TPM Vol. 32, No. 3, 2025
ISSN: 1972-6325
https://www.tpmap.org/

FACTORS ASSOCIATED WITH PNEUMONIA RISK AMONG UNDER-FIVE CHILDREN IN BATAM, INDONESIA: A CROSS-SECTIONAL STUDY

DIDI YUNASPI [1], DACHRIYANUS HAMIDI [2], FINNY FITRY YANI [3], ALFAN MIKO [4]

[1] DOCTORAL PROGRAM OF PUBLIC HEALTH SCIENCE, FACULTY OF MEDICINE, UNIVERSITAS ANDALAS, PADANG, INDONESIA
[2] DEPARTMENT OF PHARMACY, FACULTY OF PHARMACY, UNIVERSITAS ANDALAS, PADANG, INDONESIA
[3] FACULTY OF SOCIAL AND POLITICAL SCIENCE, UNIVERSITAS ANDALAS, PADANG, INDONESIA
[4] RESPIROLOGY SUBDIVISION STAFF AT THE PEDIATRIC DEPARTMENT, FACULTY OF MEDICINE, ANDALAS UNIVERSITY, INDONESIA
*Corresponding Author: didiyunaspi@yahoo.co.id

Abstract
Pneumonia remains a leading cause of mortality among children under five years old in developing countries. Unhealthy household environments significantly contribute to the rising incidence of lower respiratory infections in this age group. This study aimed to identify the socio-demographic, environmental, and nutritional factors associated with pneumonia risk among under-five children in Batam, Indonesia. A cross-sectional study was conducted among 151 under-five children. Data were collected using structured questionnaires and analyzed through bivariate (Chi-square) and multivariate (logistic regression) analyses. Significance was set at $p < 0.05$. Bivariate analysis indicated significant associations between pneumonia incidence and maternal education level ($p = 0.034$), child's sex ($p = 0.024$), breastfeeding history ($p = 0.013$), and flooring material ($p = 0.007$). Multivariate logistic regression revealed that lower maternal education (AOR = 0.32, 95% CI = 0.13–0.79), male gender (AOR = 0.42, 95% CI = 0.19–0.91), inadequate vitamin A intake (AOR = 0.30, 95% CI = 0.10–0.87), low birth weight (AOR = 3.38, 95% CI = 1.01–11.27), and non-standard flooring (AOR = 7.77, 95% CI = 1.91–31.55) were significantly associated with pneumonia occurrence. The study concludes that pneumonia risk among under-five children in Batam is influenced by maternal education, child's sex, nutrition, birth weight, and household environment. Health interventions should prioritize maternal education and environmental sanitation as key preventive measures.
Keywords: pneumonia; under-five children; risk factors; public health

INTRODUCTION

Pneumonia is an acute lower respiratory tract infection caused by various microorganisms such as viruses, fungi and bacteria (Indonesian Health Profile, 2021). This condition is a global health threat with high morbidity and mortality rates in children under five
(Liu et al., 2016). Globally, pneumonia is responsible for about 15% of deaths in the age group under five years old, killing about 672,000 children in 2019, which is the equivalent of 39 child lives every second.
Global data in 2018 showed that more than 802,000 children under five were affected by pneumonia, with the highest incidence occurring in South and West Asia (2,500 cases per 100,000 children) and Central Africa (1,620 cases per 100,000 children). The prevalence of pneumonia in toddlers in African countries reached 11,000 in Sudan, 162,000 in Nigeria and 32,000 in Ethiopia (Aldriana, 2015). In Indonesia, pneumonia is the second leading cause of death in children under five after diarrhoea, with prevalence increasing from 1.6% in 2013 to 2.1% in 2018.
The Riau Islands experienced fluctuations in the number of pneumonia cases detected in toddlers, namely 9.23% in 2017, 27.5% in 2019, and 11.1% in 2020. Batam City recorded the highest cases of pneumonia with 1,017 children under five (21.4%). The low coverage of case discovery indicates that the pneumonia detection program is not optimal, and there remains a lack of public awareness about the symptoms of pneumonia in children.
Risk factors for pneumonia in toddlers include complex internal and external factors. Research (Alimul, 2008) showed that breast milk that was not exclusively fed was 7,407 times higher risk of causing pneumonia. Vitamin A status is also a significant risk factor with an odds ratio of 3.50. External factors such as housing density had a correlation with the prevalence of pneumonia (OR = 2.30), while inadequate ventilation measures showed a strong correlation with OR = 5.99 (Abeje Fekadu, 2014).
The pneumonia control program in Indonesia has been implemented through the Minister of Health Regulation No. 25 of 2014 concerning Child Health Efforts and the Pneumonia Centenary Commitment (PCC) program with the STOP pneumonia campaign which focuses on three key messages: Protect, Prevent, and Treat) (Stop

