Ann Ig. 2024 Jan-Feb; 36(1): 15-25. doi: 10.7416/ai.2023.2580. Epub 2023 Sep 29.

Investigations on the risk factors of Acute Respiratory Infections (ARIs) among under-five children in Depok City, Indonesia

R.A. Wulandari[1], S. Fauzia[1], F. Kurniasari[1]

Key words: Acute respiratory infections, under-five children, environmental factors
Parole chiave: Infezioni respiratorie acute, bambini sotto i cinque anni, fattori ambientali

Abstract

Background. *Acute Respiratory Infections are caused by pathogens that spread rapidly. Acute Respiratory Infections include upper respiratory tract infections and lower respiratory tract infections. According to the World Health Organization (2019), Acute Respiratory Infections rank fourth among diseases that affect children with high morbidity. Indonesia's under-five mortality rate due to Acute Respiratory Infections rank first among the Association of Southeast Asian Nations. Under-five mortality due to Acute Respiratory Infections in Indonesia accounts for 22.30% of the total under-five mortality cases.*

Study design and methods. *This cross-sectional study was conducted with a total of 100 mother and child pairs selected by simple random sampling. Internal and external factors, including nutritional status, maternal age, maternal education level, presence of a smoker in the house, house ownership, household size, temperature, humidity, lighting, ceilings, floors, walls, and ventilation were investigated as the risk factors of Acute Respiratory Infections among under-five children in this study.*

Results. *Our cross-sectional study found that 68 out of 100 under-five children in this study were infected with Acute Respiratory Infections during the study period. Among the risk factors, our multivariate analysis suggests that presence of smokers, maternal age, and inadequate ceiling conditions were the potential determinants of Acute Respiratory Infections among under-five children in Depok City.*

Conclusions. *Despite the limitations of this study, we believe our results could give a comprehensive overview of the risk factors of Acute Respiratory Infections in under-five children.*

[1] *Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Depok, West Java, 16424, Indonesia*

Annali di Igiene : Medicina Preventiva e di Comunità (Ann Ig)
ISSN 1120-9135 https://www.annali-igiene.it

Introduction

Acute respiratory infections (ARIs) are caused by pathogens that spread rapidly (1). ARIs includes upper respiratory tract infections and lower respiratory tract infections (2). Pathogens of this disease include *pneumococci, Myc. tuberculosis, influenza* and *parainfluenza viruses, rhinovirus, respiratory syncytial virus (RSV),* and *coronavirus (SARS-CoV)* (1). The spectrum of ARIs symptoms varies but includes fever, cough, sore throat, shortness of breath, wheezing, and breathing difficulty (1). Theoretically, ARIs occur due to an imbalance between the hosts, agents, and environmental factors. To clearly understand the determinants of ARIs, an investigation of internal and external factors is necessary (3). Internal factors, such as nutritional status (3), immunization status (4), vitamin A consumption (5), and exclusive breastfeeding, are correlated with the immunity of the children to prevent any infectious diseases (6). Knowledge of the family (7, 8) and environmental factors such as house conditions (9) and indoor air pollution were the important external factors for respiratory infections reported in previous studies (10). Based on the US EPA, an important factor in determining indoor air pollutants is the exchange of air between inside and outside the house. This is influenced by design and construction, such as wall joints, natural ventilation, mechanical ventilation, and ceilings adequacy (11).

According to the WHO (2019), ARIs ranks fourth among diseases that affect children with high morbidity (12). Indonesia's under-five mortality rate due to ARIs ranks first among the Association of South East Asian Nations (1). Under-five mortality due to ARIs in Indonesia accounts for 22.30% of the total under-five mortality cases (1). Based on the 2018 Indonesian Basic Health Research, the percentage of ARIs in children aged 1–4 years ranks first compared to other age groups, at 13.7% (13). In Depok City alone, the prevalence of ARI in toddlers reached 14.03% of total ARI cases in toddlers in West Java Province (14). Incidences of ARIs increased between 2018 and 2020, accounting for about 25–39% of the morbidity rate of children under five in Depok City (15). Despite the high morbidity rate, there is no detailed information on the risk factors associated with the incidences of ARIs in Depok City. Therefore, in this study, we comprehensively investigated the determinants of ARIs in Depok City, including internal and external factors.

