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The Correlation Between Housing Density and House Ventilation Area and the Incidence of Acute Respiratory Tract Infections in Toddlers in Tuminting Sub-District, Manado City

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Abstract. *Background: Acute Respiratory Infections (ARI) remain the primary cause of morbidity among children under five in Indonesia, with the domestic physical environment being a significant determinant. Surveillance data from the Tuminting Health Center (2025) indicates an exceptionally high prevalence of ARI (79.0%) in toddlers within Tuminting District, Manado City. Objective: This study aimed to analyze the association between residential occupancy density and house ventilation area with the incidence of ARI in toddlers in this high-prevalence region. Methods: A cross-sectional study was conducted from July to November 2025. A purposive sample of 62 toddlers was enrolled. Primary data were collected via questionnaires, direct observation, and physical measurements of dwellings using a roller meter. Univariate analysis described variable characteristics, and the Fisher's Exact test was employed for bivariate analysis with a significance level of $p < 0.05$. Results: The majority of households had non-compliant occupancy density (83.9%), while most had adequate ventilation area (91.9%). The ARI prevalence was 79.0%. Bivariate analysis revealed a statistically significant association between high occupancy density and ARI incidence (p-value = 0.004). In contrast, no significant relationship was found between ventilation area and ARI (p-value = 0.280). Conclusion: Occupancy density is the dominant environmental risk factor contributing to the high incidence of ARI in toddlers in Tuminting District. These findings underscore that public health interventions must extend beyond improving physical housing quality (e.g., ventilation) to actively address overcrowding through healthy housing policies and targeted community education.*

Keywords: *ARI; Toddlers; Housing Density; Ventilation; Tuminting*

1. Introduction

Acute Respiratory Infections (ARI) remain a major global public health problem, affecting the respiratory tract from the upper airways to the alveoli and associated organs. ARI is caused by a wide range of microorganisms, including bacteria, viruses, and rickettsiae, which are primarily transmitted through airborne routes. The clinical spectrum varies from asymptomatic infection to severe and potentially fatal illness, largely depending on the causative pathogen (1,2).

Children under five years of age represent the most vulnerable population to ARI. This vulnerability is closely linked to the immaturity of the immune system, which limits the ability of young children to mount effective defenses against respiratory pathogens (3). Even in high-

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income countries, ARI accounts for approximately 50% of morbidity among children under five, a proportion substantially higher than that observed in older age groups.

In Indonesia, ARI continues to be a leading cause of morbidity and mortality among infants and toddlers. According to the Indonesian Health Profile 2022, national coverage for pneumonia management—representing severe ARI—remains low at 38.8%. Although some provinces report higher coverage, the burden of disease remains considerable. Mortality from pneumonia among infants is nearly three times higher than among children aged 1–4 years, highlighting the critical vulnerability of early childhood and the urgency of effective preventive strategies (4).

Susceptibility to ARI in toddlers is not determined solely by immunological factors but is also strongly influenced by the physical characteristics of the residential environment. Environmental Health Theory emphasizes that substandard housing conditions can act as major predisposing factors for disease. High residential density, inadequate ventilation, excessive humidity, poor lighting, and indoor air pollution create conditions conducive to the survival and transmission of ARI pathogens (5,6). Given that toddlers spend most of their time indoors, they are disproportionately exposed to these environmental risks.

The local context further underscores the importance of this issue. Data from the Tuminting Health Center in Manado City (2024) recorded 147 ARI cases among 169 registered toddlers, indicating an alarmingly high prevalence. This pattern suggests the presence of poorly controlled environmental risk factors. Previous studies have similarly reported that Indonesia's tropical climate and environmental conditions contribute to sustained transmission of respiratory infections (7).

Despite the high burden of ARI in Tuminting District, evidence regarding the specific contribution of physical housing conditions remains limited. Therefore, this study aimed to analyze the association between residential density and house ventilation area with the incidence of ARI among toddlers in Tuminting District, Manado City. The findings are expected to provide an evidence-based foundation for targeted interventions by primary health centers and related stakeholders..

