, 34.7]
Namibia	2013	1353	18.1 [15.3, 21.2]	20.8 [17.9, 24.0]
Rwanda	2014/15	2020	18.6 [14.9, 23.0]	21.8 [19.9, 23.8]
Serra Leone	2013	1988	17.3 [14.4, 20.6]	29.2 [26.9, 31.6]
Senegal	2010/2011	2242	28.4 [25.8, 31.2]	24.2 [21.8, 26.7]
Sao tome	2008/09	473	20.6 [15.6, 26.8]	43.1 [37.3, 49.1]
Swaziland	2005	679	39.0 [28.9, 50.2]	30.6 [27.0, 34.4]
Chad	2014/15	3279	33.3 [30.0, 36.7]	40.3 [38.4, 42.2]
Togo	2013/2014	1732	9.5 [7.5, 11.9]	14.6 [12.5, 16.8]
Tanzania	2015/16	9322	5.2 [4.4, 6.1]	3.3 [2.9, 3.8]
Uganda	2016	14,179	7.3 [6.4, 8.2]	10.2 [9.6, 10.7]
South Africa	2016	3289	3.5 [2.8, 4.4]	2.8 [2.1, 3.9]
Zambia	2018	9187	1.2 [0.9, 1.7]	2.0 [1.7, 2.4]
Zimbabwe	2015	5964	2.9 [2.2, 3.7]	4.3 [3.7, 5.0]

vitamin A supplementation, had diarrhea in the last two weeks, vaccination status, maternal education, media exposure, household wealth status, and sub-Saharan African region were found significant factors associated with ARI.

Being rural increased the odds of experiencing ARIs among under-five children by 1.25 times (AOR = 1.25, 95% CI: 1.20, 1.32) higher compared to urban under-five children. Children aged 36–47 months and 48–59 months were 1.29 times (AOR = 1.29, 95% CI: 1.21, 1.37) and 1.19 times (AOR = 1.19, 95% CI: 1.12, 1.26) higher odds of experiencing ARIs than those aged below 12 months, respectively. The odds of experiencing ARIs among female children were decreased by 5% (AOR = 0.95, 95% CI: 0.92, 0.98) compared to males. Being small size and large size at birth had 1.39 times (AOR = 1.39, 95% CI: 1.33, 1.45) and 1.28 times (AOR = 1.28, 95% CI: 1.23, 1.32) higher odds of experiencing ARIs compared to those normal-sized at birth. The odds of experiencing ARIs among children who breastfeed were decreased

Table 2 Prevalence of ARIs and residential composition by study participants characteristics in SSA

Variables	Categories	ARI prevalence (%)	Residence	
			Urban (%)	Rural(%)
Child's sex	Male	8.9	50.31	50.4
	Female	8.3	49.69	49.40
Child's age (months)	< 12	9.7	21.56	22.02
	12–23	10.0	21.29	21.08
	24–35	8.8	19.91	19.19
	36–47	7.5	19.22	19.12
	48–59	6.5	18.02	18.59
Child size at birth	Average	6.9	49.77	48.14
	Small	11.4	16.25	19.32
	Large	9.5	33.98	32.53
Maternal age (years)	15–24	9.1	27.65	29.86
	25–34	8.5	51.29	46.97
	35–49	8.1	21.06	23.17
Maternal education	No formal	8.4	19.47	43.41
	Primary	9.6	27.53	39.67
	Secondary	7.8	43.15	15.68
	Higher	5.7	9.57	1.24
Type of birth	Single	8.6	96.85	97.05
	Twin	8.4	3.15	2.95
Stunting	Normal	8.4	43.94	37.87
	Moderate	8.0	9.60	13.17
	Severe	8.8	46.45	48.96
Underweight	Normal	8.2	51.58	48.44
	Moderate	8.7	5.07	8.04
	Severe	9.0	43.36	43.53
Wasting	Normal	8.2	55.48	61.13
	Moderate	10.8	2.18	2.80
	Severe	9.0	42.32	41.07
Media exposure	No	8.2	15.77	44.57
	Yes	8.8	84.23	53.43
Wealth status	Poorest	9.6	4.66	30.51
	Poorer	8.9	7.50	27.98
	Middle	8.5	15.20	22.24
	Richer	8.3	29.15	14.26
	Richest	7.2	43.51	5.00
Vitamin A supplementation	No	7.0	48.23	48.52
	Yes	10.1	51.77	51.48
Breast feeding	Ever breast feed	8.3	94.19	95.13
	Never breast feed	12.8	5.81	4.47
Had diarrhea in the last 2 weeks	No	7.0	82.49	80.78
	Yes	15.5	17.51	19.28
Ever had vaccination	No	4.6	39.58	44.46
	Yes	11.6	60.42	55.54
Working status of mother	No	8.3	36.77	33.69
	Yes	8.3	63.23	66.31

by 27% (AOR = 0.73, 95% CI: 0.66, 0.82) than those who never breastfeed their children. Children who did not take vitamin A had 45% (AOR = 1.45, 95% CI: 1.40, 1.50) higher odds of experiencing ARIs compared to those who took vitamin A.