Methods

Study Design and Area

This study used a cross-sectional design and was conducted from April to June 2020 in Bedahan and Sawangan sub-districts, Depok, West Java, Indonesia. This area was chosen due to the high prevalence of cases there. Sample criteria were babies and toddlers aged 1–59 months whose families had lived in the area for at least one year. The informants of this study were the mothers of these children. The number of households with babies and toddlers in the two sub-districts was 140, and 112 returned the informed consent form. However, during data collection, 12 participants withdrew, so the total sample was 100 babies and toddlers. Data collection was conducted by the researcher and two enumerators (using a questionnaire) via 10–15-minute interviews. For the measurement of physical agents, such as temperature (^{o}C) measured using a thermometer, humidity (%) measured using the RH Heat Index, and lighting (Lux) measured using a Lux meter, measurements were taken in rooms often used by under-five children for activities, such as bedrooms and living rooms. Room observations included the condition of the ceiling (namely, the presence or absence of a ceiling) and the type

of floor, whether ceramic tiles, unpolished cement, or uncoated soil.

Variables

The dependent variable in this study was ARIs in babies and toddlers aged 1–59 months whose families had lived in the study area for a minimum of one year. The independent variables include child characteristics (nutritional status), family characteristics (maternal age, mother's education level, and presence of a smoker in the house), and house conditions (house ownership, household size, temperature, humidity, lighting, condition of the ceilings, types of floors, types of walls, ventilation, types of screen protectors on ventilation) (Figure 1). All variables were divided into binary categories. The nutritional status of the child was classified as undernutrition or normal following the WHO guidelines (16). Maternal age was divided into high risk (over 35 years of age) and low risk. The educational level of the mother was classified as high (graduated from high school) or low. The house conditions were divided according to the regulations of the Ministry of Health, Republic of Indonesia in 2011 (5).

Data Collection Instruments

ARIs in babies and toddlers were diagnosed by health professionals following the criteria provided by the WHO (17). Standardised questionnaires were used to investigate all independent variables. Data collection was carried out by two environmental health scholars.

Statistical Analysis

Chi-square and multiple logistic regression tests were carried out to investigate the risk factors of ARIs among under-five children. The odds ratio (OR) with 95% CI was used to identify the association between the dependent and independent variables. *P*-value <0.05 was determined as significant.

Ethical Consideration

This study was granted ethical approval by the Faculty of Public Health, University of Indonesia (No: Ket-613/UN2/F10.D11/PPM.00.02/2020). All participants signed informed consent forms before participating in the study.

Results

Basic Characteristics and House Conditions of Under-Five Children

Table 1 shows the distribution of basic characteristics and house conditions. Among 100 children, our results detected that 68 were infected with ARIs during the study period. In the child characteristics,

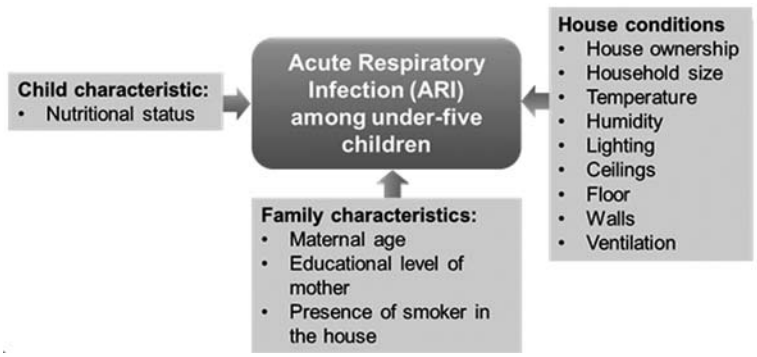

Figure 1 - Determinants of ARIs among under-five children

Table 1 - Distribution of basic characteristics and house conditions among under-five children (n=100)