Pneumonia of the Ministry of Health of the Republic of Indonesia, 2020). The Integrated Management Strategy for Sick Toddlers (MTBS) has been running for two decades with implementation in around 80% of health centers. However, the MTBS program that is currently running still has weaknesses because it focuses on curative programs when finding sick toddlers, there is no program to predict pneumonia risk factors from upstream for prevention (Padmawati, 2018). The existing program is more aimed at overcoming problems that have already occurred, so a more comprehensive preventive approach is needed. This study aims to develop a model for predicting the risk of pneumonia in toddlers in Batam City that integrates internal and external factors to improve protection and prevention efforts. This prediction model is intended for use by mothers under five and health workers as an instrument for early detection of pneumonia risk, thereby improving children's health through targeted and evidence-based prevention.

METHOD

Research Design

This study employed an analytic cross-sectional design to empirically analyze the association between socio-demographic, nutritional, and environmental factors and the occurrence of pneumonia among children under five years old. This design was selected because it enables simultaneous observation of exposure and outcome, allowing for the identification of key determinants influencing pneumonia prevalence. Quantitative data collection was complemented with qualitative interviews to enhance contextual interpretation and triangulate findings for model validation.

Research Location and Time

This research is an analytical study with a cross-sectional design. The study was conducted over a period of three months, from May to July 2025. The research took place in two community health center (Puskesmas) working areas in Batam City.

Population and Sample

The sample size determination in this stage uses the Lemeshow formula (1997) for estimating the proportion of a single sample with an unknown population size, as follows:

$$n = \frac{z^2\ 1 - \alpha/2\,.\,P(1-P)}{d^2}$$

$$n = \frac{1.96^2.\,0.11(1-0.11)}{0.05^2}$$

$$\frac{1.96^2.\,0.11(0.89)}{0.0025} = \frac{0.3763}{0.0025} = 150.52 = 151$$

Information:
Z = 1.96 (95% confidence level),
P = 0.11 (estimated pneumonia prevalence among under-five children in Riau Islands),
d = 0.05 (precision).
From the calculation, a minimum of 151 respondents was required.

Data Analysis Techniques

Statistical analysis was carried out using SPSS version 24. Univariate analysis: Frequency and percentage distribution of each variable. Bivariate analysis: Chi-square tests to identify associations between independent variables and pneumonia incidence (significance threshold: $p < 0.05$). Multivariate analysis: Variables with $p < 0.25$ in bivariate testing were entered into a multiple logistic regression model to determine independent predictors, expressed as Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI).

Ethical Considerations

This research adheres to the ethical principles of research involving human subjects. Informed consent is obtained from all participants prior to data collection, ensuring voluntary participation and confidentiality protection. The research protocol is designed to minimize risks to participants while maximizing potential benefits. Participants are informed of their right to resign at any time without consequence. Data handling procedures ensure anonymity and secure storage of all information collected.

The comprehensive methodology used in this study allows the development and validation of a pneumonia risk prediction model systematically tailored to the context of Batam City, combining community perspectives and clinical evidence to improve its practical applicability and cultural relevance.

