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Predictors of the incidence of respiratory tract infections in children under five years of age in urban areas: Evidence from Indonesia

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ABSTRAK

Infeksi saluran pernapasan akut (ISPA) masih sebagai etiologi utama kesakitan dan kematian pada anak balita, terutama di wilayah perkotaan negara berpendapatan menengah seperti Indonesia. Tujuan penelitian untuk menganalisis faktor-determinan kejadian ISPA pada balita, meliputi paparan asap rokok rumah tangga, riwayat asfiksia saat lahir, dan praktik pemberian ASI eksklusif. Penelitian menggunakan desain *case–control study*, melibatkan 88 balita (44 kasus dan 44 kontrol) yang direkrut dari Puskesmas wilayah perkotaan. Data dikumpulkan melalui wawancara terstruktur dan rekam medis, kemudian dianalisis menggunakan regresi logistik ganda untuk menghitung *adjusted odds ratio* (AOR) dengan *confidence interval* (CIs) 95%. Analisis multivariat diperoleh hasil bahwa insidens ISPA pada balita berhubungan secara bermakna dengan paparan asap rokok (AORs = 11,53; 95% CIs: 3,46–38,41), demikian pula dengan riwayat asfiksia neonatorum (AORs = 4,78; 95% CIs: 1,05–21,86). Sebaliknya, pemberian ASI eksklusif memiliki efek protektif, menurunkan risiko ISPA sekitar dua kali lipat (CORs = 2,19; 95% CIs: 1,73–2,78). Paparan asap rokok rumah tangga dan riwayat asfiksia merupakan faktor risiko signifikan terhadap insidens pada balita di wilayah perkotaan, sedangkan ASI eksklusif berperan sebagai faktor protektif utama. Studi ini menegaskan pentingnya penguatan intervensi promotif–preventif berbasis rumah tangga dan kebijakan kesehatan perkotaan yang mendukung lingkungan bebas asap rokok serta peningkatan cakupan ASI eksklusif.

Kata Kunci: ARI, paparan asap rokok, asfiksia neonatorum, ASI eksklusif, kesehatan anak perkotaan

ABSTRACT

Acute respiratory infections (ARI) remain the primary aetiology of morbidity and mortality among children under five years of age or "CU5" (Children Under 5), particularly in urban areas of low- and middle-income countries. This study aimed to identify the predictors of ARI incidence associated with household tobacco smoke exposure, neonatal asphyxia history, and exclusive breastfeeding practices among CU5 in an urban setting in Indonesia. A case–control study was conducted involving 88 CU5 old (44 cases and 44 controls), recruited from urban public health centers. Data on risk factors were obtained through structured interviews and validated medical records. Multiple logistic regression was employed to estimate adjusted odds ratios (AORs) with 95% confidence intervals (CIs). Multivariate analysis shows that two variables were significantly associated with ARI incidence: household exposure to tobacco smoke (AORs = 11.53; 95% CIs: 3.46–38.41) and history of neonatal asphyxia (AORs = 4.78; 95% CIs: 1.05–21.86). Exclusive breastfeeding had a protective effect, reducing the ARI risk by approximately twofold (CORs = 2.19; 95% CIs: 1.73–2.78). Household tobacco smoke exposure and neonatal asphyxia substantially increase the risk of ARI among urban CU5, whereas exclusive breastfeeding serves as a strong protective factor. These findings underscore the importance of strengthening promotive and preventive interventions to address household air pollution, neonatal care, and breastfeeding promotion within urban health policy frameworks.

Keywords: Acute respiratory infection, tobacco smoke exposure, neonatal asphyxia, exclusive breastfeeding, urban child health

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INTRODUCTION

Acute respiratory infection (ARI) is one of the most preventable infectious diseases; however, it is the leading cause of death and illness among children in low- and middle-income countries (WHO, 2024); (Kassaw et al., 2024). ARI is characterized by a cough accompanied by short, rapid breathing and generally results in death due to comorbidities with other childhood illnesses (Amsalu et al., 2019; Izadnegahdar et al., 2013). The World Health Organization (WHO, 2024) reports that more than 700,000 children under the age of five die each year from ARI, with 90% of these deaths due to pneumonia and bronchiolitis. Another study confirmed that approximately 65% of deaths in children under five years of age or Children Under 5 (CU5) are "amenable." The majority of these deaths are due to acute respiratory diseases, with the highest concentrations in sub-Saharan Africa and Southeast Asia, where access to health services is still limited (Navarro-Jimenez et al., 2024).

