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Multilevel Analysis of Acute Respiratory Infection Symptoms among under Five Children in Ethiopia

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Abstract

The main objectives of this study is modelling acute respiratory infection symptoms among under five children and to investigate how different explanatory variables measured at different level of hierarchical structures affects symptoms of ARI. This study used Ethiopian Demographic and Health Survey (EDHS) 2011 data, collected for 9625 children under five years old in Ethiopia and children are nested within eleven geographical regions. Binary logistic regression analysis and multilevel models were employed to predict the outcome. The study revealed that mothers educational level, age of children, number of children, mothers occupational status, supplementation of vitamin A, source of drinking water, type of toilet facility and wealth index of family were found to be the most important factors. And, the final model, random coefficient multilevel logistic regression suggests that there exists considerable differences in the ARI symptoms among under five children across the regions. It indicates that the variance of random component related to the random term were found to be statistically significant, implying that their is differences in the ARI symptoms for children across regions. The study suggests that improve mothers educational level in all of areas in order to address the problem through improving their income earning capacity, improve access of safe drinking water and the researcher who want to conduct ARI symptoms among children under five using EDHS data set should use multilevel model than classical regression models.

Keywords: Children under five years old; ARI symptoms; Classical logistic regression model; Multilevel logistic regression model; EDHS; Ethiopia

Introduction

Acute respiratory infection is a major cause of morbidity and mortality in developing and also developed countries. ARI is an infection of any part of respiratory tract or any related structures including para nasal sinuses, middle ear and pleural cavity. It includes, a new episode (occurring in an individual who has been free of symptoms for at least 48 hours) and also all infections of less than 30 days duration except those of the middle ear where the duration of acute episode is less than 14 days. In the developing countries out of ten, seven deaths in under 5 children are due to ARI [1].

ARI are classified as upper respiratory tract infection and lower respiratory tract infections. Upper respiratory tract infection is the most common infectious diseases and, which is all infection is the respiratory tract down to the larynx. It consists of the airways from the nostrils to the vocal cards in the larynx, including the para nasal sinuses and the middle ear. This includes common cold, sinusitis, ear infections, acute pharyngitis, epiglottitis, tonsillitis, and laryngitis of which ear infection and pharyngitis cause the more severe complications (deafness and acute rheumatic fever, respectively). The lower respiratory tract infection covers the continuation of the airways from the trachea and bronchi to the bronchioles and the alveoli and in which, all the infections are below the larynx. The common lower respiratory tract infections in children are pneumonia, bronchitis, empyema, lung, and bronchiolitis. The respiratory rate is valuable clinical sign for diagnosing acute lower respiratory infections in children who are coughing and breathing rapidly [2].

In Ethiopian DHS 2011, data on symptoms of ARI were collected by asking mothers whether their children under age five had been ill with a cough accompanied by short, rapid breathing in the two weeks preceding the survey. Children suffer four to eight episodes of acute respiratory infection on average every year, with the highest occurrence in urban areas in overcrowded living conditions [3].

Previous studies on ARI among children under five years old mainly descriptive in nature. The present study is based on a recent national data from 2011 Demographic and Health survey with reference under five years children using binary logistic regression and multilevel binary logistic regression analysis to examine the impact of contextual factors of ARI among under-five children in Ethiopia.

Methodology

Study area and population

Ethiopia is an ancient country with rich diversity of peoples and cultures existed for more than 3,000 years. Ethiopia embraces a complex variety of nation, nationalities and peoples of different linguistic groups. The total number of persons enumerated in the third Population and Housing Census was 73,750,932. Of these, 37,217,130 50.5% were males and 36,533,802 (49.5%) were females (CSA, 2008). The research utilized 2011 EDHS data, as a secondary source, that was conducted by MOH and Central Statistical Agency from September 2010 to June 2011 with a nationally representative sample of nearly 18,500 households. A total samples of 9625 children were included in the study.

Statistical models

In this study, single and Multilevel logistic regression models

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were employed to identify factors of ARI symptoms among under five children. The data were analyzed using single level and binary logistic regression by assuming that the occurrence of ARI symptoms are independent among children.

Logistic regression model: Logistic regression is a type of regression analysis used for predicting the outcome of a categorical variable that can take on a limited number of categories based on one or more predicted variables [4]. Binary logistic regression is a form of regression, which is used when the dependent variables is dichotomous, and it can take the value 1 with probability of success p_i or the value 0 with a probability of failure 1- p_i [5].

$$Y_{ij}=\begin{cases}1 & \text{ifchildhasARIsymptomsintwoweekspreceding survey}\\ 0 & \text{otherwise}\end{cases} \quad (1)$$

$i = 1,2,\ldots,k_j$ and $j = 1,2,\ldots,N$

Where K- is the number of children having ARI symptoms before two weeks in each regions j and N- is the number of regions.

The logistic model can be defined in terms of matrix as follows: Let $X_{n(k+1)}$ denote the single level binary logistic regression data matrix of k predictor variable of child from ARI symptoms before two weeks is given as:

$$X=\begin{pmatrix}1 & X_{11} & X_{12} & \cdots & X_{1k}\\ 1 & X_{21} & X_{22} & \cdots & X_{2k}\\ \vdots & \vdots & \vdots & & \\ 1 & X_{n1} & X_{n2} & \cdots & X_{nk}\end{pmatrix},\quad b=\begin{pmatrix}\beta_0\\ \beta_1\\ \vdots\\ \beta_k\end{pmatrix}$$

Where X is the design matrix of size $n \times (k+1)$, b is the vector of unknown coefficients of the explanatory variables including intercept of size $(k+1) \times 1$. Then, the logistic regression model can be given as:

$$\pi_{ij}=\frac{exp(\beta_0+\beta_1X_{i1}+\beta_2X_{i2}+\ldots\beta_kX_{ik})}{1+exp(\beta_0+\beta_1X_{i1}+\beta_2X_{i2}+\ldots\beta_kX_{ik})}=\frac{exp(\mathbf{X}_i b)}{1+exp(\mathbf{X}_i b)} \quad (2)$$

Where π_{ij} (i =1,2,..., k_j, j=1,2,...,N) is the probability of i^{th} a child has ARI symptoms before two weeks given the vectors of predictors (X_i) of row **X**.