Under-five children who didn't take childhood vaccination were 2.77 times (AOR = 2.77, 95% CI:2.64, 2.90) higher odds of experiencing ARIs compared to children who had a vaccination. The odds of experiencing ARIs among children who had a history of diarrhea were 1.98 (AOR = 1.98, 95% CI: 1.91, 2.05) times higher than those who didn't have a history of diarrhea. Children born to mothers who attained primary, secondary and higher education had 5% (AOR = 0.95, 95% CI: 0.91, 0.99), 26% (AOR = 0.74, 95% CI: 0.70, 0.78) and 46% (AOR = 0.54, 95% CI: 0.48, 0.62) decreased odds of experiencing ARIs compared to children born to mothers who did not have formal education, respectively. Children of mothers who did not have media exposure were 1.19 times (AOR = 1.19, 95% CI: 1.15, 1.24) had higher odds of experiencing ARIs than those born to mothers who had media exposure. The odds of experiencing ARIs among children belonged to poorer, middle, richer and richest households were decreased by 13% (AOR = 0.87, 95% CI: 0.83, 0.92), 16% (AOR = 0.84, 95% CI: 0.84, 0.89), 15% (AOR = 0.85, 95% CI: 0.80, 0.89) and 15% (AOR = 0.85, 95% CI: 0.79, 0.91) compared to those belonged to the poorest household quintile, respectively. The odds of experiencing ARIs among children in West Africa and Central Africa had 1.72 times (AOR = 1.72, 95% CI: 1.57, 1.88) and 2.16 times (AOR = 2.16, 95% CI: 2.06, 2.26) higher than those children in East Africa, respectively (Table 3).

Decomposition of the rural–urban disparity ARI symptoms among under-five children in SSA

It was found that 64.7% of the overall rural–urban difference in ARIs prevalence was attributable to the difference in characteristics (endowment) across the residence and 35.3% was explained by the difference in the effect of characteristics (change in coefficient) across residences (Table 4). Among the endowment component, a female child (B = 0.033), child aged < 12 months (B = -0.0006), child aged 36–47 months (B = -0.0004), small-sized at birth (B = 0.0009), large size at birth (B = -0.0004), moderate wasting (B = 0.0006), severe wasting (B = 0.0004), having media exposure (B = -0.0003), having diarrhea (B = 0.0013), ever had vaccination (B = -0.0035), every breastfeeding (B = -0.0035), health facility delivery (B = -0.003), being in the poorest household (B = 0.009), poorer household (B = 0.005), middle household (B = 0.001), and richer household (B = -0.003) were significantly contributed for the change in ARIs prevalence across the residence.

Among the coefficient components, a child aged less than 12 months (B = 0.0018), aged 36–47 months (B = 0.0014), ever had vaccination (B = -0.007), health facility delivery (B = -0.005), being from middle household wealth (B = 0.0013) and being from the richer household wealth index (B = 0.0025) were significant predictors contributed for the change in prevalence of ARIs across residence (Table 5).

Discussion

This study found a higher prevalence of ARIs among under-five children in rural areas. In addition, in the multilevel analysis, the odds of experiencing ARIs among under-five children in rural areas were higher than in under-five children in urban areas. The possible explanation for the rural–urban disparity in ARIs among under-five children might be due to limited health care service availability and accessibility in rural areas of LMICs specifically in sub-Saharan African countries, responsible for the large concentration of acute respiratory tract infections in under-five children in rural areas [38, 39]. Besides, the literature showed that under-five children in rural households are more likely suffered from undernutrition, which in turn, increases their susceptibility to childhood infections such as pneumonia, bronchiolitis, tosilo-pharyngitis, and otitis media [40, 41]. Moreover, a majority of children in rural areas of sub-Saharan African countries do not receive full vaccinations against common childhood illnesses [42–44] and have higher exposure to household air pollution from unprocessed fuel, which is identified as the substantial cause of respiratory illness among under-five children [45].

Female children had lower odds of experiencing ARIs compared to male children. This finding is in line with previous studies reported in Egypt [16] and Bangladesh [14]. The possible explanation might be due to sex differences in genetic and biological makeup, with a male child being biologically weaker and more susceptible to respiratory diseases [46].

Another important factor significantly associated with ARIs was child age. A child aged 37–47 months and 48—59 months had higher odds of experiencing ARIs compared to children aged less than 12 months. It is consistent with studies reported in developing countries [47, 48], this could be due to infants being relatively at a decreased level of exposure to different types of infections related to eating contaminated food prepared and limited exposure to the unhealthy environment compared to older children [49, 50]. On contrary, older children are more exposed to the environmental risk factors of ARIs as they child walk and have contact with different individuals [51].

Table 3 Factors associated with acute respiratory infection symptoms among under-five in sub-Saharan Africa