In Southeast Asia, the burden of ARI remains high despite increased public health interventions. The Institute for Health Metrics and Evaluation (IHME, 2023) reports that Indonesia, Myanmar, and the Philippines rank among the top three countries with the highest incidence and mortality rates of ARI. In Indonesia, ARI is still the leading cause of death among children under five, with an estimated more than 40,000 deaths per year, mainly caused by severe pneumonia and delayed treatment at the household level (Kemenkes RI, 2024). This fact underscores that despite a global decline of approximately 35% in the last decade, the pace of decline in ARI mortality rates in developing countries is still much slower than that in developed countries (Ashrafi-Asgarabad et al., 2023; WHO, 2024). In Indonesia, ARI is one of the leading causes of pain and death among children under five. According to Indonesia's Health Profile (Kemenkes RI, 2024), ARI accounts for approximately 22–25% of all disease cases among (CU5) who visit health facilities, with a higher incidence in densely populated, polluted urban areas. Environmental factors, such as population density, smoking habits at home, and low exclusive breastfeeding coverage, are the leading causes of high ARI rates (Kemenkes RI, 2024). In Lampung Province, the prevalence of IPR among CU5 reached 22.6%, with 42.7% of families having household members who smoke and only 58.9% of mothers providing exclusive breastfeeding (Dinas Kesehatan Provinsi Lampung, 2023).

Many studies have identified the main risk factors contributing to the incidence of ARI, including exposure to secondhand smoke in households, poor air quality, suboptimal breastfeeding practices, and congenital medical conditions such as neonatal asphyxia (Riyanto & Herlina, 2021; Troeger, Blacker, Khalil, Rao, Cao, et al., 2018; Windi et al., 2021; Zebua et al., 2023; Lutpiatina et al., 2022). Although various studies have highlighted the association between cigarette smoke exposure, exclusive breastfeeding, and the incidence of ARI, there is a significant research gap regarding the integration of these three factors into a comprehensive predictor model, particularly in the urban population of CU5 in Indonesia. Previous studies have been conducted by Kusumaningrum et al. (2018) to analyze the effects of exposure to cigarettes and breastfeeding. In addition, Setiawati et al. (2021) linked only nutritional

status and smoking habits to ARI. Another limitation is the lack of a predictive multivariate analysis-based approach to identify the relative contribution of each risk factor to ARI incidence in infants. This highlights the need for research that focuses on the development of predictive models of cigarette smoke exposure factors, history of asphyxia, and exclusive breastfeeding in the context of urban CU5. The findings of this study are expected to make a theoretical contribution to the development of epidemiological models of respiratory infectious diseases, as well as practical implications for promotive and preventive interventions for children's health in urban areas of Indonesia.

Thus, this study aimed to analyze the effects of exposure to cigarette smoke, history of asphyxia, and exclusive breastfeeding on the increased incidence of ARI in CU5 in urban areas. The results are expected to produce an integrative risk prediction model to support evidence-based public health policy. The novelty of this research lies in its holistic approach, which simultaneously combines environmental, biological, and social determinants to explain the incidence of ARI among CU5 in the urban context of Indonesia.

RESEARCH METHODS

A case control study was selected as the research design. Five community health centres in Metro City were selected as the research locations because of the high incidence of ARI in children. This study was chosen because it is considered capable of addressing the research purpose of examining the causal relationship between risk factors and effects. The research was conducted from September to November 2020. It was carried out after obtaining approval for the research protocol from the ethics committee of the Health Polytechnic of Tanjung Karang, Bandar Lampung (No. 307/KEPK-TJK/IX/2020) and research permission from the research location.

The number of samples was calculated using the 2-proportion difference test formula in Murti (2018), using the cigarette smoke exposure variable from previous research by Widayat (2014) with P1 = 0.421 and P2 = 0.15, so that an estimate of the minimum number of samples was obtained for the case group 45 and control group 45 (1:1) with age matching (years). The research sample was recruited from CU5 and their mothers (companions) who visited the Primary Health, and selected using consecutive sampling. The inclusion criteria for the sample were children who visited the Health Primary of Metro City during the study, including ARI and non-ARI (control) cases. The research sample was limited to CU5 who were treated at the Health Primary where the research was conducted, excluding children diagnosed with measles.