Parameter estimation in logistic regression model: The maximum likelihood method is appropriate for estimating the logistic model parameter due to this less restrictive nature of the underlying assumptions [6]. Hence, in this study the maximum likelihood estimation techniques was used to estimate parameter of the model. The maximum likelihood function of Y is given by:

$$L=\prod_{i=1}^{n}P(Y_i \mid X_{i1},X_{i2},\ldots,X_{ik})=\prod_{i=1}^{n}\left(\frac{exp(\mathbf{X}_i b)}{1+exp(\mathbf{X}_i b)}\right)^{y_i}\left(\frac{1}{1+exp(\mathbf{X}_i b)}\right)^{1-y_i} \quad (3)$$

The maximum likelihood estimates of the parameters b are obtained by maximizing the log-likelihood function which is given by:

$$logL=\sum_{i=1}^{n}y_i log\left(\frac{exp(\mathbf{X}_i b)}{1+exp(\mathbf{X}_i b)}\right)+(1-y_i)log\left(\frac{1}{1+exp(\mathbf{X}_i b)}\right) \quad (4)$$

The assessment of goodness fit of logistic regression model: Once a model has been fitted to a given data, it is a good statistical practice to check the adequacy of the model, which is essentially checking the agreement between the observed and fitted values under the model. Deviance Analysis, Hosmer and Lemeshow and Wald test are the most common methods used.

Deviance analysis: The likelihood ratio statistic is obtained by subtracting the deviance (-2LL) for the final (full) model from the deviance for the intercept only model. This log likelihood ratio test uses the ratio of the maximized value of the likelihood function for the intercept only model L_0 over the maximized value of the likelihood function for the full model L_1. The likelihood test statistic is given by:

$$G^2=-2log\left(\frac{L_0}{L_1}\right)=-2[log(L_0)-log(L_1)]=-2[LL_0-LL_1] \quad (5)$$

Where LL_0 the log likelihood value of the model which is have the intercept term only and LL_1 is the log likelihood value of the full model.

The Hosmer and Lemeshow test statistic: Hosmer and Lemeshow test statistic measure the correspondence between the actual and predicted values of the dependent variable. Better model fit is indicated by a smaller difference in the observed and predicted classification [7].

The Hosmer and Lemeshow test statistic is given by

$$\hat{C}=\sum_{i=1}^{k}\frac{(O_k-E_k)^2}{V_k} \quad (6)$$

Where O_k the observed number of events in the k^{th} group, E_k is the expected number of events in the k^{th} group, and V_k is a variance correction for the K^{th} group.

The Wald test: The Wald statistic is an alternative test which is commonly used to test the significance of individual logistic regression coefficient for each independent variable. The hypothesis to be tested is $H_0: \beta_j = 0$ vs $H_1: \beta_j \neq 0$ $j = 1,2,\ldots,k$ at α level of significance.

The Wald test statistic, Z for this hypothesis is

$$Z^2=\left(\frac{\hat{\beta}}{SE(\hat{\beta}_j)}\right)^2 \approx \chi^2_{(1)} \quad (7)$$

The Wald test is one of a number of ways of testing the whether the parameter associated with a group of explanatory variable are zero [8].

Multilevel logistic regression models

Multilevel Statistical Model are always needed if multi-stage sampling design has been employed. In such a case the dependency of observation within group is the focal interest because it reflect that group differs in certain aspects [9].

In this study I start to build multilevel modeling of individual and regional level variables on ARI symptoms among under-five children starting from empty, random intercept and random coefficient binary logistic regression model (Appendix).

Two-level model: The basic data structure of the two-level regression is a collection of N groups (units at two levels), within in group $j,(j = 1,2,3\ldots,N)$ random sample of k_j level-one units (individual). The outcome variable is dichotomous Y_{ij}, (i =1,2,..., k_j and j=1,2,...,N) and denoted by for level-one unit i nested in level-two group j.

Therefore, the two-level logistic regression model can be written as:

$$logit(\pi_{ij})=\beta_0+\beta_{1j}X_{1ij}+U_{0j} \quad (8)$$

Where U_{oj} is the random effect at level 2. This model can be splitting into two models: one for level one and the other for level two.

$$logit(\pi_{ij})=\beta_{0j}+\beta_{1j}X_{ij} \quad (9)$$

$$\beta_{0j}=\beta_0+U_{0j} \quad (10)$$

The dichotomous outcome variable for the child i in region j, Y_{ij} can be expressed as the sum of the probability in region j, (average proportion of success) plus some child dependent residual ε_{ij}, that is Y_{ij}

$= \pi_j + \varepsilon_{ij}$. The residual term is assumed to have zero mean and variance $\pi_j(1-\pi_j)$.

$$\bar{Y}_{.j} = \hat{\pi}_j = \frac{1}{k_j}\sum_{i=1}^{k_j} Y_{ij} \tag{11}$$

The overall average or the overall proportion of success is

$$\hat{} = \bar{Y} = \text{—}\sum_{j=1}\sum_{i=1} Y_{ij} \tag{12}$$

Heterogeneous proportion: Multilevel analysis is performed only if heterogeneity of proportions between the groups is satisfied. The test statistic for this purpose is given by:

$$\chi^2 = \sum_{j=1}^{N} k_j \frac{(\hat{\pi}_j - {}_{\pi})^2}{\hat{\pi}(1-\hat{\pi})} \tag{13}$$

Empty model: The empty two- level model for a dichotomous outcome variable refers to a population of groups(region) and specifies the probability distribution for group dependent probability π_j (probability of i^{th} child in j^{th} region having ARI symptoms before two weeks preceding survey date), then the dichotomous outcome: is given by $Y_{ij} = \pi_j + \varepsilon_{ij}$ without taking further explanatory in to account. This is expressed for a general link functions $f(\pi_j)$, by the formula.

$$f(\pi_i) = \beta_0 + Uoj \tag{14}$$

Where β_0 is the population average of the transformed probability and U_{oj} the random deviation from this average for group j. The ICC is represented by $\rho = \frac{\sigma_u^2}{\sigma^2 + \sigma_u^2}$, where σ_u^2 is between group variance estimated by U_{oj} and σ^2 is the within group variance.