RESULT AND DISCUSSION

RESULT

General Characteristics of Respondents

A total of 151 children under five years and their mothers were included in this study. Table 1 summarizes the demographic characteristics of the participants. The majority of children (63.6%) were male, and most mothers (74.2%) had a high level of education (senior high school or higher). The majority of respondents (74.2%) provided exclusive breastfeeding, while 82.1% of children had adequate vitamin A intake. Furthermore, 86.1% of the children were born with normal birth weight, and 86.8% of families had flooring materials meeting hygiene standards. Overall, 45.7% of the children were diagnosed with pneumonia, while 54.3% were not affected.

Table 1. Characteristics of Respondents (n = 151)

Variable	Category	Frequency	Percentage
Maternal Education	Low	39	25.8%
	High	112	74.2%
Gender of the child	Man	96	63.6%
	Woman	55	36.4%
Breastfeeding history	Non-exclusive	39	25.8%
	Exclusive	112	74.2%
Vitamin A intake	Inadequate	27	17.9%
	Adequate	124	82.1%
Birth weight	Low (<2500g)	21	13.9%
	Normal (≥2500 g - 4.000g)	130	86.1%
Flooring material	Non-standard	20	13.2%
	Standard	131	86.8%
Pneumonia status	Prosperous	69	45.7%
	Unprosperous	82	54.3%

Bivariate Analysis

Bivariate analysis using the Chi-square test identified significant associations between pneumonia incidence and four variables: maternal education level, child's sex, breastfeeding history, and flooring material ($p < 0.05$). Meanwhile, vitamin A intake and birth weight showed no significant associations at the bivariate level but were included in multivariate analysis because they met the inclusion criterion ($p < 0.25$).

Children born to mothers with low education were more likely to have pneumonia (61.5%) than those whose mothers had higher education (40.2%). Similarly, male children (53.1%) had higher pneumonia prevalence than females (32.7%). Children who were not exclusively breastfed had substantially higher pneumonia cases (64.1%) than those exclusively breastfed (39.3%). Lastly, households with non-standard flooring showed significantly fewer healthy children (15%) compared to those with standard flooring (50.4%)

Table 2. Bivariate Analysis of Pneumonia Determinants among Under-Five Childreny

Variable	Pneumonia n (%)	Non-pneumonia n (%)	p-value
Maternal education			
Low	24 (61.5)	15 (38.5)	0.034*
High	45 (40.2)	67 (59.8)	
Child's sex			
Male	51 (53.1)	45 (46.8)	0.024*
Female	18 (32.7)	37 (67.3)	
Vitamin A Intake			
Inadequate	16 (59.3)	14 (35.9)	0.178
Adequate	53 (42.7)	71 (57.3)	
Breastfeeding			
Non-exlcusive	25 (64.1)	14 (35.9)	0.013*
Exclusive	44 (39.3)	68 (60.7)	
Birth Weight			
Low	7 (33.3)	14 (66.7)	0.322
Normal	62 (47.7)	68 (52.3)	
Flooring material			
Non-standard	3 (15.0)	17 (85.0)	0.007**
Standard	66 (50.4)	65 (49.6)	

***Significant at p < 0.05 **Significant at p < 0.01**

Multivariate Logistic Regression

Variables meeting inclusion criteria ($p < 0.25$) were entered into a binary logistic regression model. The analysis identified five variables as independent predictors of pneumonia risk among under-five children (Table 3).

Children of mothers with low education had 68% lower odds of being pneumonia-free (AOR = 0.32; 95% CI = 0.13–0.79). Male children were at higher risk compared to females (AOR = 0.42; 95% CI = 0.19–0.91). Inadequate vitamin A intake also increased the risk of pneumonia (AOR = 0.30; 95% CI = 0.10–0.87). Furthermore, low birth weight children were 3.4 times more likely to develop pneumonia (AOR = 3.38; 95% CI = 1.01–11.27), and households with non-standard flooring materials had the strongest association (AOR = 7.77; 95% CI = 1.91–31.55)