Variables	ARIs		Total n (%)
	Yes n (%)	No n (%)	
Child characteristic Nutritional status of the child			
Undernutrition	32 (69.6)	14 (30.4)	46 (100)
Normal	36 (66.7)	18 (33.3)	54 (100)
Family characteristics Maternal age			
High risk	7 (53.8)	6 (46.2)	13 (100)
Low risk	61 (70.1)	26 (29.9)	87 (100)
Maternal education level			
Low	33 (66.0)	17 (34.0)	50 (100)
High	35 (70.0)	15 (30.0)	50 (100)
Presence of smoker			
Yes	45 (71.4)	18 (28.6)	63 (100)
No	23 (62.2)	14 (37.8)	37(100)
House conditions House ownership			
Tenancy	15 (60.0)	10 (40.0)	25 (100)
Owner	53 (70.7)	22 (29.3)	75 (100)
Household size			
Large	5 (50.0)	5 (50.0)	10 (100)
Small	63 (70.0)	27 (30.0)	90 (100)
Temperature (°C)			
Inadequate	28 (63.6)	16 (36.4)	44 (100)
Adequate	40 (71.4)	16 (28.6)	56 (100)
Humidity			
Inadequate	66 (68.0)	31 (32.0)	97 (100)
Adequate	2 (66.7)	1 (33.3)	3 (100)
Lighting			
Inadequate	29 (72.5)	11 (27.5)	40 (100)
Adequate	39 (65.0)	21 (35.0)	60 (100)
Ceiling			
Inadequate	36 (78.3)	10 (21.7)	46 (100)
Adequate	32 (59.3)	22 (40.7)	54 (100)
Floor			
Inadequate	4 (80.0)	1 (20.0)	5 (100)
Adequate	64 (67.4)	31 (32.6)	95 (100)
Wall			
Inadequate	14 (82.4)	3 (17.6)	17 (100)
Adequate	54 (65.1)	29 (34.9)	83 (100)
Ventilation			
Inadequate	48 (72.7)	18 (27.3)	66 (100)
Adequate	20 (58.8)	14 (41.2)	34 (100)
Ventilation screen			
Not available	41 (68.3)	19 (31.7)	60 (100)
Available	27 (67.5)	13 (32.5)	40 (100)

we found that 46% of the children were suffering from undernutrition. In the family characteristics, we investigated the maternal age, the maternal education level, and the presence of a smoker in the house. Our results found 13% of the mothers were categorised as high risk with regard to maternal age, 50% of the mothers had not graduated from high school, and 63% of the children in this study were living with a smoker. We investigated several factors regarding house conditions, including house ownership, household size, temperature, humidity, lighting, ceilings, floors, walls, ventilation, and ventilation screens. Our results found that 25% of the respondents were living in rented houses, 10% were living in crowded houses, 44% were living in houses with unacceptable temperatures, 97% were living in houses with unacceptable humidity, 40% were living in houses with unacceptable lighting, 46% were living in houses with inadequate ceilings, 5% were living in houses with inadequate floor conditions, 17% were living in houses with inadequate wall conditions, 66% were living in houses with inadequate ventilation, and 60% were living in houses without ventilation screens.

Bivariate Analysis of Factors Associated with ARIs among Under-Five Children

Figure 2 shows the results of the bivariate analysis between the independent and dependent variables. The associations were indicated by the odds ratio (OR) values with a 95% confidence interval (CI). Despite no statistical differences, our results found several variables that have high OR (95% CI), including maternal age (2.01 (0.62–6.57)), presence of smoker (1.52 (0.64–3.60)), ceiling (2.48 (1.02–6.00)), floor (1.94

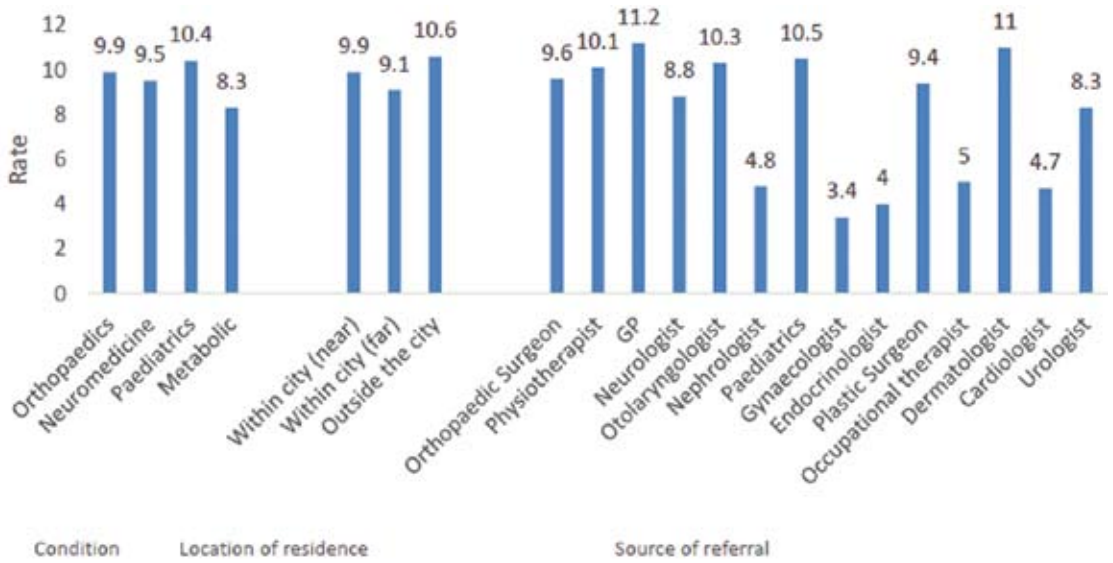

Figure 2 - Bivariate analysis of factors associated with ARIs among under-five children
*The odds ratio with a 95% confidence interval (OR (95% CI)) of each independent variable was presented. Chi-square tests were used for the analysis.