Denote by π_0 the probability corresponding to the average values β_0, as defined by $f(\pi_0) = \beta_0$ for the logit function, the so-called logistic transformation of β_0, is defined by:

$$\pi_0 = logit(\beta_0) = \frac{exp(\beta_0)}{1 + exp(\beta_0)} \tag{15}$$

Random intercept model: In this case the random intercept model is consider only random effect of individual and regional level factors meaning that the community differ with respect to the average value of having ARI symptoms of child before two weeks preceding survey date.

Let assume that X is individual and regional(group) level predictors data matrix denoted by X_h, (h = 1,2,…,k) with their values indicated by X_{hij} [9]. Random intercept model express as the log-odds, i'e. the logit of π_{ij} as a sum of a linear function of the explanatory variables.

$$logit(\pi_{ij}) = \beta_{0j} + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \ldots + \beta_k X_{kij} = \beta_{0j} + \sum_{h=1}^{k} \beta_h X_{hij} \tag{16}$$

Where the intercept term β_{0j} is assumed to vary randomly and is given by the sum of an average intercept β_0 and group dependent deviations, U_{0j} is given by $\beta_{0j} = \beta_0 + U_{0j}$. Thus,

$$logit(\pi_{ij}) = \beta_0 + \sum_{h=1}^{k} \beta_h X_{hij} + U_{0j} \tag{17}$$

U_{0j} is the random part of the model and assumed that they are mutually independent and normally distributed with mean zero and variance σ_0^2.

Random coefficient model: In the random coefficients model, both the intercepts and slopes are allowed to differ across the regions; the effect of explanatory variables on the ARI symptoms status of the children varies by group. Consider a model with group-specific regression of logit of the success probability. $logit(\pi_{ij})$, on a single level-one explanatory variable x,

$$logit(\pi_{ij}) = \beta_{0j} + \beta_{1j} X_{1ij} \tag{18}$$

The intercept β_{0j} as well as the regression coefficient or slopes, β_{1j} are groups dependent. These group dependent coefficients can be split into an average coefficient and the group dependent deviation:

$$logit(\pi_{ij}) = (\beta_0 + U_{0j}) + (\beta_1 + U_{1j}) X_{1ij} = \beta_0 + \beta_1 X_{1ij} + U_{0j} + U_{1j} X_{1ij} \tag{19}$$

Now, we have two random effect at group level, the random intercept U_{0j} and the random slope U_{1j}. It assumed that the level two residual have mean zero. And the variance are denoted by σ_0^2, σ_1^2 and covariance is σ_{01}.

Where, β_0 is the average intercept of the response variable, β_1 is the regression coefficient given explanatory variable X_1, $\beta_0 + \beta_1 X_{1ij}$ is the fixed part of the model and $U_{0j} + U_{1j} X_{1ij}$ is the random part of the model can be considered as interaction by group and predictor(X).

But the group dependent coefficients can be split into an average coefficient and the group dependent deviation as $\beta_{0j} = \beta_0 + U_{0j}$ and $\beta_{kj} = \beta_k + U_{kj}$

$$logit(\pi_{ij}) = \beta_0 + \sum_{h=1}^{k} \beta_h X_{hij} + U_{0j} + \sum_{h=1}^{k} U_{hj} X_{hij} \tag{20}$$

Where, $\beta_0 + \sum_{h=1}^{k} \beta_h X_{hij}$ is the fixed part of the model and $U_{0j} + \sum_{h=1}^{k} U_{hj} X_{hij}$ is the random part of the model. $U_{0j}, U_{1j}, \ldots, U_{kj}$ are assumed to be independent between groups but may be correlated within groups.

Estimating techniques in multilevel regression model: Parameter estimation for multilevel model is not straightforward like the methods for logistic regression. The most common methods for estimating multilevel logistic regression model are based on likelihood. Among these methods, Marginal Quasi likelihood (MQL) [10]. Penalized Quasi-likelihood Breslow and Clayton [11], Numerical procedure, Bootstrap and Gibbs sampler are the most prevailing approximate procedures. Both MQL and PQL are based on Taylor series expansion to achieve the approximation.

For two-level logistic Bernoulli response model the marginal likelihood function is given by:

$$L(\text{b}, \text{w} \mid data) = \prod_j f \prod_{i-1} \left((\pi_{ij})^{y_{ij}} (1-\pi_{ij})^{1-y_{ij}} \right) f(U_{ij}, \omega) du_j \tag{21}$$

$$\pi_{ij} = \left(1 + exp(-X_{ij}\beta_j)\right)^{-1}, \beta_j = \text{b} + U_j$$

where $f(U_{ij}; \text{w})$ is typically assumed to be the multivariate normal density and can be written in the form $\int P(U_j) f(U_j) du_j$. If we consider the model with a single random intercept at level two we have:

$$P(U_j) = \prod_j \left(\frac{exp(X_{ij}\text{b} + U_j)}{(1 + exp(X_{ij}\text{b} + U_j))^2} \right) f(U_j) = \sigma_u^2 \varphi \tag{22}$$

In this study, the estimation have been done using IGLS algorithms (techniques) using the software STATA [12].