2. Methods

This study is a quantitative study with a cross-sectional approach, where independent and dependent variables are measured at the same time. This design was chosen because it is efficient and appropriate to identify the relationship between risk factors (housing conditions) and effects (ARI occurrence) without having to wait for a long follow-up period. The research was carried out in the working area of the Tuminting Health Center, Manado City, for five months, from July to November 2025. The selection of this location is based on the initial findings of the high prevalence of ARI in toddlers in the area, which reached 147 cases out of 169 total population of toddlers by 2024, making it a critical area to study.

The population in this study is all toddlers (children under five years old) who are registered and live in Tuminting District. The sampling technique used is purposive sampling. Although in the initial description it is called "random", the purposive sampling method is more appropriately described as a non-probability sampling technique in which researchers select subjects based on pre-established inclusion criteria. The inclusion criteria include: (1) toddlers aged 12-59 months who have lived with their parents in Tuminting District for at least the last 6 months, (2) do not suffer from chronic lung diseases such as asthma or tuberculosis, and (3) parents/guardians are willing to sign an informed consent. Based on this

criterion, 62 respondents (mothers or primary caregivers of toddlers) were selected who were eligible to be samples in the study.

The research instruments used were developed to collect comprehensive and objective data. Primary data were collected using three main questionnaire tools, observation sheets and roll meters.

The data that has been collected is then statistically analyzed using a computer program. Data analysis was carried out in two stages. First, univariate analysis was conducted to describe the characteristics of each study variable, including independent variables (occupancy density and ventilation area) and dependent variables (ARI occurrence). The results of this analysis are presented in the form of frequency and percentage distributions. Second, bivariate analysis was conducted to test the relationship between occupancy density and ventilation area with the incidence of ARI. The statistical test used is the Chi-Square Test (χ^2). This test was chosen because the data analyzed was categorical. In this study, the level of statistical significance set is p-value < 0.005. A relationship is statistically significant if the test p-value is less than 0.005, indicating that the probability of a coincidental relationship is less than 0.5%.

3. Results and Discussion

3.1 Results

3.1.1 Respondent Characteristics

In this section, the distribution of respondents is explained based on individual characteristics such as age, last education and occupation. This can be seen in Tables 1 and 2.

Table 1. Distribution of Respondent Characteristics

Respondent Characteristics	n (N=62)	%
Age		
20-25	14	22,6
26-30	33	53,2
31-36	10	16,1
37-41	5	8,1
Final Education		
JUNIOR	1	1,6
SMA	55	88,7
Academic/College	6	9,7
Work		
Not working/Housewife	55	88,7
PNS	3	4,8
Private	4	6,5

In analyzing the age of respondents, researchers found that the majority of respondents were between the ages of 26 and 30, with 33 people (53.2%) falling into this category, compared to only 5 people (8.1%) in the 37–41 age group. The highest level of education achieved by respondents was high school (55 respondents, or 88.7%), followed by junior high school (one respondent, or 1.6%). In terms of employment, 55 respondents (88.7%) were housewives, four worked in the private sector (6.5%), and three were civil servants (4.8%).

3.1.2 Toddler Characteristics

Table 2. Distribution of Toddler Characteristics

Characteristics of Toddlers	n (N=62)	%
Gender		
Woman	37	59,7
Man	25	40,3
Age		
12-15 months	13	21,0
24-27 months	19	30,6
36-39 months	16	25,8
48-59 months	14	22,6

The results of the analysis of gender characteristics in toddlers showed that the majority were women (59.7%), while the minority were boys (40.3%). The analysis of the age of toddlers showed that the majority were two years old (19 toddlers, 30.6%), while the least were one year old (13 toddlers, 21%).

3.1.3 Univariate Analysis

In this section, the distribution of respondents based on research variables is explained. The study variables consisted of house occupancy density, house ventilation area and ARI incidence. This can be seen in Table 3.

