ORIGINAL RESEARCH

Determinants of Acute Respiratory Infection Among Children in Ethiopia: A Multilevel Analysis from Ethiopian Demographic and Health Survey

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Background: Acute respiratory infection (ARI) is one of the leading public health challenges among children in low- and middle-income countries. Child mortality due to ARI is disproportionately higher in African regions. In Ethiopia, an encouraging progress in the reduction of ARI was observed until 2010, however, since then the national prevalence is unchanged. There is limited information for the persistently higher prevalence of the infection. Therefore, the aim of this study was to determine regional variations and identify factors associated with the infection.

Methods: This study used data from the Ethiopian Demographic and Health Survey (EDHS) conducted in 2016. The analysis used information from 10,006 children. A two-level logistic regression analysis was used to consider the cluster random effect.

Results: Out of 10,006 children included, 15.9%, 8.9%, and 8.8% reported cough, short rapid breaths, and chest complaint respectively two weeks before the survey, making the overall prevalence of ARI 8.8%. Children aged six to 11 years (adjusted odds ratio (AOR)=1.466, 95% CI: 1.143–1.881), and 12 to 23 (AOR=1.390, 95%CI: 1.109–1.742), small birth size (AOR=1.387, 95%CI), and animal dung as cooking fuel (AOR=1.904, 95%CI: 1.152–3.146) are significantly associated with higher odds of ARI in the final multilevel modeling. The AOR (95%CI) for ARI for differing levels of altitude were: 1000 to 2000, 1.805 (1.403–2.483); 2000 to 3000, 1.882 (1.427–2.483); above 3000, 2.24 (1.023–4.907).

Conclusion: ARI is still a significant public health problem in Ethiopia among children underfive, with a huge variation in the burden across the regional states. Age of children, birth size, household cooking fuel, and altitude above sea level were important variables. Therefore, regional governments, health-care workers and concerned organizations should give emphasis to minimize ARI and the consequences associated with the disease.

Keywords: acute respiratory infection, determinant, children, Ethiopia

Introduction

In low and middle-income countries, a substantial proportion of childhood deaths are attributed to easily preventable and treatable illnesses such as acute respiratory infection (ARI), diarrhea, and malaria.[1,2] Globally, 5.4 million children under the age of five died in 2017 alone, and 73% of the deaths occurred in Africa (49%) and South East Asia (24%). The under-five mortality rate in the WHO African Region is 74/1000 live births, nearly eight times higher than that in the WHO European Region 9/1000 live births.[3] Under-five mortality in Ethiopia is 67/1000 live births based on the recent 2016 Ethiopian Demographic and Health Survey.[4] Acute

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respiratory infection is one of the leading causes of childhood diseases that often result in serious health complications and deaths among children under-five.[5] According to the global burden of disease (GBD) report in 2017, a lower respiratory infection responsible for 704,000 deaths in children younger than five years.[6] Acute respiratory infection is not only the cause of death but is also the leading causes of years of life lost due to premature mortality and one of the most frequent reasons for hospitalization.[7]

Evidence showed that children are the segments of the population more affected by ARIs than adults because of several reasons such as children breathe more rapidly, and their metabolic rate is higher. In addition, children's immune systems are not fully developed, so the incidence of respiratory infections is higher compared to adults.[8]

Studies showed that several factors have been affecting acute respiratory infection in children; sex disparity in children has an effect on the incidence of acute respiratory infections, recently conducted studies indicated that ARI was higher in boys than in girls.[9,10] Type of housing, history of parental smoking, respiratory infection among family members and the nutritional status of children were shown to affect the incidence of ARI in children.[10,11] Educational level of mothers is a significant predictor of ARI in children, children from a mother with primary or no education had a higher risk of acquiring ARI.[12,13] It is also shown that the kind of cooking fuel used at the household influences the incidence of ARI in children.[14–16] In Ethiopia, according to the Ethiopian demographic and health survey (EDHS), the prevalence of ARI in children under five years of age was 13% in 2005, and the magnitude reduced to 7% in EDHS 2011, however, the prevalence remained 7% in EDHS 2016. Despite the persistent higher prevalence of ARI among children in Ethiopia, contributing factors for the disease were not well explored. In addition, few studies conducted in the country are pocket level small and fragmented types. There is limited information on the determinants of morbidity due to ARI in children under five at a national level. Therefore, this study seeks to determine regional variations and identify factors associated with ARI among children.