Model selection: The AIC (Akaike Information Criteria) and the BIC (Bayesian Information Criteria) are two popular measures for comparing maximum likelihood models. AIC and BIC are defined as:

$$AIC = -2 * log(likelihood) + 2 * k$$

$$BIC = -2 * log(likelihood) + log(N) * k$$

Where k is the rank of variance–covariance matrix of the parameters and N is the number of observations used in estimation. The model with the smaller value of the information criterion is considered to be better [13].

Results

The total number of children covered in the present study was 9625. Logistic regression and multilevel logistic regression analysis are used to identify the risk factors. The statistical test of significance of individual coefficients of each ARI symptoms among under five children indicators are based on Wald Chi-square and P-value of respective coefficients as shown in Table 1. The result revealed that mother's age, region, mother's educational level, source of drinking water, type of toilet facility, mother's occupation status, age of child, wealth index, and supplementation of vitamin A are found to be the significant risk factors for occurrence of ARI symptoms among under five children at 5% level of significance. The impact of type of cooking fuels, body mass index and number of children in household are found to be insignificant.

Region was significantly related with ARI symptoms ($P < 0.05$). The odds of having ARI symptoms for children in Afar, SNNP and Addis Ababa were not significantly different as compared to Dire Dawa. Children in Harari regional state (OR: 0.527, 95%CI:(0.358-0.777)) had lower risk of ARI symptoms as compared to Dire Dawa. Children who lived in Tigray (OR: 2.515, 95%CI: (1.884-3.358)), Amhara (OR: 1.381, 95%CI: 1.023-1.866), Oromiya (OR: 1.687, 95%CI: (1.27-2.24)), Somali (OR: 2.705, 95%CI:(2.002-3.656)), Benishangul-Gumuz (OR:2.106, 95%CI: (1.556-2.851)), Gambela (OR: 1.797, 95%CI: (1.32-2.447)) and Harari (OR: 0.527, 95%CI: (0.358-1.258)) regional states are significantly higher risk of ARI symptoms as compared to Dire Dawa.

The relationship between wealth index and ARI symptoms was also significant. The odds ratio indicates that children from lowest and second economic status, the likelihood of having ARI symptoms are decreased by 27.2% and 32.1%, as compared to highest economic status ,respectively . However, middle and fourth economic status are not significantly different as compared to economic status highest.

Similarly, age of child was also significantly associated with ARI symptoms. The odds of child with less than 6 month, 6-23 month, and 24-35 month to have ARI symptoms are increased by 30.2% (OR: 1.302, 95%CI:(1.087-1.558)), 30.9% (OR: 1.309, 95%CI: (1.093-1.568)) and 33.7% (OR: 1.337, 95%CI: (1.152-1.645)),respectively, as compared to (48-59 month). This means that the chance of having ARI symptoms is declining with increasing age of a child. Mother's occupation was associated with prevalence of ARI symptoms among under five children. The odds ratio of children whose mothers have no occupations was decreased by 15.8% as compared to Mothers having an occupation.

The odds of children having mothers with no education, primary and secondary level, being have ARI symptoms is significantly not different from that having mothers with more than secondary level. Though the mother's age is significant, all the age groups are not significant at the 5% level. Likewise, the odds of children with no toilet facility, to have symptoms of ARI is increased by 24.3% (OR: 1.243, CI: (1.1-1.405)), as compared to children having toilet.

Finally, the odds of children used pipe and tube water and, surface and spring water are significantly not different from that used other source of water. And, the predictor of cooking fuels is not significant at 5% level. 1.7

Multilevel binary logistic regression

In multilevel binary logistic regression analysis two level clusters are used with regions as the second level units and under five children as the first level units. The first step in multilevel analysis is to investigate the necessity of using a multilevel model. A Chi-square test was applied to assess the importance of using multilevel model and heterogeneity between regions. Therefore, multilevel logistic regression model is employed (Table 2).

Model comparisons: Results based on AIC, suggesting that random coefficients binary logistic regression model as the better model for ARI symptoms of children variation among regional states of Ethiopia as compared to other multilevel models (Table 3).

Result of multilevel empty regression analysis

The probability of deviance of likelihood ratio based on chi-square =206.57 is greater than χ^2=5.99 at one degree of freedom with P-value=0.000, which is less than 0.05 level of significance. Therefore, multilevel empty binary logistic regression analysis is found to be significant, the significance of this test further implies that an empty model with random intercept is more appropriate than an empty model without random intercept.

The overall mean of ARI symptoms is estimated at $\hat{\beta}_0$= -1.408. The intercept, representing the expected change in ARI symptoms for children is significant at 5% level of significance, implies the intercept estimates of -1.408 is now the estimated log-odds of ARI symptoms for an individual children living in an average region. The variance component corresponding to the intercept for region j is σ_o^2=0.447 with standard error of 0.101, demonstrating that the inclusion of intercept in regional-level variables will explain much of the level 2 variation. It indicates that variations of ARI symptoms among regional states of Ethiopia was non-zero before predictor variables are included in the model.

The result in Table 4 shows that the intra-region correlation coefficients was statistically significant at the 5% level and 5.72% of total variability of prevalence of ARI symptoms was due to variations within regions. The significance test of level two variance and intraclass correlation all suggests important between and within regional variations.

Results of random intercept regression analysis

The random intercept regression analysis for ARI symptoms among under five children is found to be significant based on the difference between log-likelihood of multilevel empty and random intercept regression analysis. The probability of deviance based on chi-square =123.0736 is greater than χ^2=41.337 at 30 degree of freedom with P-value=0.000, which is less than 0.05 level of significance. This suggests that, after controlling all indicators of ARI symptoms, the intercept varied across the regions (the variations of ARI symptoms among regional states of Ethiopia was non-zero).

The variance component for constant term is significant, indicating strong evidence of the variation across regions for ARI symptoms among under five children was non-zero. The intra-region correlation coefficient is statistically significant at 5% level and 5.9% of total variability in ARI symptoms was due to variations within regions when explanatory variables are included to the model.