(0.21–18.07)), wall (2.51 (0.67–9.44)), and ventilation (1.87 (0.78–4.46)).

Multivariate Analysis

We performed a multivariate analysis with logistic regression to investigate the determinant factors of ARIs among under-five children in Depok City. The variables with a *p*-value of <0.25 in the previous bivariate analysis were included in this analysis. The multivariate analysis was carried out by gradually eliminating the variables that were not statistically significant. Variables that were substantially associated with ARIs based on theory and previous studies were maintained in the model, even though the *p*-value was higher than 0.05. The final result from the multivariate analysis is presented in Table 2. Among the variables maintained in the multivariate model, the presence of a smoker in the house was the determinant factor of ARIs in Depok City, with OR 2.242 (95% CI 0.987–5.094), followed by maternal age with OR 1.713 (95% CI 0.599–4.898) and ceiling condition with OR 1.641 (95% CI 0.734–3.668).

Discussion

In the present study, we investigated the prevalence of ARIs and the risk factors among children under five years of age in Depok City. Our findings showed that 68% of the children in this study were infected with ARIs during the study period. The percentage of ARIs in this study was relatively high compared to similar studies conducted in Indonesia (18, 19). The high percentage of ARIs in this study was probably because it was carried out during the transition between the wet and dry seasons. Seasonal change is known to cause decreased immunity in the population (20). After identifying the prevalence of ARIs among under-five children, we further investigated the determinants of ARIs based on three categories, including the characteristics of the children, characteristics of the mother and family, and house conditions (Figure 1).

Our results found that 69.6% of children suffering from undernutrition in this study became infected with ARIs during the study period. The association between nutritional status and infectious diseases, including ARIs, has been shown in many previous studies (6, 21, 22). It is known that children suffering from undernutrition have insufficient immunity to prevent infection, causing them to be susceptible to ARIs (8). A study in Bangladesh indicated that a lower nutrition level among children increases mortality from viral respiratory infections (23). Since we found an almost comparable distribution between children suffering from undernutrition and normal under-five children, we could not find statistical significance between nutritional status and ARIs in this study.

We further investigated the characteristics of the mother and family as risk factors of

Table 2 - Multivariate analysis of determinant factors of ARIs among under-five children

Variable	B	S.E.	p-value	OR	95% CI
Maternal age	0.538	0.536	0.316	1.713	0.599–4.898
Presence of smoker	0.808	0.419	0.054	2.242	0.987–5.094
Household size	-1.064	0.704	0.131	0.345	0.087–1.372
Ceiling	0.495	0.410	0.227	1.641	0.734–3.668
Constant	-0.376	0.561	0.502	0.686	

ARIs. Maternal age has been associated with ARIs, as suggested in a previous study (7). It was shown that older mothers/caregivers were not paying as much attention to their children as younger mothers (3). In this study, we found only 13 mothers aged over 35 years old (high risk) during the study period. Among those, seven (53.8%) of their children were detected as positive cases. Although our bivariate analysis did not find significance, our multiple regression analysis showed that maternal age was the second determinant of ARIs in this study, with OR 1.713 (95% CI 0.599–4.898). The other important factor often affecting the child's care is the maternal educational level (24, 25). In this study, the levels ofeducation of the mother was equally distributed between the high and low categories. Therefore, our result did not show a statistically significance between the education level of the mother and ARIs among under-five children.

Smoking is still a major public health problem; a previous study showed that children who are passive smokers are more susceptible to severe respiratory problems and often require hospitalisation (26). In this study, we identified that 63% of the family members were active smokers. Among the children who had active smokers in their houses, 45 (71.4%) tested positive for ARIs during the study period. Moreover, our multivariable regression logistic analysis demonstrated that the presence of smokers in the house is the first determinant of ARIs (OR 2.242 (95% CI 0.987–5.094)) in this study. Cigarette smoke has the ability to penetrate the respiratory system, increasing the susceptibility of children to infectious diseases – including ARIs – as reported in previous studies (27, 28).