Table 3. Distribution of Respondents Based on Research Variables

Variable	Category	n (N=62)	%
Residential Density	Qualify	10	16,1
	Not Eligible	52	83,9
Ventilation Area of the House	Qualify	57	91,1
	Not Eligible	5	8,1
ARI Incident	Yes	49	79,0
	Not	13	21,0

Based on data obtained from 62 respondents in Tuminting District, the results of this study reveal a very worrying picture of the health condition of toddlers and the environment in which they live. Descriptive analysis showed that the incidence of ARI in toddlers in the region was at a very high level, namely 79.0% (49 out of 62 toddlers). This figure clearly confirms the initial findings from the Tuminting Health Center (2025) that ARI is a dominant and serious health problem in the age group of toddlers in this sub-district. Only 21.0% of toddlers were free of ARI in the study period, further emphasizing the urgency of identifying and addressing the risk factors.

3.1.4 Bivariate Analysis

Furthermore, the relationship between independent variables (occupancy density and house ventilation area) and the incidence of ARI in toddlers is explained. This can be seen in Tables 4 and 5.

The Relationship between Home Occupancy Density and the Incidence of PSI in Toddlers

Table 4. The Relationship between Home Occupancy Density and the Incidence of PSI in Toddlers

Residential Density	ARI Incident				Total		*p-value*
	No		Yes				
	n	%	n	%	n	%	
Qualify	6	9,7	4	6,5	10	16,1	0,004
Not Eligible	7	11,3	45	72,6	52	83,9	
Total	13	21,0	49	79,0	62	100,0	

The Fisher's Exact test was used to analyze the relationship between housing density and the incidence of acute respiratory tract infections (ARI) in Tuminting district, Manado City, as shown in the table above. The results showed a significant relationship in Tuminting sub-district, Manado City, with a p value of 0.004 ($p < 0.005$).

The Relationship of Home Ventilation with the Incidence of ARI in Toddlers

Table 7. The Relationship between Home Ventilation Area and the Incidence of ARI in Toddlers

Ventilation Area of the House	ARI Incident				Total		*p-value*
	No		Yes				
	n	%	n	%	n	%	
Qualify	11	17,7	46	74,2	57	91,9	0,280
Not Eligible	2	3,2	3	4,8	5	8,1	
Total	13	21,0	49	79,0	62	100,0	

The Fisher's Exact test was used to analyze the relationship between ventilation area and the incidence of acute respiratory tract infection (ARI) in Tuminting district, Manado City, as shown in the table above. The results showed that there was no significant relationship in Tuminting sub-district, Manado City, with a p value of 0.280 ($p > 0.005$).

3.2 Discussion

3.2.1 Characteristics of Respondents and Description of Study Variables

This study included 62 respondents with toddlers residing in the working area of the Tuminting Health Center. The prevalence of ARI among toddlers was notably high, reaching 79.0% (49 out of 62 children). This finding corroborates routine health center data and reinforces the assertion that ARI constitutes a dominant disease burden among toddlers in this area (3).

Assessment of housing conditions revealed a marked disparity between the studied variables. The majority of households (83.9%) were classified as having residential density that did not meet health standards, indicating widespread overcrowding. In contrast, ventilation conditions were generally adequate, with 91.9% of houses meeting the recommended ventilation criteria. This contrast suggests that residential density may exert a stronger influence on ARI incidence than ventilation alone in this setting.

3.2.2 Association Between Residential Density and ARI Incidence

Statistical analysis using Fisher's Exact Test demonstrated a significant association between residential density and ARI incidence among toddlers ($p = 0.004$). This finding is consistent with previous studies conducted in other regions of Indonesia, which have also identified overcrowding as a significant risk factor for ARI (8).

Several mechanisms may explain this relationship. High residential density reduces physical distance between occupants, facilitating the transmission of pathogens via respiratory droplets and aerosols. This risk is particularly pronounced for toddlers with underdeveloped immune systems (9). Moreover, overcrowded households tend to experience poorer indoor air quality. Even when ventilation meets technical standards, excessive numbers of occupants reduce effective air exchange per person, leading to pathogen accumulation and increased exposure risk (10,11,12,13,14). Field observations in this study further revealed that many households were occupied by more than one nuclear family, creating conditions favorable for the spread of infectious respiratory diseases.