The research instrument, which used a structured questionnaire, consisted of two parts. The first part of the questionnaire contained questions regarding socio-demographic data. The second part of the questionnaire contained research variable questions, including data on diseases or diagnoses of CU5 (one question), exposure to cigarette smoke (three questions), nutritional status (one question), exclusive

breastfeeding (two questions), and asphyxia history (one question). The questionnaire was developed based on a review of relevant literature.

The collection of research data used observation techniques and structured interviews, and was conducted in accordance with strict health protocols. The observation technique involved reviewing medical records for diagnoses of ARI cases and non-ARI cases; observing Maternal and Child Health books for CU5 to collect body height and body weight (nutritional status) data; and recording asphyxia history. The interview technique was structured with parents of CU5 to obtain data on passive smoker and exclusive breastfeeding. The researcher collected the data, assisted by three enumerators, with the classification of Level IV Applied Undergraduate students who had been given the perception Equation of data collection techniques.

The data were analyzed after being checked for completeness, edited, and coded. Statistical analysis was performed using bivariate and multivariate analyses. Bivariate analysis used chi-square tests to assess outcome-related variables (ARI and non-ARI), and the results were also reported as crude ORs with 95% CIs. Variables with $p < 0.25$ were included in a multivariate analysis to identify risk factors. Multivariate analysis was carried out using a multiple logistic regression test, which was declared significant if the p-value ≤ 0.05. Regression model calibration was performed using the Hosmer test—if the p-value was > 0.05.

RESULTS AND DISCUSSION

Results

Socio-demographic characteristics

Eighty-eight (88) respondents completed the questionnaire without any missing scores (100% complete), divided into 44 case (ARI) and 44 control (non-ARI) groups. In this study, 56.8% of children were male, and 43.2% were female, as in urban residences. The majority of CU5 (93.2%) were immunized according to the program in both the case group and the remaining controls (6.8%). Children who were administered vitamin A were almost equal in the case (93.2 %) and control (100 %) groups. Meanwhile, the education of mothers was dominant in high school, both cases (65.9%) and controls (72.7%) (Table 1).

The socio-demographic dates of the subjects in Table 1 indicate that the distributions of case data (ARI) and controls are relatively heterogeneous, as indicated by the p-values > 0.05. This means that the socio-demographic data of the research subjects do not become confounding factors that affect the analysis of the research variable data.

Variable characteristics based on bivariate analysis results

Bivariate analysis to select multivariate candidate variables was performed using the chi-square test. Four variables from the bivariate analysis with a p-value of < 0.25 were included in the multivariate model:

exposure to cigarette smoke, exclusive breastfeeding, and history of asphyxia. Exposure to cigarette smoke and exclusive breastfeeding were significantly associated with the incidence of ARI in CU5 with p-value < 0.05 (Table 2).

Table 1. Socio-demographic characteristics

Variable	**Case groups (%) n=44**	**Control groups (%) n=44**	**P-value**
Gender			
Male	25 (56.8)	29 (65.9)	0.381
Female	19 (43.2)	15 (34.1)	
Given immunisation based on the programme			
No	3 (6.8)	3 (6.8)	1.000
Yes	41 (93.2)	41 (93.2)	
Given vitamin A based on the programme			
No	3 (6.8)	0 (0.0)	0.241
Yes	41 (93.2)	44 (100)	
Mother's education			
Elementary school	3 (6.8)	2 (4.5)	0.920
Junior high school	4 (9.1)	4 (9. 9)	
High school	29 (65.9)	32 (72.7)	
Collage/ University	8 (18.2)	6 (13.6)	

Table 2. Results of bivariate analysis of factors that affect the incidence of ARI in CU5

Variabel	**Cases (%) n=44**	**Controls (%) n=44**	**P-value**
Exposure to cigarette smoke			
Yes	39 (88.6)	20 (45.5)	0.0001
No	5 (11.4)	24 (54.5)	
Riwayat asfiksia			
Yes	5 (11.4%)	9 (20.5)	0.382
No	39 (88.6)	35 (79.5)	
Exclusive breastfeeding			
No	7 (15.9)	0 (0.0)	0.012
Yes	37 (84.1)	44 (100)	
Nutritional status			
Very underweight	10 (22.7)	4 (9.1)	0.145
Good – overweight	34 (77.3)	40 (90.9)	

Factors Associated with ARI incidents

Statistical analysis using multiple logistic regression tests for multivariate analysis showed that two variables out of four variables were meaningfully related to the incidence of ARI in children. In addition, the model fit, as indicated by the Hosmer-Lemeshow test with a p-value > 0.99 (Table 3), was acceptable.