Methods

This study used data from the nationally representative, cross-sectional Ethiopian Demographic and Health Survey (EDHS) conducted in 2016.[4] EDHS consist of a sample of households obtained through a two-stage stratified sampling procedure. The EDHS 2016 used the Ethiopia Population and Housing Census (PHC), which was conducted in 2007 by the Ethiopia Central Statistical Agency (CSA) as the sampling frame. In the first stage, the country was divided into a total of 645 Enumeration Areas (EAs, which are considered as the primary sampling units) (202 in urban and 443 in rural areas) were selected using probability proportional to the size technique. A household listing was carried out in all the selected EAs to use it as a sampling frame for the selection of households in the second stage.

In the second stage, an equal probability systematic sampling technique was employed to select 28 households per cluster using the household listing. All women aged 15–49 and all men age 15–59 who were either permanent residents of the selected households or visitors who stayed in the household the night before the survey were eligible to be interviewed. This analysis used information from 10,006 children under the age of five years born to women living in these households and who are alive.

Data on morbidity of children was assessed through interviewing the mothers if their child had diarrhea, fever, cough, short rapid breaths, and difficulty breathing that is chest related in the two weeks preceding the survey. In this analysis we considered ARI symptoms include cough accompanied by (1) short, rapid breathing that is chest-related, and/or (2) difficulty breathing that is chest-related.

Anemia measurement: blood specimens were collected from children aged 6–59 months for whom consent was obtained from their parents or other adults responsible for them. Blood samples were drawn from a drop of blood taken from a finger prick (or a heel prick in the case of children aged 6–11 months) and collected in a microcuvette. Hemoglobin analysis was carried out on-site using a battery-operated portable HemoCue analyser. For our analysis, based on the WHO hemoglobin level cut off points, hemoglobin level less than 7 g/dL of blood is anemic otherwise normal.[17]

Wealth Index Measurement

It is a measure of socioeconomic status (SES) of the households to indicate inequalities in the society. The households were given scores based on assets (television, bicycle/car, size of agricultural land, quantity of livestock), and dwelling characteristics (sources of drinking water, sanitation facilities, and materials used for constructing houses) using principal component analysis (PCA), and the scores were compiled into five categories of wealth quintile (poorest, poorer, medium, richer, and richest) each comprising 20% of the population.[4]

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Data Analysis

We chose relevant factors associated with incidence of acute respiratory infection through reviewing previous research and discussion of the researchers. We used some variables for analysis based on the original coding as it appears in the EDHS. However, several variables were obtained by computing from two or more variables, or by recoding the levels of individual variables. The variable toilet facility was recoded to no facility, not improved, and improved with various combinations. Similarly, the variable water source was created as per WHO recommendation as improved and not improved. Type of cooking fuels was categorized as electricity and gas, kerosene, charcoal, wood, straw and agricultural products, and animal dung. The EDHS 2016 data contain an indicator of household wealth status constructed by combining variables related to ownership of household items, dwelling characteristics and construction materials of the unit in which the household lives. A total of 21 and 13 variables were included in the bivariate and multivariate analysis respectively. A two-level logistic regression was used, a model which is most appropriate to consider the cluster random effect in a multivariate setting.[18] The main reason to apply multilevel modeling was the data collected have a hierarchical or clustered structure. The first level represents the individual and household and the second level factor is the clusters. Analysis on the data was performed using STATA (Computing Resource Center, Berkeley, CA, USA). Variables with p-values less than 0.05 during multivariate analysis was considered statistically significant.