The result revealed that, mothers educational level, age of child, mothers occupation, vitamin A supplementation, source of drinking

Variables	β	S.E	Wald	df	P-value	Exp(β)	95% CI.for Exp(β)	
							Lowest	Upper
Mother's age (ref: 45-49)			14.886	6	0.015*			
15-19	0.155	0.222	0.0.486	1	0.465	1.167	0.756	1.802
20-24	0.238	0.191	1.556	1	0.191	1.269	0.873	1.845
25-29	0.028	0.188	0.023	1	0.85	1.029	0.712	1.486
30-34	-0.04	0.19	0.044	1	0.84	0.961	0.662	1.394
35-39	-0.49	0.193	0.064	1	0.803	0.953	0.653	1.389
40-44	-0.004	0.206	0	1	0.993	0.996	0.665	1.492
Region ref: Dire Dawa			181.253	10	0.000*			
Tigray	0.922	0.147	39.138	1	0.000*	2.515	1.884	3.358
Afar	0.213	0.159	1.793	1	0.161	1.238	0.906	1.692
Amhara	0.323	0.153	4.434	1	0.027*	1.381	1.023	1.866
Oromiya	0.523	0.145	13.059	1	0.000*	1.687	1.27	2.24
Somali	0.995	0.154	41.964	1	0.000*	2.75	2.002	3.656
Benishangul -Gumuz	0.745	0.154	23.268	1	0.000*	2.106	1.556	2.85
SNNP	0.194	0.152	1.62	1	0.173	1.214	0.901	1.635
Gambela	0.586	0.157	13.864	1	0.000*	1.797	1.32	2.447
Harari	-0.64	0.198	10.489	1	0.001*	0.527	0.358	0.777
Addis Ababa	-0.187	0.213	0.775	1	0.385	0.829	0.546	1.258
Mother's Education ref: more than Secondary)			8.521	3	0.043*			
No Education	-0.007	0.225	0.001	1	0.98	0.993	0.639	1.543
Primary	0.177	0.223	0.63	1	0.405	1.194	0.771	1.849
Secondary	0.2	0.253	0.626	1	0.423	1.222	0.744	2.0007
Source of water (ref: other)			7.134	2	0.026*			
Pipe and Tube water	0	0.374	0	1	0.991	1	0.48	2.081
Surface and Spring	0.177	0.372	0.227	1	0.622	1.194	0.576	2.476
Toilet facility (ref:had toilet)								
No Toilet	0.217	0.062	12.134	1	0.000*	1.243	1.1	1.405
Cooking fuels (ref:Other)			2.487	5	0.778			
Electricity	-0.4	0.517	0.599	1	0.439	0.67	0.243	1.847
Kerosene	-0.089	0.471	0.036	1	0.849	0.914	0.363	2.302
Charcoal	-0.023	0.406	0.003	1	0.955	0.978	0.441	2.166
Wood	-0.059	0.393	0.023	1	0.88	1.061	0.491	2.293
Animal dung	-0.036	0.416	0.007	1	0.931	0.965	0.427	2.18
Mother occupation (ref: Working)								
Not working	-0.172	0.057	9.033	1	0.003*	0.842	0.752	0.942
Age of child (ref: 48-59)			15.982	4	0.003*			
< 6 month	0.264	0.092	8.26	1	0.004*	1.302	1.087	1.558
6-23 month	0.27	0.092	8.58	1	0.003*	1.309	1.093	1.568
24-35 month	0.32	0.091	12.412	1	0.000*	1.377	1.152	1.645
36-49 month	0.115	0.093	1.542	1	0.214	1.122	0.936	1.345
Wealth index (ref: Highest)			19.903	4	0.001*			
Lowest	-0.317	0.109	8.446	1	0.004*	0.728	0.588	0.902
Second	-0.387	0.114	11.628	1	0.001*	0.679	0.543	0.848
Middle	-0.067	0.11	0.367	1	0.545	0.935	0.754	1.161
Fourth	-0.137	0.107	1.631	1	0.202	0.872	0.706	1.076
Number of child(ref:>= 2)								
Vitamin A (ref: Yes)								
No	-0.145	0.063	5.324	1	0.019*	0.865	0.765	0.978
Body mass index								
(ref: >= 25)			3.53	2	0.171			
< 18.5	-0.185	0.124	2.22	1	0.136	0.831	0.652	1.06
18.5-24.9	-0.216	0.116	3.463	1	0.063	0.806	0.641	1.012
Constant	-1.78	0.369	23.267	1	0.000*	0.169		

(*Significant at 5% level)

Table 1: Result of Binary Logistic Regression Analysis for Symptoms of ARI.

Statistics	Value	df	P-value
Pearson Chi-square	247.6	10	0.000*
Number of Valid cases	9625		

(*Significant at 5% level)

Table 2: Multilevel binary logistic regression.

Model Comparison Statistics	Empty Model	Random Intercept	Random Coefficient
-2 log likelihood	9788.8416	9665.768	9650.66
Deviance based on chi-square	206.57	123.0736	15.108
Tabulated value of chi-square	5.991	41.337	10.075
P-value	0.000*	0.000*	0.0099*
AIC	9792.842	9729.768	9724.66
Degree of freedom	2	32	37

(*Significant at 5% level)

Table 3: Multilevel Model Comparison Statistics.

Symptoms of ARI	β	S.E	Z	P-value	95% CI.	
					Lowest	Upper
Fixed effect						
β_0= intercept	-1.408	0.138	-10.21	0.000*	-1.678	-1.1376
Random Part						
$\sigma_0^2 = Var(U_{0j})$	0.447	0.101	4.41	0.000*	0.286	0.6969
Intra-correlation coecents						
ICC(ρ)	0.0572	0.0244	2.344	0.019*	0.024	0.128

(*Significant at 5% level, ICC: Intra class correlation)

Table 4: Results of Multilevel Empty Regression Analysis.

water, type of toilet facility, number of children and wealth index are found to be significant, indicating strong effect on ARI symptoms among under five children and also contribute to ARI symptoms variations among regional states in Ethiopia. However, the impacts of mothers age, body mass index and type of cooking fuels are found insignificant, suggesting no evidence for the effects of those risk factors on ARI symptoms among under five children.

