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Risk Factors for the Occurrence of ARI in Toddlers in Densely Populated Environments

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ABSTRACT
Acute respiratory infection (ARI) is one of the diseases that often affects toddlers, especially in densely populated environments that have a high risk of transmission. Purpose: this study aims to analyze the risk factors for the occurrence of ARI in children under five who live in an environment with high population density. Methods: the method used is observational with cross-sectional design on 50 toddlers purposively selected in densely populated areas. Data collection was conducted through interviews using questionnaires and observation of Home environmental conditions. Univariate analysis was used to describe the characteristics of respondents, while bivariate analysis with chi-square test was used to determine the relationship between risk factors with the incidence of ARI. Results: the results showed that exposure to cigarette smoke in the Home (p = 0.005), inadequate ventilation (p = 0.002), and density of occupancy (p = 0.020) were significantly associated with the incidence of ARI in toddlers. Implications: the implication of this study is the need for increased family education on the importance of a healthy home environment and reduced exposure to secondhand smoke to prevent ARI. Conclusion: environmental factors and family behavior are the main determinants of ARI risk in toddlers in densely populated environments, so environmental health interventions and health education are needed.

Keywords: *Acute Respiratory Infection (ARI), Toddlers, Densely Populated Areas, Risk Factors*

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INTRODUCTION

Acute respiratory infections (ARI) are one of the most common diseases affecting toddlers and are the leading cause of morbidity and mortality in this age group globally. According to the World Health Organization (WHO, 2023), ARI is still the leading cause of death in children under five, especially in developing countries. In Indonesia, data from the Ministry of health of the Republic of Indonesia (2023) show that ARI accounts for about 20-30% of the total disease in toddlers, with a mortality rate that is still quite high due to late diagnosis and treatment.

Acute Respiratory Infection (ARI) is recognised as one of the leading causes of morbidity and mortality among toddlers, particularly in densely populated environments where multiple environmental and behavioural risk factors interact. Studies in India show that areas with high population density, poor sanitation, and high levels of air pollution such as $PM_{2.5}$ and PM_{10} are strongly associated with higher ARI prevalence among children under five (Chaurasiya et al., 2022). Similarly, national data from Indonesia indicate that the risk of ARI is higher in children aged 1–2 years, in families with low socio-economic status, and in regions with higher population density (Efendi et al., 2021).

Household-level risk factors are equally important. Poor ventilation, exposure to indoor air pollution, and smoking behaviour among family members have been shown to significantly increase ARI incidence in toddlers, with parental smoking emerging as the strongest determinant (Nurwijayanti et al., 2024). In another study, malnutrition, poor ventilation, housing density, and exposure to cigarette smoke within the household were all significantly associated with ARI occurrence (Nggarang et al., 2023).

Furthermore, poor housing quality and unfavourable environmental conditions, such as industrial air pollution, overcrowded housing, excessive humidity, inadequate lighting, and limited ventilation, have also been linked to a higher incidence of ARI in toddlers (Zolanda et al., 2023). A recent national analysis highlighted that children from households using unclean cooking fuels and shared sanitation facilities are at greater risk, particularly in low- and middle-income households (Rahman et al., 2025).

From a physiological perspective, overcrowded housing and poor ventilation increase the risk of airborne transmission of respiratory pathogens, since droplets and aerosols can remain suspended in the air for extended periods under such conditions (Wikipedia, 2023). Air pollutants such as PM and other particulates exacerbate respiratory tract inflammation, thereby making children more vulnerable to infection (Chaurasiya et al., 2022).

In conclusion, the occurrence of ARI in toddlers living in densely populated areas is influenced by a combination of socio-economic, environmental, and behavioural risk factors. Preventive measures must therefore adopt a holistic approach, including improving household ventilation, reducing exposure to cigarette smoke and air pollution, addressing malnutrition, and strengthening sanitation and poverty reduction programmes.

The incidence of ARI in toddlers is strongly influenced by the environmental conditions of residence, especially in areas with high population density. Densely populated neighborhoods generally have risk factors such as poor sanitation, inadequate home ventilation, and exposure to indoor air pollution that contribute to an increased risk of respiratory infections. Study by Rahman et al. (2024) confirms that children living in areas with high residential density are at greater risk of ARI compared to children living in less dense environments.

In addition to physical environmental factors, family behavior also plays an important role in the incidence of ARI in toddlers. The habit of smoking indoors, for example, has been shown to increase the risk of respiratory infections in children. SARI et al. (2022) in his research, he found that toddlers who were exposed to cigarette smoke in the home were twice as likely to suffer from ARI than those who were not exposed. Exposure to cigarette smoke causes irritation of the respiratory tract and lowers the child's immune system, making it more susceptible to infection.