Results
Sociodemographic Characteristics of Mothers

A total of 10,006 mother-child pairs were included in our analysis, 2414 (24%) of mothers of children under five were less than 24 years of age, and of these women, 9518 (95.1%) of them were in a marital relationship during the time of the survey. More than three in five women have no formal education, only 1706 (11.8%) of them reported to have secondary and above. It is also shown that 8099 (80.9%) of women were rural residents, and 1954 (19.5%) had three or more children under five years in their household. About 3706 (37%) and 1670 (16.7%) of the respondents were in the poorest and poorer wealth quantification categories respectively. More than 85% of the respondents use wood and agricultural products as a source of cooking fuel, only

4.9% of the respondents has access to electricity and gas. Regarding water source and basic sanitation facility, 5972 (60.4%) of the respondents had improved water source, and only 1748 (17.7%) of the respondents had improved toilet facility, while 4355 (44.1%) of the respondents had no toilet facility at all. Two-fifths (20.4%) of women had exposure to at least one type of media, 1196 (12%) to the radio, 1301 (13%) to TV, and 179 (1.8%) to magazine (Table 1).

Sociodemographic, Birth History and Physical Measurements of Children

Of the children included in the study, 1093 (11.3%) were less than six months of age, 2923 (30.1%) were between six and 24 months and the remaining 5680 (58.6%) were between 24 and 59 months of age. The proportion of male and female children were nearly equal (51% vs 49%) respectively. This study shows that 2031 (20.3%) of children were first births, and 3562 (35.6%) were the fifth and above births for the mother. Of the non-first births, 1052 (10.5%) were born within 18 months of an older sibling, and 862 (8.6%) were born within 18–23 months. Regarding growth and nutritional status of children, 2281 (25.3%) of children were underweight, 3223 (36.4%) were stunted, 1080 (12.1%) were wasted, and 7795 (60.2%) were anemic. The study also showed that 5425 (54.2%) and 1176 (11.8%) of the children received vitamin A supplementation and drugs against intestinal parasites respectively, in the last six months before the survey, and 713 (7.1%) of children received iron pills in the last seven days before the survey (Table 2).

Morbidity Status of Children

Morbidity assessment indicated, 1586 (15.9%), 891 (8.9%), and 884 (8.8%) of children reported to have had cough, short rapid breaths and chest complaint respectively two weeks before the survey. Overall, 885 (8.8%) of children had acute respiratory infection two weeks before the survey. However, 1354 (13.5%) and 1090 (10.9%) of children had fever and diarrhea. One-fourth (25.9%) them reported to have had at least one childhood disease; of those with the disease more than half (57.6%) had multiple morbidities (Table 3).

Regional Distribution of Childhood Morbidities

This study indicates there are huge disparities in the distributions of childhood diseases across the different regional states of Ethiopia. The burden of diarrheal diseases was 123(13.3%)

Table I Sociodemographic Characteristics of the Respondent/
Household

Variable	Categories	Frequency	Percentage
Age of mother	15–24	2414	24.1
	25–29	2978	29.8
	30–34	2238	22.4
	35–49	2376	23.7
Marital status	Never married	59	0.6
	Married	9518	95.1
	Widowed	125	1.2
	Divorced	304	3.0
Highest education of mother	No education	6387	63.8
	Primary	2538	25.4
	Secondary	697	7.0
	Higher	384	3.8
Father's educational level	No education	4604	48.9
	Primary	3034	32.2
	Secondary	972	10.3
	Higher	734	7.8
	Do not know	73	0.8
Religion	Muslim	5068	50.6
	Orthodox	2944	29.4
	Protestant	1761	17.6
	Catholic	61	0.6
	Traditional	96	1.0
	Other	76	0.8
Place of residence	Urban	1907	19.1
	Rural	8099	80.9
Number of children under five	At most one	3677	36.7
	Two	4375	43.7
	Three and above	1954	19.5
Wealth index	Poorest	3706	37.0
	Poorer	1670	16.7
	Middle	1386	13.9
	Richer	1227	12.3
	Richest	2017	20.2
Cooking fuel (n=9884)	Electricity and gas	518	5.2
	Kerosene	37	0.4
	Charcoal	896	9.1
	Wood, straw	8111	82.1
	Animal dung	319	3.2
	Others	3	0.0
Type of toilet facility	No facility	4355	44.1
	Not improved	3781	38.3
	Improved	1748	17.7
Water source	Unimproved	3912	39.6
	Improved	5972	60.4
Smoke cigarettes	No	9913	99.1
	Yes	93	0.9

(*Continued*)

Table I (Continued).