Then, we further investigated the house environmental conditions with ARIs among under-five children. The house conditions in this study were compared with the regulations of the Indonesian Health Ministry in 2011 (5). Household size, which directly correlated with crowding conditions, was reported to be associated with incidences of ARIs in a previous study (10). House crowding causes increases in the probability of exposure to droplets of infectious secretions from other family members (29). To prevent crowding, the ideal size for liveable housing is 10 m^2 per person (30). In our study, we found only 10 mother and child pairs who lived in crowded houses, which could be the reason for the insignificant result obtained by statistical analysis in this study.

Physical environmental conditions, such as temperature, humidity, and lighting, which have been reported to be directly correlated with the survival of airborne infectious disease (18, 31), were further investigated in this study. In this study, about 44% of the children were living in a house with an unacceptable temperature according to the regulation (18–30ºC). Our results showed that 63.6% of children living in a house with an unacceptable temperature were infected with ARIs during the study period, despite the insignificant result in our bivariate analysis.

We detected that about 97% of houses have unacceptable humidity levels compared with what is prescribed by the Regulations (40–60% Rh). This condition decreases the indoor air quality of the houses, resulting in a higher incidence of ARIs. Our results found that 68% of those living in houses with unacceptable humidity were infected with ARIs during the study period, despite the insignificant result in our bivariate analysis. Since humidity has been reported to be correlated with ARIs in previous studies (9,31), our results could support the findings in previous studies.

Further, we investigated the lighting in the houses with incidences of ARIs. Adequate lighting, especially sunlight, is an important factor in deactivating airborne infectious organisms (31). Our results found that 40% of houses have inadequate lighting according to the Regulations (more than 100

lux). Despite the statistical insignificance in our bivariate analysis, we found that 29 (72.5%) of the children living in houses with inadequate lighting were infected with ARIs during the study period. Since a previous study reported the correlation between lighting and ARIs (32), our results supported this finding.

We then investigated the house characteristics, including ceilings, floors, walls, and ventilation, as the risk factors of ARIs among under-five children. Ceilings are important for controlling the air exchange to prevent dust from entering the house, and they are associated with indoor air quality (33). In this study, we found that among 46 children living in houses without adequate ceilings, 36 (78.3%) were infected with ARIs during the study period. Moreover, our logistic regression analysis suggests that the ceiling is the third determinant of ARIs among under-five children in Depok (OR 1.641 (95% CI 0.734–3.668)). Despite no statistical significance being found, the result of this study supported the finding in a previous study showing that the presence of a proper ceiling is correlated with the incidence of ARIs among under-five children (10).

Another house characteristic directly correlated with indoor air quality is ventilation. Our results showed that among 66 children living in houses with inadequate ventilation, 48 (72.7%) were infected with ARIs during the study period. Moreover, among 60 houses with an absence of ventilation screens, we found that 68.3% of children had ARIs during the study period. Since a previous study reported the correlation of ventilation with ARIs among under-five children (34), the results in this study suggest the importance of adequate ventilation and the presence of a ventilation screen to prevent ARIs among under-five children.

Further, the conditions of the floors and walls in the house were investigated. Inadequate floor and wall conditions facilitate the entrance of infectious pathogens into the house. However, our study found only five houses with inadequate floor conditions and 17 with inadequate wall conditions. Among those children living in houses with inadequate floor and wall conditions, our results found that four (80%) and 14 (82.4%) were infected with ARIs during the study period. Since previous studies have suggested floor and wall conditions as risk factors of ARIs (35, 36), our results gave an overview that supported this finding.

However, this study has some potential limitations. First, this study used a cross-sectional study design, which cannot establish a cause-and-effect relationship. Second, this study had a limited number of respondents and was equally distributed in some of the variables; thus, we could not find any significant difference in our bivariate analysis. Nevertheless, our univariate analysis is consistent with previous studies and literature. Despite its limitations, the results of this study could give a comprehensive overview of ARI prevalence in Depok City – the city with the third highest prevalence of ARIs in Indonesia – and the potential determinants, including internal and external factors. Further comprehensive epidemiological study is needed to investigate the cause-effect relationship of ARIs.

Conclusions

In this study, we found that 68% of the children under five in this study were infected with ARIs during the study period. We comprehensively investigated the determinants of ARIs in under-five children from internal and external factors in this study. Although our bivariate analysis showed insignificant difference between all independent variables with ARIs, our univariate analysis provides an overview that could support the findings in previous studies.

Among the risk factors, our multivariate analysis suggests the presence of smokers, maternal age, and the ceiling absence as potential determinants of ARIs among under-five children in Depok City.