Variables	Null model	Model I (Residence)	Model II (Model I + child characteristics)	Model III (Model II + Mothers characteristics)	Model IV (Model III + Household characteristics)	Model V (Model IV + community-level characteristics)
Residence						
Urban		1	1	1	1	1
Rural		1.28 (1.24, 1.33)	1.30 (1.26, 1.35)	1.17 (1.12, 1.22)	1.11 (1.06, 1.16	1.25 (1.20, 1.32)**
Sex of child						
Male			1	1	1	1
Female			0.95 (0.92, 0.98)	0.95 (0.92, 0.98)	0.95 (0.92, 0.98)	0.95 (0.92, 0.98)*
Child age (in months)						
< 12			1	1	1	1
12–23			0.86 (0.82, 0.90)	0.85 (0.81, 0.89)	0.89 (0.85, 0.94)	0.84 (0.80, 1.03)
24–35			0.84 (0.80, 0.88)	0.83 (0.79, 0.87)	0.87 (0.83, 0.92)	0.83 (0.79, 1.01)
36–47			1.42 (1.34, 1.51)	1.44 (1.36, 1.53)	1.54 (1.46, 1.64)	1.29 (1.21, 1.37)*
48–59			1.32 (1.25, 1.41)	1.32 (1.24, 1.40)	1.42 (1.33, 1.51)	1.19 (1.12, 1.26)*
Type of birth						
Single			1	1	1	1
Multiple			0.90 (0.82, 0.99)	0.95 (0.86, 1.05)	0.95 (0.86, 1.05)	0.94 (0.85, 1.04)
Child size at birth						
Average			1	1	1	1
Small			1.57 (1.50, 1.64)	1.41 (1.35, 1.47)	1.41 (1.35, 1.47)	1.39 (1.33, 1.45)**
Large			1.35 (1.30, 1.40)	1.35 (1.30, 1.40)	1.35 (1.30, 1.40)	1.28 (1.23, 1.32)**
Stunting						
Normal			1	1	1	1
Moderate			0.93 (0.88, 0.98)	0.93 (0.87, 0.98)	0.92 (0.87, 1.04)	0.93 (0.87, 1.12)
Severe			0.89 (0.82, 0.95)	0.88 (0.81, 0.95)	0.87 (0.81, 0.99)	0.84 (0.78, 1.03)
Underweight						
Normal			1	1	1	1
Moderate			1.06 (0.98, 1.14)	1.04 (0.96, 1.12)	1.04 (0.97, 1.12)	1.04 (0.97, 1.25)
Severe			1.21 (1.08, 1.35)	1.19 (1.06, 1.33)	1.18 (1.05, 1.33)	1.19 (1.06, 1.34)*
Wasting						
Normal			1	1	1	1
Moderate			1.12 (1.02, 1.24)	1.14 (1.02, 1.26)	1.14 (1.03, 1.27)	1.13 (1.02, 1.26)**
Severe			1.06 (0.97, 1.17)	1.13 (1.02, 1.24)	1.13 (1.03, 1.25)	1.14 (1.04, 1.26)**
Breastfeeding						
Never breastfeed			1	1	1	1
Ever breastfeed			1.43 (1.34, 1.53)	0.81 (0.72, 0.90)	0.80 (0.72, 0.90)	0.73 (0.66, 0.82)*
Vitamin A supplementation						
Yes			1	1	1	1
No			1.26 (1.22, 1.30)	1.31 (1.26, 1.36)	1.31 (1.27, 1.36)	1.45 (1.40, 1.50)**
Had diarrhea in the last two weeks						
No			1	1	1	1
Yes			2.04 (1.97, 2.12)	2.04 (1.96, 2.11)	2.04 (1.97, 2.12)	1.98 (1.91, 2.05)**
Ever had vaccination						
Yes			1	1	1	1
No			3.13 (2.99, 3.28)	3.16 (3.01, 3.32)	3.33 (3.17, 3.49)	2.77 (2.64, 2.90)*
Maternal educational status						
No				1	1	1
Primary				1.05 (1.01, 1.09)	1.06 (1.02, 1.10)	0.95 (0.91, 0.99)*
Secondary				0.88 (0.84, 0.92	0.90 (0.86, 0.95)	0.74 (0.70, 0.78)*
Higher				0.57 (0.51, 0.65)	0.62 (0.54, 0.70)	0.54 (0.48, 0.62)*

Table 3 (continued)

Variables	Null model	Model I (Residence)	Model II (Model I + child characteristics)	Model III (Model II + Mothers characteristics)	Model IV (Model III + Household characteristics)	Model V (Model IV + community-level characteristics)
Place of delivery						
Home				1	1	1
Health facility				0.80 (0.77, 0.83)	0.86 (0.82,0.89)	0.99 (0.94, 1.04)
Working status						
No				1	1	1
Yes				0.98 (0.95, 1.02)	0.98 (0.95, 1.02)	0.99 (0.95, 1.02)
Media exposure						
Yes					1	1
No					1.14 (1.10, 1.19)	1.19 (1.15, 1.24)*
Household wealth status						
Poorest					1	1
Poorer					0.87 (0.83, 0.91)	0.87 (0.83, 0.92)*
Middle					0.81 (0.77, 0.86)	0.84 (0.80, 0.89)*
Richer					0.78 (0.74, 0.82)	0.85 (0.80, 0.89)*
Richest					0.73 (0.68, 0.78)	0.85 (0.79, 0.91)*
Sub-Saharan Africa region						
East Africa						1
West Africa						1.72 (1.57, 1.88)*
Southern Africa						0.96 (0.92, 1.01)
Central Africa						2.16 (2.06, 2.26)*
LLR	-57,818/342	-57,726.622	-54,432.061	52,074.165	52,001.92	51,335.396
Deviance	115,636.684	115,453.244	108,864.122	104,148.330	104,003.84	102,670.792

Table 4 Overall decomposition analysis result of urban–rural disparity in acute respiratory infection symptoms among under-five children in sub-Saharan Africa

ARI	Coef. (95% CI)	Percent contribution
E	0.01 (0.009, 0.004)	64.7
C	0.006 (0.003, 0.01)	35.3
Residual	0.017 (0.015, 0.02)	

Being small or large size at birth was significantly associated with higher odds of ARIs compared to an average-sized child at birth. This is consistent with study findings in India [52] and Argentina [53]. These might be due to small and large size children at birth having commonly underlined medical conditions like malnutrition, chronic illnesses such as down syndrome, congenital heart diseases, and infectious diseases, in turn, these increase their risk of infections [54, 55]. The odds of experiencing ARIs among children who didn't take vitamin A supplementation were lower compared to children who took vitamin A supplementation. It is supported by a previous study [56], this might be because vitamin A plays a vital role in the development of the epithelium mucosae of the respiratory tract and improves humoral and cellular immunity by influencing the synthesis of immunoglobulins [57].