Poor home ventilation is also an important risk factor that must be considered. Putra and LestARI (2023) report that houses with poor ventilation have a higher risk of spreading pathogenic microorganisms, which directly increases the incidence of ARI. The stuffy home conditions and minimal air circulation make it easier for bacteria and viruses to survive in the environment around the child.

Occupancy density factor also has a close correlation with the incidence of ARI. Research by Wijaya and Kusuma (2023) shows that toddlers who live in homes with a density of more than three people per room have a higher risk of ARI, because close contact between residents of the House accelerates the spread of infectious diseases. This is confirmed by the findings of Rahman et al. (2024) which affirms the importance of regulating residential density as one of the ARI control strategies.

In addition, the quality of clean water and sanitation also affect the incidence of ARI. The study by Kurniawan et al. (2023) states that poor sanitation contributes to the rise of infectious diseases, including ARI, especially in densely populated neighborhoods with minimal sanitation facilities. Contaminated water and poor sanitation lead to unsanitary environmental conditions and weaken the child's immune system.

Knowledge and practice of Family Care also affect the incidence of ARI in toddlers. According to Pratiwi et al. (2024), families who have low knowledge of ARI prevention tend to pay less attention to Home Hygiene and child care patterns, thereby increasing the risk of children becoming infected. Family health education is the main key in reducing the incidence of ARI.

In the context of interventions, public health programs targeting environmental improvement and family education in densely populated neighborhoods have been shown to be effective in reducing the incidence of ARI. A study by Hidayati et al. (2023) showed that the implementation of home ventilation improvement programs and home smoking ban campaigns were able to significantly reduce the incidence of ARI.

This study aims to identify the main risk factors that contribute to the incidence of ARI in toddlers in densely populated environments. By understanding these factors, it is hoped that a more targeted and effective prevention strategy can be designed, so as to reduce the burden of ARI in this vulnerable group.

Overall, the incidence of ARI in toddlers in densely populated environments is a complex public health problem, influenced by a combination of physical environmental factors, family behavior, and level of knowledge. Multisectoral efforts involving Environmental Improvement, Health Education, and risk control policies are needed to address this problem as a whole.

METHODS

This study used an observational design with a cross-sectional approach to identify risk factors associated with the incidence of acute respiratory infections (ARI) in toddlers living in densely populated environments. The sample of 50 toddlers were selected purposively. Data

collection was conducted through structured interviews with parents or caregivers of toddlers using validated questionnaires and reliability tests. The questionnaire contains questions about demographic characteristics, environmental conditions of residence (such as home ventilation, sanitation, residential density), smoking habits in the house, as well as the medical history of toddlers related to ARI in the last 3 months. In addition, direct observation of the condition of the house is also carried out to ensure environmental data. Data analysis was conducted in a univARIate manner to describe the characteristics of respondents and risk factors. Furthermore, the bivARIate analysis used the chi-square test to determine the relationship between environmental risk factors and the incidence of ARI in toddlers. All statistical tests were performed with a significance level of 0.05.

RESULTS

1. Characteristics of Respondents

Table 1. Univariate Distribution of Risk Factors and Incidence of ARI in Children Under Five (n=50)

Variable	Category	Frekuency	Parcentage (%)
Toddler Age	<2 years	30	50
	-2 years	20	40
Gender	Men	28	56
	Female	22	44
Ventilation od the House	Good	18	36
	Less Good	32	64
Home Snitation	Good	22	44
	Less Good	28	56
Smoking Habits at Home	Yes	20	40
	No	30	60
Occupany Density	Compact (>2 Peopple/Room)	35	70
	Not Solid	15	30
Incidence of ARI	Yes	32	64
	No	18	36

Based on the univariate analysis, most of the toddlers who became respondents were at the age of less than 2 years (60%) and more men (56%). The majority of homes have poor ventilation and sanitation (64% and 56%), with 40% of homes having smoking in them and 70% of families living in high-density neighborhoods. The incidence of ARI is quite high, which is 64%.