Funding: This research received no external funding.
Ethics Approval and Consent to Participate: This study was granted ethical approval by the Faculty of Public Health, University of Indonesia (No: Ket-613/UN2/F10. D11/PPM.00.02/2020). All participants signed informed consent forms before participating in the study.
Competing Interest: The authors declare that there are no competing interests.
Authors' Contributions: RAW contributed substantially to the concept, methodology, validation resources, data curation, drafting of the manuscript, writing of the original draft, supervision, writing review and editing, and finalised approval of the version to be published. SF made critical input to the formal analysis, investigation, data curation, and writing/original draft preparation. FK contributed to validation, data curation, writing/review and editing, and visualisation.
Acknowledgment: The authors would like to acknowledge Dr. Al Asyary and Yosephine Roma Intan for technical support.

Riassunto

Indagini sui fattori di rischio per le infezioni respiratorie acute (ARI) tra i bambini d'età inferiore a 5 anni a Depok City, Indonesia

Premessa. L'infezione respiratoria acuta è causata da un agente patogeno che si diffonde rapidamente. Le infezioni respiratorie acute comprendono le infezioni del tratto respiratorio superiore e le infezioni del tratto respiratorio inferiore. Secondo l'Organizzazione Mondiale della Sanità (2019), le infezioni respiratorie acute sono al quarto posto tra le malattie che colpiscono i bambini con elevata morbosità. Il tasso di mortalità sotto i cinque anni dell'Indonesia attribuibile a infezioni respiratorie acute è al primo posto tra i paesi dell'Associazione delle nazioni del sud-est asiatico**.** La mortalità sotto i cinque anni dovuta a infezioni respiratorie acute in Indonesia rappresenta il 22,30% del totale dei casi di mortalità sotto i cinque anni.

Disegno e metodi dello studio. Questo studio trasversale è stato condotto su di un totale di 100 coppie madre-bambino selezionate mediante campionamento casuale semplice. Sono stati studiati con analisi multivariata - come fattori di rischio delle Infezioni respiratorie acute tra i bambini d'età inferiore ai 5 anni - fattori interni ed esterni, tra cui stato nutrizionale, età materna, livello di istruzione materna, presenza di fumatori in casa, proprietà della casa, dimensioni della famiglia, temperatura, umidità, illuminazione, soffitti, pavimenti, pareti e ventilazione.

Risultati. Lo studio ha rilevato che 68 bambini sotto i cinque anni su 100 sono stati infettati da infezioni respiratorie acute durante il periodo di osservazione.Tra i fattori di rischio, la nostra analisi multivariata suggerisce che la presenza di fumatori, l'età materna e le disastrose condizioni del soffitto domestico erano i potenziali determinanti delle infezioni respiratorie acute tra i bambini sotto i cinque anni a Depok City.

Conclusioni. Nonostante i limiti di questo studio, riteniamo che i nostri risultati possano avder fornito una panoramica completa dei fattori di rischio delle infezioni respiratorie acute nei bambini sotto i cinque anni.

References

1. Fathmawati F, Rauf S, Indraswari BW. Factors related with the incidence of acute respiratory infections in toddlers in Sleman, Yogyakarta, Indonesia: Evidence from the Sleman Health and Demographic Surveillance System. Rahman MA, editor. PLoS One (Internet). 2021 Sep 24; **16**(9): e0257881. Available on: https://dx.plos.org/10.1371/journal.pone.0257881.
2. Bhurtel R, Prasad Pokhrel R, Kalakheti B. Acute Respiratory Infections among Under-five Children Admitted in a Tertiary Hospital of Nepal: A Descriptive Cross-sectional Study. J Nepal Med Assoc (Internet). 2022 Jan 23; **60**(245): 17-21. Available on: https://www.jnma.com.np/jnma/index.php/jnma/article/view/6889.
3. Hassen S, Getachew M, Eneyew B, et al. Determinants of Acute Respiratory Infection (ARI) among under-Five Children in Rural Areas of Legambo District, South Wollo Zone, Ethiopia: A Matched Case–Control Study. Int J Infect Dis. 2020 Jul; **96**: 688-95. doi: 10.1016/j.ijid.2020.05.012. Epub 2020 May 12.
4. Islam F, Sarma R, Debroy A, Kar S, Pal R. Profiling Acute Respiratory Tract Infections in Children from Assam, India. J Global Infect Dis. 2013 Jan; **5**(1): 8-14. doi: 10.4103/0974-777-X.107167.
5. Fahdiyani R, Raksanagara AS, Sukandar H. Influence of Household Environment and Maternal Behaviors to Upper Respiratory Infection among