3.2.3 Association Between Ventilation Area and ARI Incidence

The analysis showed no significant association between ventilation area and ARI incidence among toddlers ($p = 0.280$). This result aligns with findings from previous studies that also reported no meaningful correlation between ventilation size and ARI occurrence (15).

The absence of an observed association may be attributed to the dominant effect of residential density. Severe overcrowding likely diminishes the protective effect of adequate ventilation, as incoming fresh air may rapidly become recontaminated by infected occupants. Furthermore, ventilation effectiveness is determined not only by its area but also by factors such as airflow direction, wind speed, and the presence of cross-ventilation. Consequently, although ventilation area met the minimum standard of 10% of floor area, its functional effectiveness in improving indoor air quality may have been limited (16,11,12,13,14).

Conclusion

Based on the results and discussion of the study, it can be concluded that there is a significant relationship between residential density and the incidence of ARI in toddlers in Tuminting District, Manado City, while the ventilation area does not show a significant relationship. These findings indicate that the very poor occupancy factor (83.9% of houses are not eligible) is the main determinant driving the high prevalence of ARI (79.0%), where this overcrowding condition has outweighed the positive effects of technically adequate ventilation (91.9% eligible). Thus, efforts to overcome ARI in the future need to prioritize interventions that address the problem of population density, which involves more complex socio-economic aspects, in addition to continuing to maintain the physical quality of the house.

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Conflicts of Interest

The authors declare no conflict of interest

References

1. Garmini R, Kohri K, Shatriadi H, Maftukhah NA. Analysis of application hygiene principles of food and safety employees tofu factory in Padang Selasa, Bukit Besar Palembang. *J Phys Conf Ser*. 2020;1477(7).
2. Vanessa T, Yulianto A, Efendi R. Health education on clean and healthy behavior and ARI incidence among toddlers. *Bagimu Negeri*. 2023;7(2):131–5.
3. Achjar KAH, et al. *Communicable diseases*. Jakarta: PT Sonpedia Publishing Indonesia; 2024.
4. Ministry of Health of the Republic of Indonesia. *Indonesia Health Profile 2022*. Jakarta: MoH RI; 2022.
5. Kunoli FJ, et al. Housing environmental factors and ARI among toddlers. *J Environ Health*. 2017.
6. Dondo L, Ndoen IH, Sakke D. Physical housing conditions, smoking behavior, and ARI in toddlers. *J Pergizi Pangan*. 2023;12(1).
7. Wardani IA, Astuti D. Physical home environment factors associated with ARI in toddlers: a literature review. *EOHSJ*. 2022;2(2).
8. Ruhban A, Sahrun NI, Indraswari NLS. Housing conditions and ARI incidence. *J Sulolipu*. 2023;23(2).
9. Sarwoko. Residential density, ventilation, and ARI in toddlers. *J Cendekia Medika*. 2021;6(1).
10. Pratiwi N, et al. Indoor air quality and ARI risk. *J Environ Health*. 2022.
11. Sumampouw, O. J., & Tongkotou, A. D. (2024). Rumah Sehat pada Masyarakat Pesisir Kabupaten Minahasa Utara. *Sam Ratulangi Journal of Public Health*, *5*(1), 30-40.
12. Pinontoan, O. R., & Sumampouw, O. J. (2020). *Dasar Kesehatan Lingkungan*. Deepublish.
13. Pinontoan, O. R., Sumampouw, O. J., & Nelwan, J. E. (2020). *Epidemiologi kesehatan lingkungan*. Deepublish.
14. Sumampouw, O. J., & Nelwan, J. E. (2024). *Dasar Kesehatan Lingkungan Konsep Dasar Dan Pencemaran Lingkungan*. Deepublish.
15. Hukmi A, et al. Home ventilation and ARI among toddlers. *J Environ Health*. 2023.

16. Aristatia D, et al. Healthy housing ventilation standards and health implications. *J Environ Architecture*. 2021.