Table 3 indicates that the proportion of cases exposed to cigarette smoke was higher than that of the controls. Children under five years of age exposed to cigarette smoke are at risk of experiencing ARI 11.53 times compared to those who are not exposed to cigarette smoke (AORs 11,531: 3.461-38.413). A history of asphyxia is 4.78 times greater at risk of experiencing ARI than having no history of asphyxia

in CU5 (AORs 4.784: 1.047-21.860). In addition, CU5 who were given exclusive breastfeeding had a gross chance ratio (Crude ORs) of 2.19 times more likely to suffer from ARI than those who were not given exclusive breastfeeding (ORs 2.189: 1.726-2.776).

Table 3. The results of a multivariate analysis of determine that affect the incidence of ARI in CU5

Variabel	Cases (%) n=44	Controls (%) n=44	Crude ORs (CI: 95%)	Adjusted ORs (CIs: 95%)	P-value
Exposure to cigarette smoke			9.36 (3.10-28.23)	11.53 (3.46-38.41)	
Yes	39 (88.6)	20 (45.5)		1.00	0.0001
No	5 (11.4)	24 (54.5)			
History of asphyxia			11.53 (3.46-38.41)	4.784 (1.04-21.86)	
Yes	10 (22.7)	4 (9.1)			0.043
No	34 (77.3)	40 (90.9)			
Exclusive breastfeeding			2.18 (1.72-2.77)	1.00	
No	7 (15.9)	0 (0.0)			-
Yes	37 (84.1)	44 (100)		1.00	
Nutritional status			0.49 (0.15-1.63)	1.00	
Very underweight	5 (11.4%)	9 (20.5)			-
Good – overweight	39 (88.6)	35 (79.5)		1.00	

Remarks: Crude OR = gross opportunity ratio; Adjusted OR = adjusted risk ratio. Hosmer Lemeshow test > 0.99.

Discussion

This study aims to analyse the factors associated with the incidence of ARI in the research subjects, focusing on three main variables: exposure to cigarette smoke, history of asphyxia at birth, and exclusive breastfeeding. Based on the results of the double logistic regression analysis, it was found that two variables, namely exposure to cigarette smoke and a history of asphyxia, contributed significantly to the incidence of ARI. The regression model showed a good fit (Hosmer-Lemeshow test, $p > 0.05$), indicating that it can be used to predict ARI occurrence with adequate validity.

The study shows that children exposed to cigarette smoke had an 11.53 times higher risk of developing ARI than those who were not exposed (AORs 11,531; 95% CIs: 3,461–38,413). These findings are consistent with the results of a global meta-analysis by Troeger, Blacker, Khalil, Rao, Reiner Jr, et al. (2018) and Navarro-Jimenez et al. (2024), which showed that exposure to household pollutants, including tobacco smoke, contributes significantly to more than 20% of deaths from ARI in CU5 in lower-middle-income countries.

Studies in Ethiopia and Vietnam have also shown a strong correlation between indoor air pollution and an increased incidence of childhood pneumonia. Theoretically, this relationship can be explained by the Bronfenbrenner model of health ecology, which posits that microenvironmental (household) factors and parental behavior interact directly with a child's health status (Amsalu et al., 2019; Kassaw et al., 2024). In the Indonesian context, these results underscore the urgency of family-based interventions to create a "smoke-free home environment", which has been empirically proven to be effective in reducing the incidence of ARI and improving children's lung function (Zebua et al., 2023; Zhou et al., 2024)

In the context of this research conducted in urban areas, the relationship is increasingly relevant due to the phenomenon of urban environmental complexity, including the combination of outdoor air pollution and household pollutants (indoor–outdoor pollution coupling). A health research study in urban areas by Ashrafi-Asgarabad et al. (2023) confirmed that in densely populated areas, the combined effects of cigarette smoke and urban environmental pollution are synergistic, increasing airway inflammation by up to 2.5 times compared to single exposure. Therefore, the results of this study not only strengthen the epidemiological evidence but also confirm that interventions to prevent ARI in urban areas should be oriented towards creating smoke-free homes as the primary mitigation effort against the risk of ARI in CU5.