Variable	Categories	Frequency	Percentage
Media exposure	No	7964	79.6
	Yes	1960	20.4
Radio	No	8810	88.0
	Yes	1196	12.0
Magazine	No	9827	98.2
	Yes	179	1.8
TV	No	8705	87.0
	Yes	1301	13.0

in the Amhara region, and the magnitude was 125(12.6%) among children in Tigray regional state. The highest and lowest percentages of cough was observed in Tigray and Benishangul regions, where, 302(30.4%) and 41(5%) of children in the regions reported cough respectively. Similarly, the burden of shortness of breath was the highest Tigray region with the prevalence of 161(16.2%) and lowest in Benishangul regional state with prevalence of 21 (2.6%). The overall magnitude of acute respiratory infection was highest in Tigray region with 167(16.8%), followed by Addis Ababa 51 (11.4%) and Oromia 157(10.5%) regional states (Table 4). The Maps of Ethiopia containing regional states of the country are shown in Figure 1.

Factors Associated with Acute Respiratory Infection Among Under-Five Children

In bivariate logistic regression analysis, sex, age, birth size, twin status, stunting, underweight, reading magazines, maternal educational level, place of residence, cooking fuel, toilet facility, and altitude were showed association with acute respiratory infection at 20% level of significance. However, only age of children, birth size, cooking fuel, and altitude were appeared significant in the final multilevel modeling.

The multivariate analysis showed, children aged between 6 to 11 months and 12 to 23 months were about 50% at higher odds of acquiring acute respiratory infection as compared to those less than 6 months (AOR= 1.466, 95% CI: 1.143, 1.881, and AOR= 1.390, 95% CI: 95% CI: 1.109, 1.742). While, children aged between 48 to 59 months were 27% less likely to be affected with an acute respiratory infection as compared to children with less than 6 months of age (AOR= 0.727, 95% CI: 0.571, 0.925). Children of smaller size at births have 38% higher

Table 2 Sociodemographic Characteristics of Children less than 59 Months of Age in Ethiopia

Variable	Categories	Frequency	Percentage
Age in months	Less than 6 6 to 24 24 and above	1093 2923 5680	11.3 30.1 58.6
Sex	Male Female	5107 4899	51.0 49.0
Birth order	First Second 3 to 4 5 and above	2031 1706 2707 3562	20.3 17.0 27.1 35.6
Succeeding	Last <20 20+	7012 632 2362	70.1 6.3 23.6
Preceding	First born <18 months 18 to 23 months 24 to 35 months 36 and above	2040 1052 862 2550 3502	20.4 10.5 8.6 25.5 35.0
Twin	Single birth 1st of multiple 2nd of multiple	9786 116 104	97.8 1.2 1.0
Anaemia	Severe Moderate Mild Not anemic	311 2531 1849 3104	4.0 32.5 23.7 39.8
Underweight	Yes No	2281 6752	25.3 74.7
Stunting	Yes No	3223 5632	36.4 63.6
Wasting	Yes No	1080 7839	12.1 87.9
Size at birth (n=9905)	Large Average Small	3021 4196 2688	30.5 42.4 27.1
Vitamin A last 6 months (n=9805)	No Yes	4380 5425	44.7 55.3
Drugs for IP last 6 months (n=9808)	No Yes	8632 1176	88.0 12.0
Taking iron pills last 7 days (n=9838)	No Yes	9125 713	92.8 7.2

Table 3 Frequency of Childhood Morbidities in Children less than 59 Months of Age in Ethiopia