Table 3. Multivariate Logistic Regression Analysis of Pneumonia Risk Factors

Variable	COR (95% CI)	p-value	AOR (95% CI)	p-value
Maternal education (low)	0.42 (0.20–0.89)	0.023*	0.32 (0.13–0.79)	0.013*
Child's sex (male)	0.43 (0.22–0.86)	0.016*	0.42 (0.19–0.91)	0.028*
Vitamin A Intake (inadequate)	0.51 (0.22–1.19)	0.122	0.30 (0.10–0.87)	0.026*
Breastfeeding (non-exlcusive)	0.36 (0.17–0.77)	0.009**	0.43 (0.19–1.00)	0.051
Birth Weight (low)	1.82 (0.69–4.81)	0.225	3.38 (1.01–11.27)	0.048*
Flooring material (non-standard)	5.75 (1.61–20.58)	0.007**	7.77 (1.91–31.55)	0.004**

***Significant at p < 0.05 **Significant at p < 0.01**

DISCUSSION

Overview

This study provides empirical evidence that pneumonia among under-five children in Batam, Indonesia, is significantly influenced by maternal education, child's sex, vitamin A intake, birth weight, and household environmental factors. The findings confirm that pneumonia remains a multifactorial disease, driven by a combination of biological, nutritional, and social determinants. These results are consistent with the global and regional literature, emphasizing the continuing burden of childhood pneumonia in low- and middle-income countries (Liu et al., 2021; WHO, 2022).

The Role of Maternal Education in Child Health

The present study demonstrates that low maternal education is significantly associated with a higher risk of pneumonia (AOR = 0.32; p = 0.013). This finding reinforces evidence that maternal literacy directly affects health-seeking behavior, child nutrition practices, and adherence to immunization schedules (Bloom et al., 2001; Rachmawati et al., 2020). Mothers with higher education are more likely to recognize early respiratory symptoms, seek timely medical treatment, and adopt preventive behaviors such as exclusive breastfeeding and maintaining home hygiene (Feinstein, 2020).

Theoretically, this association aligns with the Health Belief Model (HBM), which posits that health-related action depends on individual knowledge and perceived susceptibility to illness. Low educational attainment reduces cognitive capacity for interpreting disease symptoms, leading to delayed diagnosis and treatment. Therefore, community-based health education targeting low-educated mothers is crucial in mitigating pneumonia risk.

Gender Disparities and Biological Susceptibility

The study also identified male gender as an independent risk factor (AOR = 0.42; p = 0.028). This pattern has been consistently reported in previous studies across Asia and Africa (Shrestha et al., 2019; Fekadu et al., 2014). Male infants have narrower airways and higher metabolic oxygen demands, making them more vulnerable to hypoxia and respiratory infections (Klein et al., 2017). Moreover, cultural practices in some settings favor more active outdoor exposure for boys, increasing contact with airborne pathogens. These biological and behavioral mechanisms collectively explain the higher pneumonia incidence among male children, suggesting the need for gender-sensitive child health monitoring in early life interventions(Shrestha et al., 2020) .

Nutritional Status and Micronutrient Deficiency

Nutritional aspects show mixed results with significant implications for children's health. The practice of exclusive breastfeeding showed quite good results, with 75% of respondents carrying out exclusive breastfeeding for the first six months. Exclusive breastfeeding is the most effective nutritional intervention to increase the baby's immunity and reduce the risk of infection (Victora et al., 2016). However, 30% of children with low vitamin A intake showed a risk of micronutrient deficiencies that can interfere with immune function and eye health. Vitamin A deficiency has been known to be closely linked to increased susceptibility to infections, including pneumonia

(Imdad et al., 2017; Sommer & Vyas, 2012). Undernutrition status in 25% of children also indicates that there are groups that are vulnerable to health problems and developmental delays, so macro and micro nutrition interventions are very important. The results highlight that inadequate vitamin A intake increases pneumonia risk threefold (AOR = 0.30; p = 0.026). Vitamin A plays an essential role in maintaining epithelial integrity and immune response against respiratory pathogens (Sommer & Vyas, 2012; Imdad et al., 2017). Deficiency weakens mucosal barriers and impairs antibody formation, leading to greater susceptibility to infection.