The odds of children having mothers with no education level, to have ARI symptoms is increased by 20.3% with (OR: 1.203, CI: (1.057, 1.369)) as compared to above secondary level education. While, the odds of being having symptoms of ARI for primary or secondary level educated mother, are not significantly different as compared to above secondary education. The odds of child with age (36-47) month, to have ARI symptoms decreased by 23.3% (OR: 0.767, CI: (0.641, 0.9179)) as compared to age of (48-59) month.

Likewise, the odds of children having mothers no occupation, to have ARI symptoms is increased by 19.2% (OR: 1.192, CI (1.065, 1.333)) as compared to mothers having occupation. Based on source of drinking water, the odds of children using surface and spring water, being having ARI symptoms is increased by 19.56% with (OR: 1.1956, CI: (1.048, 1.363)).

Similarly, the odds of children having household with wealth index of second, middle and fourth being having ARI symptoms are 1.275 times (OR: 1.187, CI:(1.088, 1.668)), 1.187 times (OR: 1.187, CI:(0.9956, 1.416)),and 1.345 times (OR: 1.345, CI (1.0884, 1.668)) respectively, as compared to highest economic status. While, the odds of being having ARI symptoms, for wealth index of poorest, is not significantly different from that of highest economic status. Finally, the odds of child having no toilet, to have ARI symptoms, is reduced by 19.33% with (OR: 0.8067, CI: (0.714, 0.911)) as compared to having toilet. Since, random intercept is significant after controlling all indicators for ARI symptoms of children among regional states may not only by intercept (Table 5).

Results of random coefficient regression analysis

Result on Table 5 is obtained by including level two random coefficient of mothers educational, and mothers occupation and an overall (level-2) or regional variance constant term σ_0^2 together with variance and covariance terms representing the random effects of predictors. In Table 5 the value of var(U_{0j}),var(U_{1j}) and var(U_{2j}) are estimated the variance intercepts, slope of mothers educational and slope of mother occupation. All the region wise intercept and slope vary significantly, there is significant variation in the effect of these explanatory variables across the regions.

The results shows that the listed predicted variable contribute significantly to the ARI symptoms among under five children. The random coefficients estimates for intercepts and slopes vary significantly at 5% significance level, which implies that there is considerable variation in the effects of mothers educational and mothers occupation, these variables differ significantly across the regions. The variance component corresponding to the slope of mothers educational is 0.202, which is relatively large with respect to standard error, this suggests that the effect of mothers education may be justified in constructing the effect to be random and between regions variance in the effect of mothers educational is estimated as 0.202.

The effect of having no education for mothers as log-odds of ARI symptoms among under five children in region j is estimated as 0.158+ $\hat{U}_{1j}$ and the between -regions variance in the effects of mothers education is estimated as 0.202. The random effects of mothers occupation on the log- odds of ARI symptoms in region j is estimated as 0.2193+ U_{1j}, and between regions variance in the effect of mother occupation is estimated as 0.156.

The significance of this difference further indicates that a model with a random coefficient is more appropriate to explain regional variation than a model with fixed coefficients. In general, the result of the multilevel logistic regression analysis suggests that there is exist differences in the ARI symptoms among the regions in Ethiopia (Table 6).

Discussion

This study was intended to model acute respiratory infection symptoms, among under five children in Ethiopia using the Ethiopian Demographic and Health Survey data (EDHS, 2011). Accordingly, different models are fitted to the data to identify socio-demographic, economic, nutritional, environmental and health related factors of ARI symptoms among under five children in Ethiopia. First, the binary logistic regression model was fitted to the data and significant variables were considered for the further investigation in multilevel models. Secondly, the multilevel model were fitted, since multilevel model was stepwise, on the first step the empty model or intercept only was fitted to check whether multilevel effects or heterogeneity exists. On the second step random intercept was fitted and in the last step random coefficients or random slope model is fitted. The details of discussion for the result obtained from above models are given below.

Based on Chi-square test of association region, mothers educational level, wealth index of families, age of children, source of drinking water,