Having diarrhea in the last two weeks increases the odds of experiencing ARIs compared to children who did not have a history of diarrhea. This is consistent with study findings in Indonesia [58], and Bangladesh [59], it could be due to diarrhea can cause nutritional depletion because of the loss of zinc and other nutrients, which in turn increases the risk of ARIs [60]. Unvaccinated children had lower odds of experiencing ARIs compared to vaccinated children, which is supported by literature reported in India [61], and Cameroon [23]. Common childhood vaccines like PCV and pentavalent are effective in preventing common respiratory infections caused by streptococcus pneumonia, H-influenza, and measles, and therefore unvaccinated children are at higher risk of contracting ARIs [62].

Maternal education and wealth status were found to be significant predictors of ARIs. Better wealth and higher maternal education are responsible for decreased risk of ARIs among under-five children. These are supported by studies reported in Bangladesh [63], Iraq [28],

Table 5 Results of decomposition of the rural–urban disparity in acute respiratory infection symptoms in under-five children in sub-Saharan Africa

Variables	Categories	Difference due to endowment			Difference due to coefficient		
		Coef with 95% CI	Pct	*p*-value	Coef with 95% CI	Pct	
Sex of child	Male	Ref			Ref		
	Female	0.033 (0.071, 0.59)*	0.02	0.001	0.0003 (-0.00017, 0.0019)	1.98	0.41
Type of birth	Single	Ref			Ref		
	Twin	0.0006 (-0.26, 0.0001)	0.04	0.161	-0.0002 (-0.004, 0.001)	-0.97	0.76
Child age (months)	< 12	-0.0006 (-0.0007, -0.0004)*	-0.33	0.021	0.0018 (0.0006, 0.003)*	10.5	0.02
	12–23	0.0004 (0.0003, 0.0005)*	0.24	0.031	0.0014 (0.00017, 0.0026)*	8.1	0.03
	24–35	0.0002 (0.0001, 0.0003)*	1.1	0.001	0.001 (-0.0005, 0.0023)	6.4	0.101
	36–47	-0.0004 (-0.0008, -0.002)*	-0.02	0.035	0.0006 (-0.001, 0.001)	0.34	0.2
	48–59	Ref			Ref		
Child size at birth	Average	Ref			Ref		
	Small	0.0009 (0.0007, 0.001)*	5.15	0.041	-0.0007 (-0.001, 0.0003)	-3.7	0.132
	Large	-0.0004 (-0.0005, -0.003)*	-2.33	0.02	-0.0019 (-0.001, 0.001)	-1.11	0.432
Wasting	Normal	Ref			Ref		
	Moderate	0.0006 (0.00006, 0.0001)*	0.32	0.04	-0.0001 (-0.001, 0.0008)	-0.7	0.42
	Severe	0.0004 (0.0003, 0.0005)*	0.23	0.032	0.0013 (-0.007, 0.003)	7.5	0.34
Media exposure	No	Ref			Ref		
	Yes	-0.003 (-0.004, -0.002)*	16.6	0.012	-0.0005 (-0.004, 0.003)	3.15	0.61
Diarrhea in the last two weeks	No	Ref			Ref		
	Yes	0.0013 (0.0012, 0.0014)*	7.5	0.034	-0.0001 (-0.0007, 0.0005)	-0.69	0.31
Ever breast feeding	No	Ref			Ref		
	Yes	-0.0024 (-0.0030, -0.0018)*	-1.38	0.04	0.0006 (-0.0003, 0.0004)	0.34	0.43
Ever had vaccination	No	Ref			Ref		
	Yes	-0.0035 (-0.0038, -0.0033)*	-20.26	0.023	-0.007 (-0.009, -0.005)*	-40.9	0.0023
Place of delivery	Home	Ref			Ref		
	Health facility	-0.003 (-0.004, -0.002)*	18.14	0.03	-0.005 (-0.008, -0.001)	-26.6	0.003
Wealth status	Poorest	0.009 (0.008, 0.011)*	54.42	0.01	-0.0006 (-0.001, -0.00008)*	1.16	0.021
	Poorer	0.005 (0.003, 0.006)*	27.39	0.042	0.0002 (-0.0004, 0.0008)	1.16	0.12
	Middle	0.001 (0.0007, 0.0014)*	6.11	0.028	0.0013(0.0003, 0.002)*	7.26	0.02
	Richer	-0.003 (-0.004, -0.0015)*	-15.17	0.019	0.0025 (0.001, 0.004)*	14.6	0.031
	Richest	Ref			Ref		

and Afghanistan [64]. The possible explanation might be due to education enhancing mother's healthcare-seeking behavior and their level of adherence to appropriate childcare practices like exclusively breastfeeding children until 6 months, initiation of appropriate complementary feeding, and vaccinating their children, which could, in turn, reduce the risk of ARIs [65, 66]. Health facility delivery lowers the odds of ARIs among under-five children, it is supported by previous studies [48, 67]. Under-five children born to mothers who had no media exposure had higher odds of experiencing ARIs than those children born to mothers who didn't have media exposure. Media exposure enhances the knowledge level of women to be able to use maternal health care services such as ANC, health facility delivery, PNC, appropriate child feeding practices, and child vaccinations, which could reduce their risk of infections [14].