Symptoms	Presence	Frequency	Percent
Cough	No Yes, last two weeks Do not know	8337 1586 83	83.3 15.9 0.8
Short rapid breaths	No Yes Do not know	9028 891 87	90.2 8.9 0.9
Chest complaint	No Yes Do not know	9115 884 7	91.1 8.8 0.1
Over all ARI	Yes No	885 9121	8.8 91.2
Fever	No Yes Do not know	8564 1354 88	85.6 13.5 0.9
Diarrhea	No Yes, last two weeks Do not know	8826 1090 90	88.2 10.9 0.9
Morbidity combined	No morbidity One morbidity Multiple morbidity	7417 1097 1492	74.1 11.0 14.9

Abbreviation: ARI, acute respiratory infections.

acute respiratory infection as compared to children of households who use electricity (AOR= 1.904, 95% CI:1.152, 3.146). In this study there is a strong association between acute respiratory infection and altitude level; children from 1000 to 2000, 2000 to 3000 and greater than 3000 meters had 1.81, 1.89, and 2.24 times higher risk of developing acute respiratory infection compared to children from low altitude (less than 1000 meters) (AOR= 1.805, 95% CI: 1.403, 2.322, AOR= 1.882, 95% CI: 1.427, 2.483, & AOR= 2.241, 95% CI: 1.023, 4.907) respectively (Table 5).

Discussions

According to the WHO 2017 report, ARIs are among the leading causes of childhood diseases that often result in serious health complications and deaths in children under five years of age.[19] The Sustainable Development Goal (SDG) target 3.2 aimed, by 2030, to end preventable deaths of newborns and children under five years of age, with all countries aiming to reduce under-five mortality to at least as low as 25 per 1000 live births.[20] As part of the implementation, prevention of ARIs is considered an effective strategy. This study aimed at determining the

odds of having an acute respiratory infection as compared to children with average birth size, (AOR= 1.387, 95% CI: 1.198, 1.605).

Children from households who used animal dung as a source of cooking fuel had 90% higher odds of developing

Table 4 Frequency Distributions of Childhood Morbidities across Regions in Ethiopia

Region	Morbidity in the Last Two Weeks				
	Cough N (%)	Fever N (%)	Shortness of Breath N (%)	Chest N (%)	ARI Combined N (%)
Tigray	302 (30.4)	234 (23.6)	161 (16.2)	161 (16.2)	167 (16.8)
Afar	163 (16.8)	152 (15.6)	72 (7.4)	71 (7.3)	95 (9.8)
Amhara	158 (17.0)	113 (12.2)	109 (11.7)	107 (11.5)	77 (8.3)
Oromia	347 (23.2)	221 (14.8)	224 (15.0)	224 (15.0)	157 (10.5)
Somali	125 (8.9)	114 (8.1)	66 (4.7)	66 (4.7)	81 (5.8)
Benishangul	41 (5.0)	59 (7.2)	21 (2.6)	20 (2.5)	26 (3.2)
SNNPR	211 (17.5)	188 (15.6)	121 (10.0)	120 (10.0)	112 (9.3)
Gambela	55 (8.2)	95 (14.2)	40 (6.0)	40 (6.0)	41 (6.1)
Harari	41 (7.3)	53 (9.4)	17 (3.0)	17 (3.0)	30 (5.3)
Addis Ababa	68 (15.2)	66 (14.8)	29 (6.5)	27 (6.0)	51 (11.4)
Dire Dawa	75 (14.5)	59 (11.4)	31 (6.0)	31 (6.0)	48 (9.3)
Total	1586 (15.9)	1354 (13.5)	891 (8.9)	884 (8.8)	885 (8.8)

cross-regional variations and identifying the determinant factors of ARIs among children under five years of age in Ethiopia.

The study found that 8.8% of children under five years have reported history of ARI two weeks before the survey.

Despite various efforts made to prevent childhood diseases in Ethiopia, the prevalence has persisted since 2011.[4,21] Our findings showed that there is a huge disparity in the distribution of ARIs in children across the different regional states of Ethiopia. The highest prevalence of ARI, 16.8%,

Figure 1 The maps of regional states in Ethiopia. Image courtesy with permission from https://www.ethiovisit.com/addis-ababa/65/.

