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Binary Logistic Regression Analysis in Determining Risk Factors of Acute Respiratory Infection (IRA) on Under-Five Children

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ABSTRACT

Acute Respiratory Infection (ARI) is a prevalent ailment and stands as one of the primary causes of mortality among children under the age of five. As reported by the Ministry of Health of the Republic of Indonesia, ARI predominantly affects children aged one to four years, with an incidence rate of 13.7%. Binary logistic regression is utilized to predict the likelihood of ARI occurrences in children under five, employing a linear combination of log-odds pertaining to suspected contributory factors. This study aims to evaluate the risk factors associated with ARI and develop an optimal logistic regression model by analyzing data from 166 participants who visited the Tarus regional health center between July 21 and September 1, 2023. Factors considered in this research as predictors for ARI (dependent variable Y) include Immunization Status (X_1), exposure to cigarette smoke at residence (X_2), exposure to wood smoke at residence (X_3), exclusive breastfeeding (X_4), and nutritional status (X_5). The final analysis revealed that incomplete immunization, exposure to cigarette smoke, and exposure to wood smoke at residence significantly heighten the risk of ARI. The most fitting logistic model obtained was expressed as $logit(\pi_{ijk}) = -1.1051 + 1.2297X_1 + 0.8709X_2 + 1.31085X_3$.

Keywords: Acute Respiratory Infection (ARI), Binary Logistic Regression, Risk Factors

INTRODUCTION

Acute Respiratory Infection (ARI) is an infection that affects the upper respiratory system such as vocal chords and noses, or lower respiratory system such as the lungs (Dagne et al., 2020). Anatomically, ARI is categorized into upper respiratory infections (URIs), which encompass conditions such as coughs, colds, pharyngitis, and tonsillitis, and lower respiratory infections (LRIs), which include bronchitis, bronchiolitis, and pneumonia. (Mirino et al., 2022). Microorganisms, including bacteria and viruses, are recognized as the primary causative agents of Acute Respiratory Infections (ARI). (Phommasone et al., 2022)

ARI stands as a prominent contributor to child mortality in developing nations (Hassen et al., 2020). An estimated 4 out of 15 million deaths annually among children under the age of five are attributed to Acute Respiratory Infections (ARI). Children under the age of five are estimated to undergo three to six episodes of Acute Respiratory Infections (ARI) annually, with ARI accounting for 20-30% of all deaths within this age group. (WHO, 2003). According to Alemayehu et al. (2019), occurrence of ARI in developing countries is reported to be 10 to 50 times higher than in developed countries, with children under the age of five being particularly vulnerable.

According to a report by the Research and Community Development Agency in 2018, the prevalence of Acute Respiratory Infections (ARI) in Indonesia was 4.4%, with the highest prevalence observed in the age range of one to four years at 25.8%. The Provinces with the

highest proportion of ARI include Papua, Bengkulu, West Papua, East Nusa Tenggara and Central Kalimantan. To minimize risk of death caused by ARI, the government has provided various treatments and carried out preventive measures such as vitamin A supplementation, complete immunization programs, and implementing the Integrated Management of Childhood Illness (IMCI) program.

Meanwhile, reports from Badan Pusat Statistik Nusa Tenggara Timur (2022), Central Statistics Agency of East Nusa Tenggara, pneumonia cases among children under five in East Nusa Tenggara tended to fluctuate during the years 2020 to 2022. In 2020 there were 3,803 reported cases, then it decreased to 1,775 cases in 2021 before rising again to 3,091 cases in 2022. The 2021 annual national health report showed that pneumonia was responsible for 14.4% of postnatal mortality and 9.4% of mortality in children aged 12 to 59 months. (Kementerian Kesehatan RI, 2022).

Acute Respiratory Infection (ARI) remains a significant health concern in Indonesia due to its adverse effects on individuals, serving as a catalyst for other diseases. This impact is not confined to children but extends to adults as well. (Najmah, 2016).

This study seeks to investigate the risk factors associated with Acute Respiratory Infections (ARI) in Kupang Regency, with a particular focus on the Tarus sub-district. Several studies have identified numerous factors linked to a high incidence of Acute Respiratory Infections (ARI) among children under the age of five. These encompass both intrinsic factors such as age, nutritional status, immunization status, and gender, as well as extrinsic factors like housing conditions, socio-economic status, and level of education. (Adjabeng et al., 2023). To examine the probability of an ARI occurrence considering the aforementioned factors, logistic regression can be employed.

Binary logistic regression analysis is a regression method used to model the relationship between multiple independent variables and a binary response variable, which typically represents outcomes as "YES" or "NO.". It is one of the most commonly employed technique in family medicine research to categorize, explain, or predict the values associated with a particular characteristic, behavior, or outcome. A notable case is the research conducted by Heydari & Al-Thalabi (2022) who investigated risk factors contributing to cancer in Baghdad. In this study, logistic regression was used to analyze the factors ~~that~~ influencing the risk of ARI along with the chance of infection by taking into account all or some of these factors. The parameters of the multinomial and ordinal logistic regression models were estimated out using the Maximum Likelihood Estimation (MLE) method (Hosmer & Lemeshow, 2000).