In the multivariate decomposition analysis, the urban–rural disparity in ARIs among under-five children was due to the difference in the composition of sex of the child, child age, child size at birth, wasting status, media exposure, having a diarrheal illness, ever had the vaccination, ever breastfeeding, health facility delivery and household wealth status, and change in the effect of child age, ever had the vaccination, health facility delivery and household wealth status across the residence. It could be due to improved wealth, health facility delivery, breastfeeding, childhood vaccination, and media exposure can improve childhood nutritional status, which in turn improves immune competency [68, 69]. Several childhood vaccines against respiratory infections are currently available and are part of the Expanded Program of Immunization (EPI) schedule [70, 71]. Therefore, the decreased incidence of ARIs in urban areas might be attributable to the increased immunization coverage in urban areas specifically in SSA [72]. In addition, breast milk provides immunologic protection against numerous illnesses during childhood, therefore breastfeeding children rather than formula-feeding children has decreased the incidence of acute respiratory tract infections [73, 74]. Overall, these could be responsible for the decreased incidence of ARIs among under-five children in urban areas.

Policy implications

In this study, we found that rural children under five were highly affected by ARIs. This information has been used as a preventive measure that is linked to maternal and child health. From a policy point of view, the interventions which are designed to tackle ARIs such as childhood vaccination, nutrition, environmental sanitation, exclusive breastfeeding practice, and maternal education should be scaled to sustain the reduction in ARIs related to under-five mortality in SSA. Childhood vaccination and nutrition are vital to reducing childhood mortality and morbidity. Enhancing the availability of education to women is needed to increase the chance of child survival as they adhered to maternal and child health guidelines and recommendations.

Strengths and limitations of the study

The study was done based on the weighted Demographic and Health Survey (DHS) data of 36 SSA to ensure representativeness and to obtain reliable estimates. As the study was cross-sectional, we are unable to show a temporal relationship; however, multilevel modeling was employed to consider the clustering effect to obtain reliable estimates and SE. In addition, all information related to ARIs was provided by mothers and was not validated by applying medical examinations/investigation, and was thus subjective. Therefore, it is prone to recall bias since the retrospective data on their previous history were collected.

Conclusion

Under-five children in rural areas were more likely to suffer from ARIs in SSA. Public health interventions should target children in poor households, and unvaccinated and undernourished children to narrow the rural–urban disparity in ARIs. Sex of children, child age, child size at birth, vitamin A supplementation, diarrhea in the last two weeks, ever had the vaccination, maternal education, wealth status, media exposure, and breastfeeding status were significantly associated with ARIs in the multivariable analysis. Therefore, enhancing maternal education, health facility delivery, vitamin A supplementation, and childhood vaccination is vital to reduce the incidence of ARIs among under-five children.

Abbreviations

AOR: Adjusted odds ratio; ARIs: Acute respiratory infection symptoms; CI: Confidence interval; CPR: DHS: Demographic and health survey; ICC: Intraclass correlation coefficient; LLR: Log-likelihood Ratio; LR: Likelihood ratio; SSA: Sub-Saharan Africa; WHO: World health organization.

Acknowledgements

We greatly acknowledge MEASURE DHS for granting access to the EDHS data sets.

Authors' contribution

GAT, MGW, TSA, ABT, YY, AZA, HGA, AML, and ZTT conceived the study. GAT, MGW, TSA, ABT, YY, AZA, HGA, AML, and ZTT analyzed the data, drafted the manuscript, and reviewed the article. GAT, MGW, TSA, ABT, YY, AZA, HGA, AML, and ZTT extensively reviewed the article. All authors read and approved the final manuscript.

Funding

No funding was obtained for this study.

Availability of data and materials

Data is available online and you can access it from www.measuredhs.com.

Declarations

Ethical approval and consent to participate

Since the study was a secondary data analysis of publically available survey data from the MEASURE DHS program, ethical approval and participant consent were not necessary for this particular study. We requested DHS Program and permission was granted to download and use the data for this study from http://www.dhsprogram.com. There are no names of individuals or household addresses in the data files. All the methods were performed by the relevant guidelines and regulations. Procedures and questionnaires for standard DHS surveys have been reviewed and approved by ICF Institutional Review Board (IRB). Additionally, country-specific DHS survey protocols are reviewed by the ICF IRB and typically by an IRB in the host country. ICF IRB ensures that the survey complies with the U.S. Department of Health and Human Services regulations for the protection of human subjects, while the host country IRB ensures that the survey complies with the laws and norms of the nation. Comprehensive information about the ethical protocols is accessible through https://dhsprogram.com/methodology/Protecting-the-Privacy-of-DHS-Survey-Respondents.cfm.

Consent for publication

Not applicable since the study was a secondary data analysis.

Competing interests

The authors declare that they have no conflict of interest.

Author details

[1]Department of Epidemiology and Biostatistics, Institute of Public Health, College of Medicine and Health Sciences and Comprehensive Specialized Hospital, University of Gondar, Gondar, Ethiopia. [2]Department of Human Anatomy, College of Medicine and Health Sciences and Comprehensive Specialized Hospital, University of Gondar, Gondar, Ethiopia. [3]Department of Human Physiology, College of Medicine and Health Sciences and Comprehensive Specialized Hospital, University of Gondar, Gondar, Ethiopia. [4]Department of Midwifery, School of Nursing and Midwifery, College of Medicine and Health Sciences, Wollo University, Dessie, Ethiopia.