Furthermore, the analysis found that a history of asphyxia at birth increased of ARI in chidren. He has a 4.78 times higher risk of exposure to ARI than children without a history of ARI (AORs 4.784; 95% CI: 1.047–21.860). Neonatal asphyxia can result in long-term impaired lung function, including decreased pulmonary vital capacity and respiratory immune system disorders, which increase susceptibility to lower airway infection (Izadnegahdar et al., 2013). Physiologically, hypoxia conditions at birth can cause damage to lung tissue and immune system disorders, making children more susceptible to recurrent infections. This factor reinforces the importance of quality antenatal and neonatal services as an indirect prevention strategy against ARI (Navarro-Jimenez et al., 2024).

This research is consistent with a study in Ethiopia by Amsalu et al. (2019) and Kassaw et al. (2024), who found that children with neonatal complications had a higher prevalence of ARI than children without complications. WHO (2024) also confirmed that a history of perinatal complications, such as asphyxia, is an important predictor of mortality due to pneumonia and ARI in children developing countrie. The important clinical implications of these findings are related to neonatal care policy and long-term monitoring of post-asphyxia children. Recent studies by Kassaw et al. (2024) show that the integration of early screening for respiratory disorders and pulmonary rehabilitation in children with a history of neonatal hypoxia can reduce the incidence of ARI by up to 30%. Thus, the results of this study reinforce the urgency of strengthening quality antenatal and neonatal services as an indirect preventive strategy against ARI, especially in urban areas with a high rate of perinatal complications.

Another predictor of risk factors related to the incidence of ARI is exclusive breastfeeding. The results of the analysis showed that children who did not receive exclusive breastfeeding had a 2.19 times higher risk of developing ARI than those who received exclusive breastfeeding (CORs 2.189; 95% CI: 1.726–2.776). Breastfeeding protects CU5 from infectious diseases, including ARI. Breast milk contains antibodies, especially secretory immunoglobulin A (sIgA). In addition, other protective factors, such as lactoferrin and lysosomes, play important roles in protecting the airway mucosa against pathogens (Kemenkes RI, 2018). This aligns with global findings that exclusive breastfeeding acts as a natural

immunomodulator, strengthens the mucosal immune system, and reduces the frequency of recurrent respiratory infections (Binns et al., 2016; Zhou et al., 2024).

Previous studies by Windi et al. (2021), Setiawati et al. (2021), and Lutpiatina et al. (2022) are consistent with the findings of this study that exclusive breastfeeding during the first six months of life significantly reduces the incidence of ARI. Global research by Ashrafi-Asgarabad et al. (2023) and Troeger, Blacker, Khalil, Rao, and Reiner Jr et al. (2018) also shows that low exclusive breastfeeding coverage contributes to increased ARI burden in lower-middle-income countries, including Indonesia.

In the urban context of Indonesia, where air pollution levels and exposure to household cigarette smoke are high, the protective effects of breastfeeding are becoming increasingly important, as they help reduce susceptibility to airborne infectious agents and droplets. Therefore, exclusive breastfeeding should continue to be promoted as a primary preventive strategy for ARI in urban public health programs. Clinically and policy-wise, these findings reinforce the urgency of strengthening exclusive breastfeeding promotion programs in urban areas as a primary preventive intervention for ISI in infants. Future research should explore the relationships among breastfeeding duration, maternal nutritional status, pollutant exposure, and the immunological effectiveness of breastfeeding, using a longitudinal cohort design to clarify the causal relationships.

The potential for recall bias in the design of the case-control study is an unavoidable limitation. Nevertheless, this design remains relevant and efficient for identifying the main determinants of ARI among children in areas with high prevalence (Amsalu et al., 2019; Kassaw et al., 2024). Further research is recommended using a longitudinal cohort design or a multifactor risk-prediction model-based analytical approach to strengthen the evidence of causality and provide a stronger scientific basis for urban child health policies.

CONCLUSION

This study shows that exposure to cigarette smoke and a history of neonatal asphyxia are significantly related to an increase in the incidence of ARI in children under five years of age in urban areas, while exclusive breastfeeding shows a protective effect. These results reinforce the evidence that ARI is multifactorial, influenced by interactions among environmental determinants, family behavior, and the child's biological conditions. This research contributes to strengthening the multifactor predictor model based on the ecological public health approach, which is relevant to the Indonesian urban context and aligns with the global context. This study has practical implications for public health policies to strengthen promotive and preventive interventions at the household level by controlling cigarette smoke, improving the quality of neonatal services, and optimizing exclusive breastfeeding coverage.

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