Table 5 Association between Acute Respiratory Infection and Predictor Variables among Children under five in Ethiopia

Variables	Levels	COR	AOR
Sex	Boy	1	1
	Girl	0.980 (0.883–1.088)	0.994 (0.883–1.119)
Child age (months)	<6		1
	6–11	1.502 (1.206–1.872)	1.466 (1.143–1.881)*
	12–23	1.410 (1.160–1.715)	1.390 (1.109–1.742)*
	24–35	1.168 (0.957–1.426)	1.238 (0.982–1.561)
	36–47	0.973 (0.794–1.193	0.980 (0.773–1.242)
	48–59	0.708 (0.574–0.873)	0.727 (0.571–0.925)*
Birth size	Average		1
	Smaller	1.340 (1.181–1.520)	1.387 (1.198–1.605)*
	Larger	1.036 (0.911–1.177)	1.144 (0.988–1.323)
Child is twin	Single birth		1
	1st of multiple	1.096 (0.681–1.763)	0.977 (0.571–1.670)
	2nd of multiple	0.968 (0.574–1.633)	0.930 (0.519–1.668)
Stunting	No		1
	Yes	0.930 (0.831–1.042)	0.941 (0.814–1.088)
Underweight	No		1
	Yes	0.991 (0.875–1.122)	0.955 (0.815–1.119)
Read magazine	No		1
	Yes		0.675 (0.399–1.142)
Education of mother	No education		1
	Primary	1.216 (1.080–1.370)	1.18 (1.02–1.36)
	Secondary	0.901 (0.724–1.121)	1.00 (0.76–1.33)
	Higher	0.769 (0.567–1.042)	0.95 (0.62–1.45)
Place of residence	Urban		1
	Rural	1.151 (1.003–1.320)	0.931 (0.689–1.259)
Cooking fuel	Electric and gas		1
	Kerosene	0.807 (0.306–2.123)	0.802 (0.244–2.64)
	Charcoal	0.957 (0.712–1.285)	1.01 (0.697–1.464)
	Wood, straw	1.031 (0.810–1.311)	1.267 (0.869–1.848)
	Animal dung	1.565 (1.100–2.213)	1.904 (1.152–3.146)*
	Others	0	0
Toilet facility	No facility	1	1
	Not improved	1.024 (0.911–1.150)	0.908 (0.775–1.063)
	Improved	0.985 (0.848–1.144)	1.047 (0.830–1.322)
Altitude (meters)	<1000	1	1
	1000–1999	1.701 (1.468–1.970)	1.805 (1.403–2.322)*
	2000–2999	1.780 (1.515–2.090)	1.882 (1.427–2.483)*
	≥3000	1.885 (1.205–2.950)	2.241 (1.023–4.907)*

Notes: *Statistically significant at *p*-value of 0.05 (95%CI not including 1)
Abbreviations: CO, crude odds ratio; AOR, adjusted odds ratio.

occurred in Tigray and the lowest, 3.2%, in Benishangul-Gumuz region. There could be several reasons for the regional variations in the disease distributions including environmental, climatic, and infrastructure difference across the regions. In addition, the difference in the altitude of the regions in Ethiopia could contribute to the difference in ARI. This study indicated that the age of children was a significant predictor of acquiring an ARI, where children

aged between six and 11, and 12 and 23 months had about 50% and 40% higher risk of ARI respectively compared to children less than six months. However, children aged 48 months and above had 27% less chance of getting an ARI compared to children aged less than six months. This could be due to the introduction of complementary feeding at the sixth month and increasing child mobility, which likely increases exposure to microbes and other risk factors.[22,23] However, as the age of children increases beyond 48 months the risk of ARI decreases, which could be due to maturation of immunity and adaptation to infectious agents.[24,25] Our finding is in line with a study conducted in the Democratic Republic of Congo where the risk of the ARI increased in the first 8–20 months after birth but improved gradually thereafter.[26]

In our study children who were smaller at birth were more likely to report an ARI compared to children with average birth size, where smaller sized children had a 38% higher chance of developing an ARI (AOR= 1.387, 95%CI: 1.198–1.605). This finding is consistent with a study conducted by Atul Choube et al in India, where significantly higher prevalence of ARI was observed among children having low birth weight.[27] The lower concentrations of interleukin 7 in plasma, and shorter telomere length in peripheral blood mononuclear cells among low birth weight children could increase the susceptibility to several infectious agents including acute respiratory infections.[28–32]