Toddlers. Kesmas: National Public Health J. 2016 Feb; **10**(3): 120-6. doi: 10.21109/kesmas.v10i3.589.
6. Tazinya AA, Halle-Ekane GE, Mbuagbaw LT, Abanda M, Atashili J, Obama MT. Risk Factors for Acute Respiratory Infections in Children under Five Years Attending the Bamenda Regional Hospital in Cameroon. BMC Pulm Med. 2018 Jan 16; **18**(1): 7. doi: 10.1186/s12890-018-0579-7.
7. Chowdhury S, Mishu AA, Rahman MM, Zayed NM. An Analysis of Factors for Acute Respiratory Infections (ARI) in Children under Five of Age in Bangladesh: A Study on DHS, 2014. J Midwifery Women Health Gynaecol Nurs. 2020 Mar-Aug; **2**(2): 26-32. doi: 10.5281/ZENODO.3745849.
8. Merera AM. Determinants of Acute Respiratory Infection among Under-Five Children in Rural Ethiopia. BMC Infect Dis. 2021 Nov 30; **21**(1): 1203. doi: 10.1186/s12879-021-06864-4.
9. Ramadhanyanti GN, Budiyono B, Nurjazulil N. Faktor-Faktor Risiko Lingkungan Rumah Dan Perilaku Yang Berhubungan Dengan Kejadian Infeksi Saluran Pernafasan Akut (Ispa) Pada Balita Di Kelurahan Kuningan Kecamatan Semarang Utara. J Kesehatan Masyarakat. 2015 Jan; **3**(1): 513-22.
10. Tin Tin S, Woodward A, Saraf R, et al. Internal Living Environment and Respiratory Disease in Children: Findings from the Growing Up in New Zealand Longitudinal Child Cohort Study. Environ Health. 2016 Dec 8; **15**(1): 120. doi: 10.1186/s12940-016-0207-z.
11. Aftab A, Noor A, Aslam M. Housing quality and its impact on Acute Respiratory Infection (ARI) symptoms among children in Punjab, Pakistan. PLOS Glob Public Heal (Internet). 2022; **2**(9): e0000949. Available on: http://dx.doi.org/10.1371/journal.pgph.0000949.
12. Nshimiyimana Y, Zhou Y. Analysis of risk factors associated with acute respiratory infections among under-five children in Uganda. BMC Public Health (Internet). 2022 Dec 17; **22**(1): 1209. Available on: https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-022-13532-y.
13. Kemenkes RI. Laporan Riskesdas 2018 Kementrian Kesehatan Republik Indonesia (Internet). Vol. 53, Laporan Nasional Riskesdas 2018. Badan Penelitian dan Pengembangan Kesehatan; 2019. p. 68-72. Available on: http://www.yankes.kemkes.go.id/assets/downloads/PMK No. 57 Tahun 2013 tentang PTRM.pdf.
14. Badan Penelitian dan Pengembangan Kesehatan. Laporan Riskesdas Provinsi Jawa Barat (Internet). Lembaga Penerbit Badan Litbang Kesehatan. 2019. 69-74 p. Available on: https://litbang.kemkes.go.id.
15. Depok City Health Office. Profil Dinas Kesehatan Kota Depok Tahun 2019.
16. World Health Organization (WHO). Malnutrition; 2021.
17. Bulla A, Hitze KL. Acute Respiratory Infections: A Review. Bull World Health Organ. 1978; **56**(3): 481-98.
18. Hidayanti R, Yetti H, Putra AE. Padang Risk Factors for Acute Respiratory Infection in Children Under Five in Padang, Indonesia. J Matern Child Health. 2019; **4**(2): 62-9. doi: 10.26911/thejmch.2019.04.02.01.
19. Oktaria V, Danchin M, Triasih R, et al. The Incidence of Acute Respiratory Infection in Indonesian Infants and Association with Vitamin D Deficiency. PLoS One. 2021 Mar 23; **16**(3): e0248722. doi: 10.1371/journal.pone.0248722.
20. Liu X, Huang J, Li C, et al. The Role of Seasonality in the Spread of COVID-19 Pandemic. Environ Res. 2021 Apr; **195**: 110874. doi: 10.1016/j.envres.2021.110874. Epub 2021 Feb 19.
21. Calder P, Carr A, Gombart A, Eggersdorfer M. Optimal Nutritional Status for a Well-Functioning Immune System Is an Important Factor to Protect against Viral Infections. Nutrients. 2020 Apr 23; **12**(4): 1181. doi: 10.3390/nu12041181.
22. Morais AHA, Aquino JS, da Silva-Maia JK, Vale SHL, Maciel BLL, Passos TS. Nutritional Status, Diet and Viral Respiratory Infections: Perspectives for Severe Acute Respiratory Syndrome Coronavirus 2. Br J Nutr. 2021 Apr 28; **125**(8): 851-62. doi: 10.1017/S0007114520003311. Epub 2020 Aug 26.
23. Chowdhury F, Shahid ASMSB, Ghosh PK, et al. Viral Etiology of Pneumonia among Severely Malnourished Under-Five Children in an Urban Hospital, Bangladesh. PloS One. 2020 Feb 4; **15**(2): e0228329. doi: 10.1371/journal.pone.0228329.
24. Akinyemi JO, Morakinyo OM. Household Environment and Symptoms of Childhood Acute Respiratory Tract Infections in Nigeria, 2003–2013: A Decade of Progress and Stagnation. BMC Infect Dis. 2018 Jul 3; **18**(1): 296.