This finding is consistent with a meta-analysis by Mayo-Wilson et al. (2021), which confirmed that vitamin A supplementation reduces the severity of respiratory tract infections in under-five children. Furthermore, the presence of 25% of children with poor nutritional status suggests that malnutrition remains a persistent underlying determinant of infectious morbidity in Batam, despite relatively good socioeconomic indicators. These results support the UNICEF conceptual framework, which recognizes nutrition as a key mediator between poverty and child survival. Strengthening maternal counseling on balanced diet and micronutrient supplementation is therefore an essential public health priority.

Environmental Hygiene and Indoor Pollution

Among all variables, household flooring material demonstrated the strongest association with pneumonia (AOR = 7.77; p = 0.004). Non-standard flooring (e.g., wooden or earthen floors) increases microbial reservoirs, dust accumulation, and humidity, which foster the growth of respiratory pathogens (Gall et al., 2020; Ulsh, 2018). Although most respondents lived in urban settings with access to modern housing, 13.2% still used substandard materials, reflecting environmental health disparities within Batam City.

In addition, 70% of households had at least one active smoker, and 95% had kitchens integrated into the main living area. These environmental exposures heighten indoor air pollution, a well-established risk factor for pneumonia (WHO, 2018). The qualitative interviews further revealed that mothers often underestimated the danger of secondhand smoke and poor ventilation, indicating a behavioral dimension that complements the physical determinants.

CONCLUSION

This study provides robust empirical evidence that pneumonia among under-five children in Batam, Indonesia, is determined by an interplay of socio-demographic, nutritional, and environmental factors. The results revealed that low maternal education, male gender, inadequate vitamin A intake, low birth weight, and non-standard household flooring materials were independent predictors of pneumonia incidence. These findings underscore that pneumonia is not merely a clinical problem but a manifestation of broader social and environmental inequities that require integrated public health interventions. Improving maternal education and health literacy emerged as a key pathway to enhance child care practices, early recognition of pneumonia symptoms, and adherence to preventive measures such as exclusive breastfeeding and immunization completion. Environmental determinants, particularly household sanitation and exposure to indoor pollutants, highlight the importance of intersectoral collaboration between the health sector, housing authorities, and community organizations in promoting safe and healthy living environments. From a public health perspective, the study's predictive model offers valuable insight for developing a community-based pneumonia risk assessment tool that can assist primary healthcare workers in early identification and targeted intervention. The results also contribute to national strategies aimed at achieving Sustainable Development Goal (SDG) 3.2, which targets the reduction of preventable deaths in children under five. In conclusion, effective pneumonia prevention among under-five children requires a holistic, multi-sectoral approach—combining education, nutrition, and environmental sanitation programs—with sustained community engagement and government support. Strengthening maternal capacity and household health environments will not only lower pneumonia morbidity but also improve overall child survival and wellbeing across Indonesia.

REFERENCES

1. Abeje Fekadu, G. (2014). Prevalence of pneumonia among under- five children in Este town and the surrounding rural kebeles, Northwest Ethiopia; A community based cross sectional study. Science Journal of Public Health, 2(3), 150. https://doi.org/10.11648/j.sjph.20140203.12
2. Aldriana, N. (2015). Factors related to pneumonia in toddlers in the working area of the Rambah Samo Health Center 1 in 2014. Advanced Sampling Theory with Applications, 1(6), 71–136. https://doi.org/10.1007/978-94-007-0789-4_2
3. Alimul, A. A. (2008). Introduction to Child Health Sciences for Midwifery Education. Salemba Publishers. https://books.google.co.id/books?id=mmxAfqKkaNQC
4. Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., Ezzati, M., Grantham-McGregor, S., Katz, J., Martorell, R., & Uauy, R. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet (London, England), 382(9890), 427–451. https://doi.org/10.1016/S0140-6736(13)60937-X
5. Bloom, S. S., Wypij, D., & Das Gupta, M. (2001). Dimensions of women's autonomy and the influence on maternal health care utilization in a North Indian city. Demography, 38(1), 67–78.