Received: 16 June 2021 Accepted: 21 October 2022
Published online: 03 November 2022

References

1. Cashat-Cruz M, Morales-Aguirre JJ, Mendoza-Azpiri M: Respiratory tract infections in children in developing countries. In: Seminars in pediatric infectious diseases: 2005: Elsevier; 2005: 84–92.
2. Williams BG, Gouws E, Boschi-Pinto C, Bryce J, Dye C. Estimates of world-wide distribution of child deaths from acute respiratory infections. Lancet Infect Dis. 2002;2(1):25–32.
3. Bellos A, Mulholland K, O'Brien KL, Qazi SA, Gayer M, Checchi F. The burden of acute respiratory infections in crisis-affected populations: a systematic review. Confl Heal. 2010;4(1):1–12.
4. Goodarzi E, Sohrabivafa M, Darvishi I, Naemi H, Khazaei Z: Epidemiology of mortality induced by acute respiratory infections in infants and children under the age of 5 years and its relationship with the Human Development Index in Asia: an updated ecological study. Journal of Public Health 2020:1–8.
5. Feigin VL, Roth GA, Naghavi M, Parmar P, Krishnamurthi R, Chugh S, Mensah GA, Norrving B, Shiue I, Ng M. Global burden of stroke and risk factors in 188 countries, during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet Neurology. 2016;15(9):913–24.
6. Mokdad AH, Forouzanfar MH, Daoud F, Mokdad AA, El Bcheraoui C, Moradi-Lakeh M, Kyu HH, Barber RM, Wagner J, Cercy K. Global burden of diseases, injuries, and risk factors for young people's health during 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. The Lancet. 2016;387(10036):2383–401.
7. Akinyemi JO, Morakinyo OM. Household environment and symptoms of childhood acute respiratory tract infections in Nigeria, 2003–2013: a decade of progress and stagnation. BMC Infect Dis. 2018;18(1):1–12.
8. Yousif TK, Khaleq B. Epidemiology of acute respiratory tract infections (ARI) among children under five years old attending tikirit general teaching hospital. Middle East J Fam Med. 2006;4(3):4–23.
9. Rudan I, Tomaskovic L, Boschi-Pinto C, Campbell H. Global estimate of the incidence of clinical pneumonia among children under five years of age. Bull World Health Organ. 2004;82:895–903.
10. Mtango F, Neuvians D. Acute respiratory infections in children under five years Control project in Bagamoyo District, Tanzania. Transactions of the Royal society of Tropical Medicine and Hygiene. 1986;80(6):851–8.
11. Triana E, Purwana R: Factors Affecting The Incidence of Acute Respiratory Tract Infection in Children under Five at Betungan Community Health Center, Bengkulu. In: 6th International Conference on Public Health 2019: Sebelas Maret University: 40–45.
12. El Arifeen S, Akhter T, Chowdhury HR, Rahman KM, Chowdhury EK, Alam N. Causes of death in children under five years of age. Chapter. 2005;9:125–33.
13. Ujunwa F, Ezeonu C. Risk factors for acute respiratory tract infections in under-five children in enugu Southeast Nigeria. Ann Med Health Sci Res. 2014;4(1):95–9.
14. Sultana M, Sarker AR, Sheikh N, Akram R, Ali N, Mahumud RA, Alam NH. Prevalence, determinants and health care-seeking behavior of childhood acute respiratory tract infections in Bangladesh. PLoS ONE. 2019;14(1):e0210433.
15. Mejía-Guevara I, Zuo W, Bendavid E, Li N, Tuljapurkar S. Age distribution, trends, and forecasts of under-5 mortality in 31 sub-Saharan African countries: A modeling study. PLoS Med. 2019;16(3):e1002757.
16. Khalek EA, Abdel-Salam DM. Acute respiratory tract infections in children under 5 years of age in Upper Egypt. International Journal of Community Medicine and Public Health. 2016;3(5):1161–6.
17. Kjærgaard J, Anastasaki M, Stubbe Østergaard M, Isaeva E, Akylbekov A, Nguyen NQ, Reventlow S, Lionis C, Sooronbaev T, Pham LA. Diagnosis and treatment of acute respiratory illness in children under five in primary care in low-, middle-, and high-income countries: A descriptive FRESH AIR study. PLoS ONE. 2019;14(11):e0221389.
18. Mir F, Ariff S, Bhura M, Chanar S, Nathwani AA, Jawwad M, Hussain A, Rizvi A, Umer M, Memon Z. Risk factors for acute respiratory infections in children between 0 and 23 months of age in a peri-urban district in Pakistan: A matched case–control study. Front Pediatr. 2022;9:704545.
19. Yaya S, Bishwajit G, Okonofua F, Uthman OA. Under five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis. PLoS ONE. 2018;13(10):e0205977.