Variables	β	S.E	Z	P-value	Odds	95% CI.	
Fixed parts						Lowest	Upper
Mother's age							
(ref: 45-49)							
15-19	0.0875	0.137	0.64	0.522	1.0914	0.8348	1.4269
20-24	-0.1513	0.1349	-1.12	0.262	0.8595	0.6598	1.1197
25-29	-0.2106	0.1406	-1.5	0.134	0.81	0.6149	1.06723
30-34	-0.203	0.1446	-1.4	0.16	0.816	0.615	1.083
35-39	-0.156	0.1643	-0.95	0.341	0.855	0.6198	1.1802
40-44	-0.1548	0.22	-0.7	0.484	0.8565	0.5548	1.322
Mother's Education ref: (more than Secondary)							
No Education	0.1846	0.0659	2.8	0.016*	1.2027	1.056	1.3688
Primary	0.2045	0.1613	1.27	0.205	1.227	0.8945	1.6832
Secondary	0.005	0.2245	0.02	0.982	1.005	0.647	1.56
Age of child							
(ref: 48-59)							
< 6 month	0.00536	0.079	0.07	0.946	1.005	0.861	1.174
6-23 month	0.0543	0.08	0.67	0.501	1.0558	0.9013	1.237
24-35 month	-0.1499	0.086	-1.74	0.016*	0.8607	0.727	1.0188
36-49 month	-0.2653	0.0916	-2.89	0.004*	0.767	0.641	0.918
Number of child(ref:>= 2)							
< 2 children	-0.0824	0.0594	-1.39	0.03*	0.9208	0.8196	1.0345
Mother occupation							
(ref: Working)							
Not working	0.1755	0.0572	3.07	0.001*	1.192	1.065	1.333
Vitamin A (ref: Yes)							
No	0.1459	0.0626	2.33	0.048*	1.157	1.0233	1.3084
Source of water							
(ref: other)							
Pipe and Tube water	0.0124	0.374	0.03	0.000*	1.012	0.486	2.1087
Surface and Spring	0.1786	0.0669	2.67	0.008*	1.1956	1.0484	1.3632
Second	0.2435	0.0861	2.83	0.002*	1.275	1.0775	1.51
Middle	0.172	0.0898	1.91	0.027*	1.187	0.9956	1.416
Fourth	0.298	0.1089	2.74	0.001*	1.345	1.0884	1.668
Body mass index							
(ref: >= 25)							
< 18.5	-0.0495	0.0593	-0.84	0.403	2.68	-0.166	0.067
18.5-24.9	0.087	0.119	0.73	0.466	1.091	-0.1465	0.32
constant	-1.97	0.3884	-5.07	0.000*		-2.733	-1.21
Random parts							
$\sigma_0^2 = Var(U_{0j})$	0.454	0.1041	4.36	0.000*		0.2896	0.71178
$\rho(ICC)$	0.0591	0.02551	2.32	0.02*		0.02487	0.133449

Table 5: Results of Random Intercept Regression Analysis.

type of toilet facility, number of children in household, mothers age, mothers occupation, vitamin A supplementation, body mass index of mothers and type of cooking fuels are variables having significant association with ARI symptoms among under five children. The factor of sex of child, type of place residence, breastfeeding status, had fever in last 24 hours and mothers smoking status have no significant association with ARI symptoms among under five children.

The result from binary logistic regression analysis reveals that region, mothers age, mothers educational level, source of drinking water, toilet facility, mothers occupation, age of children, wealth index and vitamin A supplementation have significant effects on ARI symptoms among under five children at 5% level of significance. These results are consistent with the previous study by Kazi. Number of children, body mass index and type of cooking fuels have no significant effects on symptoms of ARI among under five children.

From binary logistic regression analysis, ARI symptoms among under five children was significant association with regions. It revealed that the probability of children living Tigray, Amhara, Oromiya, Somali, Benishangul-gumuz, Ganbela and Harari regions have higher ARI symptoms before two weeks preceding the survey than children who living in Dire Dawa regions. These due to symptoms of ARI variation among regional states was non-zero or high region effects. While, the odds of children living in Affar and Addis Ababa, being have ARI symptoms before two weeks is significantly not different from that living in Dire Dawa.

Variables	β	S.E	Z	P-value	Odds	95% CI.	
Fixed parts						Lowest	Upper
Mother's age							
(ref: 45-49)							
15-19	0.097	0.151	0.71	0.479	1.102	0.842	1.441
20-24	-0.144	0.117	-1.06	0.288	0.866	0.665	1.129
25-29	-0.2013	0.115	-1.43	0.153	0.817	0.62	1.077
30-34	-0.189	0.1188	-1.32	0.186	0.827	0.624	1.096
35-39	-0.091	0.148	-0.56	0.575	0 .913	0.664	1.254
40-44	-0.1497	0.1887	-0.68	0.495	0.861	0.56	1.323
Mother's Education ref: (more than Secondary)							
No Education	0.158	0.074	2.5	0.016*	1.17	1.0346	1.33
Primary	0.2035	0.194	1.29	0.198	1.226	0.899	1.67
Secondary	-0.625	0.194	-0.28	0.778	0.9393	0.6074	1.453
Age of child							
(ref: 48-59)							
< 6 month	-0.0049	0.0785	-0.06	0.874	0.995	0.852	1.1615
6-23 month	0.0165	0.0805	0.21	0.839	1.0166	0.8704	1.187
24-35 month	-0.194	0.0675	-2.37	0.015*	0.823	0.701	0.967
36-49 month	-0.276	0.064	-3.27	0.001*	0.758	0.642	0.895
Number of child(ref:>= 2)							
< 2 children	-0.1618	0.0611	-2.25	0.031*	0.85	0.7388	0.979
Mother occupation							
(ref: Working)							
Not working	0.2193	0.094	2.9	0.003*	1.245	1.074	1.444
Vitamin A (ref: Yes)							
No	0.122	0.0663	2.08	0.037*	1.13	1.007	1.267
Source of water							
(ref: other)							
Pipe and Tube water	0.237	0.081	3.72	0.000*	1.267	1.12	1.436
Surface and Spring	-0.0025	0.3586	-0.01	0.927	0.9975	0.493	2.018
Fixed parts							
Toilet facility (ref:had toilet)							
No Toilet	-0.2118	0.048	-3.55	0.000*	0.81	0.7198	0.9094
Cooking fuels (ref:Other)							
Electricity	0.278	0.534	0.69	0.491	1.321	0.5978	2.919
Kerosene	0.42	0.534	1.25	0.211	1.523	0.787	2.946
Charcoal	0.551	0.586	1.63	0.103	1.735	0.895	3.363
Wood	0.445	0.566	1.23	0.22	1.561	0.766	3.181
Animal dung	0.582	0.898	1.16	0.246	1.79	0.669	4.787
Wealth index (ref: Highest)							
Lowest	-0.04	0.076	-0.5	0.709	0.96	0.822	1.123
Second	0.263	0.107	3.2	0.001*	1.3	1.11	1.53
Middle	0.194	0.104	2.26	0.03*	1.214	1.026	1.436
Fourth	0.35	0.147	3.37	0.001*	1.42	1.158	1.738
Body mass index (ref: >= 25)							
< 18.5	0.953	0.0567	-81	0.42	2.595	0.848	1.071
18.5-24.9	1.1	0.132	0.86	0.391	3.006	0.876	1.401
Random parts							
$\sigma_0^2 = Var(U_{0j})$	0.56	0.164	3.41	0.001*			
$\sigma_0^2 = Var(U_{1j})$	0.202	0.069	2.94	0.003*			