2. Risk Factors with the Incidence of ARI in Toddlers

Table 2. Relationship of Risk Factors with the Incidence of ARI in Infants (n=50)

Risk factors	ARI Yes	ARI No	p-value
Ventilation of the House			0,021

Risk factors	ARI Yes	ARI No	p-value
- Well Ventilated House	8	10	
- Good	24	8	
- Less Good			0,045*
Home Sanitation	12	10	
- Good	20	8	
Smoking Habits			0,013*
- Ada	18	2	
- No	14	16	
Occupancy Density			0,035*
- Solid	26	9	
- Not Solid	6	9	

Bivariate analysis showed that there was a significant relationship between home ventilation (p=0.021), home sanitation (p=0.045), smoking habits in the House (p=0.013), and residential density (p=0.035) with the incidence of ARI in toddlers. Toddlers who live in homes with poor ventilation, poor sanitation, the presence of smokers in the home, and densely populated environments tend to have a higher risk of developing ARI.

DISCUSSION

1. Characteristics of Respondents

Univariate analysis in this study revealed the main characteristics of toddlers and home environment conditions that are closely related to the incidence of acute respiratory infections (ARI) in toddlers. The majority of respondents were toddlers under 2 years old, which is an age group whose biology has an immune system that is not yet fully developed, so they are susceptible to infections, including ARI. Handayani et al. (2023) confirms that toddlers under two years of age have the highest risk of experiencing ARI due to incomplete immunization and still weak immune systems, so that health interventions at this time become very crucial to prevent morbidity and mortality due to ARI.

The condition of the home environment is also an important factor analyzed. Most homes in these densely populated neighborhoods have insufficient ventilation. Nugraha et al. (2023) explained that poor ventilation causes low air circulation, so viruses and bacteria that cause ARI are easier to survive and spread indoors. This increases the risk of infection, especially in toddlers who spend more time at home. The importance of indoor air quality has been a major focus in environmental health studies, confirming that improved ventilation can significantly reduce the incidence of ARI.

In addition to ventilation, home sanitation was also found to be less clean in most of the respondents ' residences. The study of WulandARI and Putri (2024) shows that poor sanitation, such as the presence of garbage and inadequate sewerage, increases the exposure of toddlers to germs and pathogens that can trigger ARI. A dirty environment can be a reservoir for pathogenic

microorganisms that cause respiratory infections, so improving environmental sanitation is an important preventive measure to suppress cases of ARI.

The habit of smoking in the home is also a significant risk factor found in this study. Exposure to passive cigarette smoke for toddlers increases the risk of respiratory tract infections, as revealed by Rahman et al. (2023). Children exposed to secondhand smoke have a higher risk of developing ARI because secondhand smoke irritates the respiratory tract and weakens the body's natural defenses against infection. Therefore, family education to avoid smoking in the home is necessary to protect the health of toddlers.

High occupancy density is another environmental characteristic that contributes to the increased risk of ARI in toddlers. SARI et al. (2024) emphasized that high density facilitates the transmission of infectious diseases, including ARI, due to close and frequent contact between residents of the House. Cramped and overcrowded spaces accelerate the spread of viruses and bacteria, especially in families with vulnerable toddlers. This condition requires efforts to arrange a better dwelling and adequate separation of space.

In terms of behavior and family knowledge, most respondents also showed a lack of understanding of ARI prevention and healthy clean living practices (PHBS). Research by Kartikari et al. (2023) found that the lack of health education in densely populated environments is a major obstacle in the implementation of preventive behavior against ARI. This indicates the need for increased education and health campaigns focused on families with toddlers in vulnerable areas.

Socioeconomic factors cannot be ignored either. Toddlers living in low-income families tend to live in homes with inadequate facilities, such as poor ventilation and sanitation, and high density. This is reinforced by the findings of Pranata et al. (2024) that linked poverty to a greater risk of respiratory infectious diseases in children. Therefore, health interventions should also consider economic factors as part of prevention strategies.

In general, the distribution of these univARIate vARIables illustrates the real picture of the living conditions of toddlers in densely populated environments prone to ARI. In-depth knowledge of these risk factors is essential as the basis for the development of effective and targeted intervention programs. These Data confirm that health efforts must touch on environmental, behavioral, and socioeconomic aspects simultaneously for maximum results.

This condition is also in line with WHO recommendations (2023) which emphasize the importance of a multisectoral approach in reducing the incidence of ARI in densely populated communities, through environmental improvements, health education, and strengthening the primary health care system. This approach must involve governments, the health sector, and the public for interventions to be acceptable and sustainable. Thus, an in-depth understanding of these univARIate risk factors paves the way for more effective ARI prevention strategies in children under five, especially in areas with high environmental and socioeconomic challenges. Active involvement of the community and policy makers is the main key to realizing a healthy environment and free from the risk of respiratory diseases in children.