MATERIAL AND METHOD

The research design used in this study is cross-sectional. Data collection was conducted between July 21 to September 1, 2023, at Tarus Health Centre in Kupang Regency, NTT (location coordinate: 10.1350°S, 123.6846°E). The health centre mainly provides services for citizens residing in Central Kupang district (location coordinate: 10.1301°S, 123.7050°E), an area with a population of 64,939 (BPS Kabupaten Kupang, 2023).

This study focused on children under five years of age, with a total of 166 randomly selected respondents participating. Following medical examinations conducted by physicians, parents accompanying participants were requested to complete a brief questionnaire comprising six questions

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concerning the variables pertinent to the study. All variables in this study are categorical, each with binary outcome. The response variable used in this research was occurrence of IRA, with five independent variables, namely immunization status, exposure to cigarette smoke in residence, exposure to wood smoke in residence, exclusive breastfeeding, and nutritional status. The variables and their categorical coding and are shown in Table 1.

Table 1. Variable Coding and Proportions

Var	Sym	Category	Coding
IRA	Y	Yes	1
		No	0
Immunization Status	X_1	Partial	1
		Complete	0
Exposure to cigarette smoke in residence	X_2	Yes	1
		No	0
Exposure to Wood smoke in residence	X_3	Yes	1
		No	0
Exclusive Breastfeeding	X_4	Yes	1
		No	0
Nutritional Status	X_5	Good	1
		Poor	0

The sample size for this study concurred with the standard rule proposed by Agresti and Franklin (2009), namely 10 cases for each independent variable. The data from the questionnaires were entered into SAS Software (On Demand Version) using data step. Subsequently logistic procedure was implemented to perform a multivariable binary logistic regression. The statistical outputs from the procedure including regression coefficients, odds-ratios, confidence intervals and p-values were analysed to establish a logistic model and determine risk factors related to ARI occurrence according to the standard rules of statistical analysis.

Odds-ratios with a 95% confidence interval were used as a measure of strength of association between the outcome variable and the independent variables. Independent variables that achieved significance at 5% level and 95% confidence interval were identified as valid risk factors of ARI (Gebrerufael & Hagos, 2023).

RESULT AND DISCUSSION

RESULT

The research team were granted a permission by the head of Tarus Regional Health Center to collect data from July 21 to September 1, 2023, namely 31 workdays. During this period, a total of 166 children under the age of five participated as research respondents. them, 108 children were diagnosed with IRA, constituting an overall occurrence rate of 65.06%. All respondents in the study were classified as having good nutritional status (X_5), indicating that there were no participants with poor nutrition. Since the variable for nutritional status does not vary among respondents, it will not have any influence on the logistic regression model analysis. Therefore, we will exclude this variable from the subsequent analysis.

When the four independent variables were included in the model, the global goodness of fit was assessed using the Likelihood Ratio Test, yielding a chi-squared value of $\chi_4^2 = 33.98$ and a p-value of $p < 0{,}0001$, which indicates significance at the 5% level. Similarly, the Score Test also suggests that the model sufficiently explains the data (with $\chi_4^2 = 31.92$ and a p-value of $p < 0.0001$). This is emphasized by the fact that the full model yields a lower AIC value (190.8) compared to the model with intercept only (216.8).

Table 2. Effects of the 4 Independent Variables on IRA

Var	Regression Coefficient (β_i)	OR (95% CI)	p-value
X_1	1.2196	3.386 (1.480, 7.745)	0.0039*
X_2	0.8772	2.404 (1.144, 5.052)	0.0206*
X_3	1.3128	3.717 (1.743, 7.924)	0.0007*
X_4	0.0430	1.044 (0.486, 2.242)	0.9121
Intercept	-1.1346		0.0124*
(n)	166		

Table 2 presents the statistical outputs of the SAS logistic procedure. From the regression coefficient column, the log odds of the full model, denoted by $logit(\pi_{ijkl}) = -1.1346 + 1.2196X_1 + 0.8772X_2 + 1.3128X_3 + 0.0430X_4$, has been determined, where $i, j, k, l \in \{0,1\}$. Odds ratios are obtained by calculating the e^{β_i}'s. As an illustration, the odds of developing ARI among children under five who live with smokers is given by $e^{\beta_2} = e^{0.8772} = 2.404$ $(95\% CI = (1.144, 5.052)$.

According to this model, children under five who lived with smokers are estimated to be 2.404 times as likely to develop Acute Respiratory Infections (ARI) compared to those who did not reside with smokers.

The multivariable logistic regression statistical output presented in table 2 showed that exclusive breastfeeding (variable X_4) was not a significant predictor of ARI occurrence on 5% level of significance (p-value=0.9121). Hence by parsimony principle, we used the backward elimination process to eliminate variable X_4.

After implementing the SAS logistic procedure for the remaining three independent variables, the Likelihood Ratio Test for goodness of fit yielded a chi-squared value of $\chi_3^2 = 33.931$ with a p-value of $p < 0.0001$. This indicates that the model is acceptable at the 5% level of significance. Based on the coefficient column from table 3, the corresponding logistic model is given by $logit(\pi_{ijk}) = -1.1051 + 1.2297X_1 + 0.8709X_2 + 1.31085X_3$.