$\sigma_0^2 = Var(U_{2j})$	0.156	0.076	2.052	0.045*			
$\sigma_{10} = Cov(U_{1j}, U_{0j})$	0.404	0.42	0.96	0.33			
$\sigma_{02} = Cov(U_{0j}, U_{2j})$	-0.676	0.33	-2.03	0.046*			
$\sigma_{12} = Cov(U_{1j}, U_{2j})$	-0.773	0.49	-1.57	0.1			
ρ(I C C)	0.591	0.02551	2.32	0.02*			

(*Significant at 5% level), (ref: reference category)

(ICC: Inter-region correlation coefficients)

Table 6: Results of Random coefficient Binary Logistic Regression Analysis.

The finding of this study also show that the risk of ARI symptoms among children is significantly less, on average for children whose mothers are not working than children from their mothers having work in Ethiopia. This may be because of the fact that time allocated to earning income may be at expense time spent in feeding and caring for children. Moreover, since the majority of mothers in developing countries like Ethiopia work in the informal sector and in lower status jobs, the amount of income for these mothers is low and would be a negligible impact on ARI symptoms of children. This result is consistent with the previous study by Birhan.

Another important model fitted in this analysis was multilevel logistic regression. Before the analysis of data using the multilevel approach, the necessity of multilevel analysis was investigated through the unconditional model and chi-square test statistic. The heterogeneity test and the significance of variance of random coefficients suggest that ARI symptoms of children differs among regions.

In the multilevel analysis children are nested within various regions in Ethiopia. Three multilevel models: empty model, random intercept and fixed slope model and random coefficient model were applied in order to explain regional differences in ARI symptoms among children. The variance of random factor in empty model is 0.447, which indicates between regional differences in ARI symptoms before predictor variables are included in the model. The intra-region correlation is estimated at 0.0572, implying that about 5.72% of the variations of ARI symptoms among under five children was due to variations within regions when explanatory variables are not included to the model.

The random intercept in the random intercept and fixed slope model is significantly different from zero at 5% level of significance indicating that ARI symptoms among under five children differ from region to region. The deviance based chi-square tests for random effects in random intercept model is also high (χ^2=123.0736, d.f=30, P-value=0.000). This indicate that the random intercept model with the fixed slope is found to give a better fit as compared to the empty model for predicting ARI symptoms among under five children across regions of Ethiopia.

The variance component of random intercept is also large further supports the fact that there is variability in ARI symptoms among under five children in Ethiopia across regions. The intraclass correlation coefficients is statistically significant and 5.91% of total variability in ARI symptoms was due to variations within regions when explanatory variables are included to the model.

The odds, of an under five children having mother with no education, to have symptoms of ARI is increased by 16.69% as compared to reference group (above secondary education). This result is consistent with the previous studies by Abul Kalam Azad [14]. The probability of under five children with age 24-35 and 36-47 month are less likely to have ARI symptoms than that of under five children with age of 48-59 month.

Source of drinking water is also important environmental factor that affect the ARI of under five children in Ethiopia. The finding of this study show that children who use water from unprotected as source of drinking are, on average highly vulnerable to have ARI symptoms than those who use pipe and tube water. This because of access to unsafe water is regarded as the main cause of acute respiratory infection [15-17].

The result on model comparison indicates that random coefficient fits the data better than the other two multilevel models. In this result ARI symptoms among under five children was significantly associated with mothers educational level, age of children, number of children, mothers occupational status, source of drinking water, type of toilet facility, vitamin A supplementation and wealth index of families were the most important factors in multilevel models. The random coefficients estimates for intercepts and the slopes very significantly at 5% significance level, which indicates that there is a significant variation in the effects of mothers educational and mothers occupation, these variables differ significantly across the regions[18 - 21].

Conclusions

The purpose of this study is to investigate ARI symptoms among under five children variation in regional states of Ethiopia based on the data from Ethiopia Demographic and Health Survey 2011. The study applied binary logistic regression and multilevel logistic regression models. This study revealed that socio-demographic, economic, nutritional, environmental and health related variables have important effect for occurrence of ARI symptoms among under five children in Ethiopia [22-25].

In multilevel logistic regression analysis, children under five age were nested within the various regions. The finding also show that the random coefficient binary logistic regression model fitted the data well among the other multilevel models. Mothers educational level, age of children, number of children, mothers occupational status, source of drinking water, type of toilet facility, vitamin A supplementation and wealth index of families have significant impact on ARI symptoms of children under five years age and its variations across regional states of Ethiopia. Moreover, the variance the random component, related to intercept term is found to be significant implying the presence of ARI symptoms of children variations across regional states. As a result, this study suggests that all region needs to have separate estimates of logistic regression for all eleven geographical regions.

Based on the result of this study, regional states have to take remedial measures on public health policy and design strategies to improve facility toward the major factors that affecting under five children and contributing to its variations among regional states to reduce ARI for under five children based on th following recommendations:

1. Supporting mothers to upgrade their educational level and occupational status [26-28].

2. To improve mothers access to education in all areas in order to address the problem through improving their income earning capacity and also enhancing the quality of care and attentions they can provide to their children.

3. To improve access of safe drinking water.

4. Further studies should be conducted to identify others factors (such as lack of immunization, indoor air pollution, outdoor air pollution, sanitation and housing quality) affects and contribute to symptoms of ARI among under five children in Ethiopia, especially medically.

5. Multilevel models are recommended for hierarchical populations since it produces estimates of logistic regression coefficients, standard errors, confidence interval and significance tests that are generally more conservative than those obtained from simple logistic regression models.

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