20. Banda B, Mazaba M, Mulenga D, Siziya S. Risk factors associated with acute respiratory infections among under-five children admitted to Arthur's Children Hospital, Ndola, Zambia. Asian Pacific Journal of Health Sciences. 2016;3:153–9.
21. Harerimana J-M, Nyirazinyoye L, Thomson DR, Ntaganira J. Social, economic and environmental risk factors for acute lower respiratory infections among children under five years of age in Rwanda. Archives of Public Health. 2016;74(1):1–7.
22. Kumar SG, Majumdar A, Kumar V, Naik BN, Selvaraj K, Balajee K. Prevalence of acute respiratory infection among under-five children in urban and rural areas of puducherry, India. Journal of natural science, biology, and medicine. 2015;6(1):3.
23. Tazinya AA, Halle-Ekane GE, Mbuagbaw LT, Abanda M, Atashili J, Obama MT. Risk factors for acute respiratory infections in children under five years attending the Bamenda Regional Hospital in Cameroon. BMC Pulm Med. 2018;18(1):1–8.
24. Madhi SA, Klugman KP: Acute respiratory infections. Disease and Mortality in Sub-Saharan Africa 2006:149.
25. Seidu A-A, Dickson KS, Ahinkorah BO, Amu H, Darteh EKM, Kumi-Kyereme A. Prevalence and determinants of acute lower respiratory infections among children under-five years in sub–Saharan Africa: evidence from demographic and health surveys. SSM-population health. 2019;8:100443.
26. Smith KR, Mehta S. The burden of disease from indoor air pollution in developing countries: comparison of estimates. Int J Hyg Environ Health. 2003;206(4–5):279–89.
27. Selvaraj K, Chinnakali P, Majumdar A, Krishnan IS. Acute respiratory infections among under-5 children in India: A situational analysis. Journal of natural science, biology, and medicine. 2014;5(1):15.
28. Siziya S, Muula AS, Rudatsikira E. Diarrhoea and acute respiratory infections prevalence and risk factors among under-five children in Iraq in 2000. Ital J Pediatr. 2009;35(1):1–9.
29. Tadesse M, Defar A, Getachew T, Amenu K, Teklie H, Asfaw E, Bekele A, Kebede A, Assefa Y, Demissie T: Countdown to 2015: Ethiopia's progress towards reduction in under-five mortality: 2014 country case study. 2015.
30. Cha S. The impact of the worldwide Millennium Development Goals campaign on maternal and under-five child mortality reduction:'Where did the worldwide campaign work most effectively?' Glob Health Action. 2017;10(1):1267961.
31. Rutherford ME, Mulholland K, Hill PC. How access to health care relates to under-five mortality in sub-Saharan Africa: systematic review. Tropical Med Int Health. 2010;15(5):508–19.
32. Weber A-C, Bogler L, Vollmer S, Simen-Kapeu A, Ekpini RE, Zagre NM: The wealth gradient in diarrhoea, acute respiratory infections, and malaria in childhood over time: A descriptive analysis using DHS and MICS from Western and Central Africa between 1995 and 2017. Journal of Global Health 2021, 11.
33. Adesanya OA, Darboe A, Mendez Rojas B, Abiodun DE, Beogo I. Factors contributing to regional inequalities in acute respiratory infections symptoms among under-five children in Nigeria: a decomposition analysis. International journal for equity in health. 2017;16(1):1–22.
34. https://dhsprogram.com/data/. In.
35. Graham NM, Douglas RM, Ryan P. Stress and acute respiratory infection. Am J Epidemiol. 1986;124(3):389–401.
36. De Onis M, Blössner M. The World Health Organization global database on child growth and malnutrition: methodology and applications. Int J Epidemiol. 2003;32(4):518–26.
37. Powers DA, Yoshioka H, Yun M-S. mvdcmp: Multivariate decomposition for nonlinear response models. Stand Genomic Sci. 2011;11(4):556–76.
38. AMOAH PA: Social capital, health literacy, and access to healthcare: a study among rural and urban populations in Ghana. 2017.
39. Ritter R: Access and Barriers to Health Care Services in rural Malawi. 2021.
40 Endris N, Asefa H, Dube L. Prevalence of malnutrition and associated factors among children in rural Ethiopia. BioMed research international. 2017;2017:6587853.
41. Odunayo SI, Oyewole AO. Risk factors for malnutrition among rural Nigerian children. Asia Pacific Journal of Clinical Nutrition. 2006;15(4):491–5.
42. Sanou A, Simboro S, Kouyaté B, Dugas M, Graham J, Bibeau G. Assessment of factors associated with complete immunization coverage in