Household cooking fuel was found to affect ARI, children from households who use animal dung as a source of cooking fuel had a 90% higher risk of developing ARI compared to children from households who use electricity. Several studies support our finding, a study conducted in northwest Ethiopia revealed that children from households using wood, dung, or straw as a cooking fuel have a three-fold higher risk of suffering from ARI compared to children from households using electricity.[33] Similarly, a study done in Addis Ababa and Pakistan showed, the use of biomass fuels including animal dung for cooking exposes children to the risk of ARI.[34–36] This may be due to children exposed to cooking smoke coming from the combustion of the biomass, consequently leading to an ARI.[37]

In our study, there is a strong association between altitude and odds of getting an ARI in children; the disease revealed a trend of rising following increasing altitude level. Children living in the altitudes between 1000 and 2000, 2000 and 3000, and greater than 3000 meters had 1.81, 1.89, and 2.24 times higher risk of developing ARI compared to children from lower altitudes (less than 1000 meters). In the context of Ethiopia, electricity is accessible to very few households particularly in the urban areas, there is no access for the rural community to get cleaner cooking fuels. People often use wood, animal dung, straw, and other organic materials as a source of fuel to cook food. Especially people living at the higher altitude use biomass fuels both for cooking and heating their houses, these smoky wood stoves may lead children to be exposed to the smoke that might result in ARIs. In addition, several studies confirm that respiratory infection is a common health problem at high altitude compared to the lowlands.[38–40]

The use of data with large sample size and considering several explanatory variables make this study appealing. Moreover, the use of multilevel analysis is another strength of this study. Despite its strength, these findings should be interpreted considering the following limitations. First, the cross-sectional nature of the source data, does not let us measure seasonal variations in disease episodes or the impact on the results of this study. Second, our estimates on incidence of ARIs are based on women's self-report based on illness perception of the mothers could introduce bias . Third, the birth size of children is taken from subjective report of the mothers, which could have result bias. Nevertheless, these biases are nondifferential, as they are independent of the characteristics of the women or of their children.

Conclusions

Based on the findings our study, there is a huge regional disparity in the magnitude of ARI in children across the regions in Ethiopia; children in Tigray region were disproportionally more affected than any other regions in the country. The prevalence of ARI in Tigray region is nearly twice the national average. Therefore, the regional government, regional health bureaus, and other concerned organizations need to see and evaluate their activities in the to minimize the prevalence of ARI and similar childhood illnesses. The risk of getting ARI from the time of initiation of complementary food up to 24 months of age is much higher than the risk before six months, however, gradually the risk decreases from the age of 24 months onwards. The families, health-care workers and program planners on child health care should give emphasis to this critical period to reduce the risk of childhood diseases. Children with smaller birth size were more likely to report ARI, therefore, specifically, these highly vulnerable children should receive special attention in the health-care

system to minimize child mortality from ARI and its complications. Household cooking fuel is the other variable that showed significant association with ARI. The regional health offices should work on awareness to minimize exposure to smoke to prevent ARI. In addition, government and concerned organizations should work to access alternative clean cooking fuel sources. Children from households from a higher altitude above sea level should receive prior attention as they are more affected compared to their counterparts.

Ethics Approval and Consent to Participate

The data for this study was received from the DHS office upon request. The data was collected by Ethiopian Central Statistical Agency (CSA) and Federal Ministry of Health (FMoH) by technical assistance of ICF through the DHS Program. The ethical clearance was provided by the Federal Democratic Republic of Ethiopia Ministry of Science and Technology and the Institutional Review Board of ICF International. Written consent to participate in the study was obtained from parents and the data were recorded anonymously.

Data Sharing Statement

The study used the Ethiopian Demographic and Health Survey 2016. The data is available and can be obtained from the DHS (https://dhsprogram.com/Data/) upon request.

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Author Contributions

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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