doi: 10.1186/s12879-018-3207-5.
25. Andualem Z, Azene ZN, Azanaw J, Taddase AA, Dagne H. Acute Respiratory Symptoms and Its Associated Factors among Mothers Who Have under Five-Years-Old Children in Northwest, Ethiopia. Environ Health Prev Med. 2020 Jun 15; **25**(1): 20. doi: https://doi.org/10.1186/s12199-020-00859-4.
26. Duarte DMG, Botelho C. [Clinical Profile in Children under Five Year Old with Acute Respiratory Tract Infections]. J Pediatr (Rio J). 2000 May-Jun; **76**: 207-12. Portguese. doi: 10.2223/JPED.55.
27. Peat JK, Keena V, Harakeh Z, Marks G. Parental Smoking and Respiratory Tract Infections in Children. Paediatr Respir Rev. 2001 Sep; **2**(3): 207-13. doi: https://doi.org/10.1053/prrv.2001.0142.
28. Samet JM. Adverse Effects of Smoke Exposure on the Upper Airway. Tob Control. 2004 Mar; **13**(Suppl 1): i57-60. doi: 10.1136/tc.2003.005454.
29. Colosia AD, Masaquel A, Hall CB, Barrett AM, Mahadevia PJ, Yogev R. Residential Crowding and Severe Respiratory Syncytial Virus Disease among Infants and Young Children: A Systematic Literature Review. BMC Infect Dis. 2012 Apr 20; **12**: 95. doi: 10.1186/1471-2334-12-95.
30. Central Bureau of Statistic. Indikator Perumahan Dan Kesehatan Lingkungan; 2022.
31. Tang JW. The Effect of Environmental Parameters on the Survival of Airborne Infectious Agents. J R Soc Interface. 2009 Dec 6; **6**(Suppl 6): S737-46. doi: 10.1098/rsif.2009.0227.focus. Epub 2009 Sep 22.
32. Mahendra IGAP, Farapti F. Relationship between Household Physical Condition with The Incedence of ARI on Todler at Surabaya. J Berkala Epidemiologi. 2018; **6**(3): 227-35. doi: 10.20473/jbe.V6I32018.227-235.
33. Fathmawati F, Rauf S, Indraswari BW. Factors Related with the Incidence of Acute Respiratory Infections in Toddlers in Sleman, Yogyakarta, Indonesia: Evidence from the Sleman Health and Demographic Surveillance System. PloS One. 2021 Sep 24; **16**(9): e0257881. doi: 10.1371/journal.pone.0257881.
34. Murray EL, Brondi L, Kleinbaum D, et al. Cooking Fuel Type, Household Ventilation, and the Risk of Acute Lower Respiratory Illness in Urban Bangladeshi Children: A Longitudinal Study: Risk of Acute Lower Respiratory Illness. Indoor Air. 2012 Apr; **22**: 132-9. doi:10.1111/j.1600-0668.2011.00754.x. Epub 2011 Nov 12.
35. Sunarsih E, Purba IG. Risk Factor Analysis of Acute Respiratory Infection on Children Under Five Years Old in Tanjung Pering Village Ogan Ilir. Int J Sci. 2015; **22**(1): 21-30. https://www.gssrr.org/index.php/JournalOfBasicAndApplied/article/view/3841.
36. Aftab A, Noor A, Aslam M. Housing Quality and Its Impact on Acute Respiratory Infection (ARI) Symptoms among Children in Punjab, Pakistan. PLOS Global Public Health. 2022 Sep 21; **2**(9): e0000949. doi: 10.1371/journal.pgph.0000949.

Corresponding author: Ririn Arminsih Wulandari, Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Depok, West Java, 16424, Indoneia
e-mail: ririn.arminsih@gmail.com

ORCID ID: 0000-0003-4790-259X