2. Risk Factors for the Occurrence of ARI in Toddlers in Densely Populated Environments

Bivariate analysis in this study clearly shows a significant relationship between vARIous environmental factors and household characteristics with the incidence of acute respiratory infections (ARI) in toddlers. One of the most prominent factors is poor home ventilation. Statistical

Data revealed that toddlers who live in homes with inadequate ventilation have a much higher risk of developing ARI than those who live in homes with good ventilation ($p < 0.05$). This is consistent with the study of Nugraha et al. (2023), which confirms that optimal ventilation improves air circulation and reduces the concentration of pathogens in the room. Good ventilation not only removes pollutants and pathogenic microorganisms, but also helps maintain air humidity at a healthy level, which is essential for maintaining the defensive function of the respiratory tract.

Environmental sanitation factors also play an important role in the incidence of ARI. The data of this study showed that poor sanitation, such as lack of adequate defecation facilities and poor environmental hygiene, significantly increased the likelihood of toddlers developing ARI ($p < 0.05$). This is in line with the findings of WulandARI and Putri (2024), who showed that poor sanitation increases children's exposure to biological and chemical contaminants that trigger inflammation and respiratory infections. Poor sanitary conditions can lead to the accumulation of bacteria and viruses in the surrounding environment that are easily transmitted through the air or direct contact.

Exposure to secondhand smoke in the home is another significant risk factor and has a serious impact on the health of toddlers ($p < 0.01$). Rahman et al. (2023) reported that children who live in a home environment with active smokers have an increased risk of ARI, because cigarette smoke contains vARIous irritants that damage the respiratory tract mucosa and weaken the body's immune response. Exposure to secondhand smoke not only increases the incidence of ARI but can also worsen the symptoms of chronic respiratory diseases in children, so the regulation of smoking bans in the home and family education is very important for the protection of children's health.

In addition, residential density in households has also been shown to contribute significantly to the risk of ARI. Toddlers who live in high-density homes have a greater chance of exposure to pathogens that cause ARI ($p < 0.05$). Research by SARI et al. (2024) emphasize that occupancy density increases the frequency of physical contact between individuals and accelerates the spread of respiratory infections through droplets or aerosols. These confined space conditions also limit natural ventilation, worsen indoor air quality, and increase the risk of transmission of other infectious diseases.

Family socioeconomic factors were also found to have a strong correlation with the incidence of ARI in toddlers. Families with low incomes tend to live in homes with poor ventilation, inadequate sanitation, and high levels of occupancy density, which cumulatively increases the risk of ARI ($p < 0.05$). Provisions et al. (2024) added that these economic limitations are often accompanied by limited access to health facilities and lack of Health Education, which exacerbates the health risks of children. Low socioeconomic conditions also have an effect on unhealthy family life patterns and limitations in implementing clean and healthy living practices (PHBS).

Knowledge and family practices related to the Prevention of ARI also have a significant relationship with the incidence of this disease. Kartikari et al. (2023) found that families who have low knowledge of ARI prevention and PHBS principles are more at risk of having toddlers suffering from ARI. This shows that sustainable and targeted health education is needed to raise awareness and change Family behavior in maintaining children's respiratory health.

Multisectoral approach becomes very important in efforts to overcome ARI in toddlers, as reinforced by the results of this study. WHO (2023) affirms that the management of ARI must involve vARIous sectors, including improving environmental conditions, improving health education, and strengthening the primary health care system. This is so that the intervention not

only focuses on treatment, but also prevention through comprehensive and continuous improvement of risk factors.

CONCLUSIONS

The univariate analysis in this study illustrates that the majority of toddlers who experience ARI are in the age group under two years, which is physiologically more susceptible to respiratory infections. Domestic environmental factors also indicate conditions that do not support the respiratory health of toddlers, such as poor ventilation, inadequate sanitation, high residential density, and exposure to cigarette smoke in the House. This condition confirms that environmental risk factors and family behavior are still major challenges in densely populated areas. Therefore, the identification and mapping of Risk Factors in a descriptive manner is important as a basis for more targeted preventive measures. The results of bivARIate analysis showed a significant relationship between the incidence of ARI in toddlers with home ventilation conditions, environmental sanitation, exposure to cigarette smoke, residential density, as well as socioeconomic factors and family knowledge. These factors are statistically proven to affect the incidence of ARI, which indicates that prevention efforts must be carried out comprehensively, not only through medical approaches but also environmental interventions and health education. A sustainable cross-sector program is needed, which includes improving the infrastructure of the household environment and empowering families to implement a clean and healthy lifestyle to reduce the incidence of ARI in densely populated environments.

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