children aged 12–23 months: a cross-sectional study in Nouna district, Burkina Faso. BMC Int Health Hum Rights. 2009;9(1):1–15.
43. Singh M, Badole C, Singh M. Immunization coverage and the knowledge and practice of mothers regarding immunization in rural area. Indian J Public Health. 1994;38(3):103–7.
44. Bhatia V, Swami H, Rai SK, Gulati S, Verma A, Parashar A, Kumari R. Immunization status in children. The Indian Journal of Pediatrics. 2004;71(4):313–5.
45. Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. Bull World Health Organ. 2000;78:1078–92.
46 Liselele HB, Boulvain M, Tshibangu KC, Meuris S. Maternal height and external pelvimetry to predict cephalopelvic disproportion in nulliparous African women: a cohort study. BJOG: An International Journal of Obstetrics & Gynaecology. 2000;107(8):947–52.
47. Selwyn B: The epidemiology of acute respiratory tract infection in young children: comparison of findings from several developing countries. Reviews of infectious diseases 1990, 12(Supplement_8):S870-S888.
48. Berman S: Epidemiology of acute respiratory infections in children of developing countries. Reviews of infectious diseases 1991, 13(Supplement_6):S454-S462.
49. Chantry CJ, Howard CR, Auinger P. Full breastfeeding duration and associated decrease in respiratory tract infection in US children. Pediatrics. 2006;117(2):425–32.
50. Chonmaitree T, Revai K, Grady JJ, Clos A, Patel JA, Nair S, Fan J, Henrickson KJ. Viral upper respiratory tract infection and otitis media complication in young children. Clin Infect Dis. 2008;46(6):815–23.
51. Cabello C, Manjarrez M, Olvera R, Villalba J, Valle L, Paramo I. Frequency of viruses associated with acute respiratory infections in children younger than five years of age at a locality of Mexico City. Mem Inst Oswaldo Cruz. 2006;101(1):21–4.
52. Bhat R, Manjunath N. Correlates of acute lower respiratory tract infections in children under 5 years of age in India. Int J Tuberc Lung Dis. 2013;17(3):418–22.
53. Cerqueiro MC, Murtagh P, Halac A, Avila M, Weissenbacher M. Epidemiologic risk factors for children with acute lower respiratory tract infection in Buenos Aires, Argentina: a matched case-control study. Reviews of infectious diseases. 1990;12((Supplement_8)):S1021–8.
54. Mussi-Pinhata MM, Motta F, Freimanis-Hance L, de Souza R, Szyld E, Succi RC, Christie CD, Rolon MJ, Ceriotto M, Read JS. Lower respiratory tract infections among human immunodeficiency virus-exposed, uninfected infants. Int J Infect Dis. 2010;14:e176–82.
55. Lanari M, Giovannini M, Giuffre L, Marini A, Rondini G, Rossi G, Merolla R, Zuccotti G, Salvioli G. Prevalence of respiratory syncytial virus infection in Italian infants hospitalized for acute lower respiratory tract infections, and association between respiratory syncytial virus infection risk factors and disease severity. Pediatr Pulmonol. 2002;33(6):458–65.
56. Fawzi WW, Mbise R, Spiegelman D, Fataki M, Hertzmark E, Ndossi G. Vitamin A supplements and diarrheal and respiratory tract infections among children in Dar es Salaam. Tanzania The Journal of pediatrics. 2000;137(5):660–7.
57. Villamor E, Fawzi WW. Effects of vitamin A supplementation on immune responses and correlation with clinical outcomes. Clin Microbiol Rev. 2005;18(3):446.
58. Agustina R, Shankar AV, Ayuningtyas A, Achadi EL, Shankar AH. Maternal agency influences the prevalence of diarrhea and acute respiratory tract infections among young Indonesian children. Matern Child Health J. 2015;19(5):1033–46.
59. Ullah MB, Mridha MK, Arnold CD, Matias SL, Khan MSA, Siddiqui Z, Hossain M, Paul RR, Dewey KG. Factors associated with diarrhea and acute respiratory infection in children under two years of age in rural Bangladesh. BMC Pediatr. 2019;19(1):1–11.
60. Barros A, Ross D, Fonseca W, Williams L, Moreira-Filho D. Preventing acute respiratory infections and diarrhoea in child care centres. Acta Paediatr. 1999;88(10):1113–8.
61. Islam F, Sarma R, Debroy A, Kar S, Pal R. Profiling acute respiratory tract infections in children from Assam, India. Journal of global infectious diseases. 2013;5(1):8.
62. Girard MP, Cherian T, Pervikov Y, Kieny MP. A review of vaccine research and development: human acute respiratory infections. Vaccine. 2005;23(50):5708–24.
63. Yaya S, Bishwajit G. Burden of acute respiratory infections among under-five children in relation to household wealth and socioeconomic status in Bangladesh. Tropical medicine and infectious disease. 2019;4(1):36.
64. Rana J, Uddin J, Peltier R, Oulhote Y. Associations between indoor air pollution and acute respiratory infections among under-five children in Afghanistan: do SES and sex matter? Int J Environ Res Public Health. 2019;16(16):2910.
65. Guldan GS, Zeitlin MF, Beiser AS, Super CM, Gershoff SN, Datta S. Maternal education and child feeding practices in rural Bangladesh. Soc Sci Med. 1993;36(7):925–35.
66. Francis LA, Hofer SM, Birch LL. Predictors of maternal child-feeding style: maternal and child characteristics. Appetite. 2001;37(3):231–43.
67. Organization WH. Severe acute respiratory infections treatment centre: practical manual to set up and manage a SARI treatment centre and a SARI screening facility in health care facilities. In.: World Health Organization; 2020.
68. Singh PK. Trends in child immunization across geographical regions in India: focus on urban-rural and gender differentials. PLoS ONE. 2013;8(9):e73102.
69. Doctor HV, Nkhana-Salimu S, Abdulsalam-Anibilowo M. Health facility delivery in sub-Saharan Africa: successes, challenges, and implications for the 2030 development agenda. BMC Public Health. 2018;18(1):1–12.
70. Sigurdsson S, Kristinsson KG, Erlendsdóttir H, Hrafnkelsson B, Haraldsson Á. Decreased incidence of respiratory infections in children after vaccination with ten-valent pneumococcal vaccine. Pediatr Infect Dis J. 2015;34(12):1385–90.
71. Regan AK, De Klerk N, Moore HC, Omer SB, Shellam G, Effler PV. Effect of maternal influenza vaccination on hospitalization for respiratory infections in newborns. Pediatr Infect Dis J. 2016;35(10):1097–103.
72. Atkinson SJ, Cheyne J. Immunization in urban areas: issues and strategies. Bull World Health Organ. 1994;72(2):183.
73. Cushing AH, Samet JM, Lambert WE, Skipper BJ, Hunt WC, Young SA, McLaren LC. Breastfeeding reduces risk of respiratory illness in infants. Am J Epidemiol. 1998;147(9):863–70.
74. Pandolfi E, Gesualdo F, Rizzo C, Carloni E, Villani A, Concato C, Linardos G, Russo L, Ferretti B, Campagna I. Breastfeeding and respiratory infections in the first 6 months of life: A case control study. Front Pediatr. 2019;7:152.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

BMC