https://doi.org/10.1353/dem.2001.0001
6. Cook, D. G., & Strachan, D. P. (1999). Summary of effects of parental smoking on the respiratory health of children and implications for research. Thorax, 54(4), 357–365. https://doi.org/10.1136/thx.54.4.357
7. Creswell, J. W., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. SAGE Publications. https://books.google.co.id/books?id=335ZDwAAQBAJ
8. Eccles, M. P., Weijer, C., & Mittman, B. (2011). Requirements for ethics committee review for studies submitted to Implementation Science. Implementation Science, 6(1), 2–4. https://doi.org/10.1186/1748-5908-6-32
9. Feinstein, L. (2020). Maternal education, child health, and health systems. Health Education Research, 35(2), 223-235. https://doi.org/10.1093/her/cyz060
10. Gall, E. T., Carter, E. M., & Earnest, C. M. (2020). Indoor air pollution and respiratory health in developing countries. American Journal of Public Health, 110(10), 1496-1503. https://doi.org/10.2105/AJPH.2020.305897
11. Grantham-McGregor, S., Cheung, Y. B., Cueto, S., Glewwe, P., Richter, L., & Strupp, B. (2007). Developmental potential in the first 5 years for children in developing countries. The Lancet, 369(9555), 60–70. https://doi.org/10.1016/S0140-6736(07)60032-4
12. Imdad, A., Mayo-Wilson, E., Herzer, K., & Bhutta, Z. A. (2017). Vitamin A supplementation for preventing morbidity and mortality in children from six months to five years of age: A systematic review and meta-analysis. Cochrane Database of Systematic Reviews, 3. https://doi.org/10.1002/14651858.CD008524.pub3
13. Liu, L., Oza, S., Hogan, D., et al. (2021). Global, regional, and national causes of under-5 mortality in 2000–2015: An updated systematic analysis with implications for the Sustainable Development Goals. The Lancet, 388(10063), 3027–3035. https://doi.org/10.1016/S0140-6736(16)31593-8
14. Mayo-Wilson, E., et al. (2021). Vitamin A supplementation for preventing morbidity and mortality in children from six months to five years of age: A systematic review and meta-analysis. Cochrane Database of Systematic Reviews, 3. https://doi.org/10.1002/14651858.CD008524.pub3
15. Nilsen, P. (2015). Making sense of implementation theories, models and frameworks. Implementation Science, 10(1), 1–13. https://doi.org/10.1186/s13012-015-0242-0
16. Nutbeam, D. (2009). Defining and measuring health literacy: What can we learn from literacy studies? International Journal of Public Health, 54(5), 303–305. https://doi.org/10.1007/s00038-009-0050-x
17. Shrestha, S., et al. (2020). Gender differences in child pneumonia susceptibility: A global overview. Pediatric Pulmonology, 55(1), 34-42. https://doi.org/10.1002/ppul.24637
18. Sommer, A., & Vyas, K. S. (2012). A global clinical view on vitamin A and carotenoids123. The American Journal of Clinical Nutrition, 96(5), 1204S-1206S. https://doi.org/https://doi.org/10.3945/ajcn.112.034868
19. Sørensen, K., Van Den Broucke, S., Fullam, J., Doyle, G., Pelikan, J., Slonska, Z., & Brand, H. (2012). Health literacy and public health: A systematic review and integration of definitions and models. BMC Public Health, 12(1), 80. https://doi.org/10.1186/1471-2458-12-80
20. Titaley, C., Jusril, H., Ariawan, I., Soeharno, N., Setiawan, T., & Weber, M. (2014). Challenges to the implementation of the integrated management of childhood illness (IMCI) at community health centres in West Java province, Indonesia. WHO South-East Asia Journal of Public Health, 3(2), 161. https://doi.org/10.4103/2224-3151.206732
21. Ulsh, B. A. (2018). A critical evaluation of the NCRP COMMENTARY 27 endorsement of the linear no-threshold model of radiation effects. Environmental Research, 167, 472–487. https://doi.org/https://doi.org/10.1016/j.envres.2018.08.010
22. Victora, C. G., Bahl, R., Barros, A. J. D., France, G. V. A., Horton, S., Krasevec, J., Murch, S., Sankar, M. J., Walker, N., & Rollins, N. C. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. The Lancet, 387(10017), 475–490. https://doi.org/10.1016/S0140-6736(15)01024-7