Table 3. Effects of the 3 Independent Variables on IRA

	Regression Coefficient (β_i)	OR (95% CI)	p-value
X_1	1.2297	3.420 (1.525, 7.673)	0.0029*
X_2	0.8709	2.389 (1.147, 4.977)	0.0201*
X_3	1.3085	3.701 (1.743, 7.858)	0.0007*
Intercept	-1.1051		0.0025*
(n)	166		

From the p-value column in Table 3, it is evident that immunization status, exposure to cigarette smoke in residence, and exposure to wood smoke in residence are all considered significant risk factors for the development of Acute Respiratory Infections (ARI) in children under five, at the 5% significance level. Therefore, the model cannot be further reduced. According to the principle of parsimony, this model represents the optimal choice.

As an example, from the final model, the log-odds of a child develop IRA given that the child had been completely immunized $(X_1 = 0)$, lived with cigarette smokers $(X_2 = 1)$, and was exposed to wood smoke in the residence $(X_3 = 1)$ is $logit(\pi_{011}) = 1.07665$. The probability of this child develops ARI given the conditions is then given by

$$\pi_{011} = \frac{e^{1.07665}}{1 + e^{1.07665}} = 0.74.$$

DISCUSSION

Multiple logistic regression analysis from above results had suggested that

Immunization status, presence of smokers in residence, exposure to wood smoke in residence had significant association to ARI. The odds ratio shown in Table 3 can be interpreted as follows.

- The odds ratio 3.42 (95%CI=(1.525, 7.673)) indicates that children under five who are not fully immunized are 3.42 times more likely to develop ARI compared to those who receive complete immunization.
- The odds ratio 2.389 (95%CI=(1.147, 4.977)) indicates that children under five who lived with smokers are 2.389 times more likely to develop Acute Respiratory Infections (ARI) compared to those who do not live with smokers.

- The odds ratio of 3.7 (95%CI = 1.743, 7.858) suggests that children under the age of five whose homes are contaminated with wood smoke are 3.7 times more likely to contract Acute Respiratory Infections (ARI) compared to those whose homes are not contaminated with kitchen wood smoke.

Based on these interpretations of odds ratios, it was observed that Acute Respiratory Infections (ARI) were more prevalent among children who were not fully immunized. This finding is consistent with the study conducted by (Haryanti et al., 2022) in Bengkulu and Hartawan et al. (2019) in Lombok.

According to Tjahjowargo and Gunardi (2017) DPT immunization can prevent the occurrence of diphtheria and pertussis which are classified as variations of IRA. The immunization development program by the government so far, which includes PCV, has proved to significantly reduce the incidence of pneumonia in under-five children (Tian et al., 2023). Immunization is one of the most cost-effective ways to prevent serious infectious diseases. Inadequate vaccination is a risk factor for increased morbidity (illness) and death due to IRA, especially pneumonia (Zolanda et al., 2021).

Children who lived in the same house as cigarette smokers are exposed to cigarette smokes and hence thus rendering them passive cigarette smokers.

They are also found to be more common among children with IRA (OR=2.389, 95%CI=(1.147, 4.977)). This correlation was to be anticipated and could be explained by the fact that smoking weakens the inherent defence system of the respiratory tract, rendering it more susceptible to pathogens bypassing the initial protective barrier of the respiratory system (van Zyl-Smit et al., 2020). It also links to higher rates of morbidity and mortality resulting from pneumonia and influenza. Initiating anti-smoking initiatives may aid in raising awareness among the public regarding the hazards of tobacco smoke overall, with a particular focus on the well-being of children.

Children under five who were exposed to wood smoke were also found to have a higher risk of developing ARI compared to those who were not exposed (OR=3.7, 95%CI=(1.743, 7.858)). WHO (2022) wrote that women and children are disproportionately affected by the significant health consequences resulting from the use of polluting fuels and household technologies. This is due to the fact that women and children often undertake tasks such as cooking and gathering firewood, resulting to prolonged exposure to harmful smoke. Data released by BPS NTT (2018) showed that 79% of households in Kupang regency were still using wood as the primary fuel for cooking. Therefore, it is imperative to raise awareness and provide education regarding the hazards associated with wood smoke.

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CONCLUSION AND SUGGESTION

This study has concluded that incomplete immunization, exposure to cigarette smoke, and exposure to wood smoke are significant predictors the development of Acute Respiratory Infections (ARI) in children under the age of five. Public healthcare providers, in collaboration with various stakeholders, should devise strategies to; raise awareness about the importance of immunization, decrease the smoking habits in houses with children and raise awareness about the dangers of wood smoke on children. For instance, health workers could organize monthly health education sessions at every village to encourage people to a transition from using wood as the main fuel for cooking to a more modern stove that generates less smoke.

The best logistic model for ARI in this study is given by $logit(\pi_{ijkl}) = -1.1346 + 1.2196X_1 + 0.8772X_2 + 1.3128X_3 + 0.0430X_4$.

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