Mapping of Acute Respiratory Infection (ARI) Vulnerability in Toddlers Based on Physical Condition of Houses in Palu City, Indonesia

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Abstract

Acute Respiratory Infection (ARI) is one of the causes of high morbidity and mortality, especially in toddlers. The study purpose was to determine the susceptibility of ARI among children under five in these locations by considering the physical condition of houses (ventilation, density of occupancy, types of floors and walls). This research uses an ecological study with a Geographic Information System (GIS) approach. The research population in Talise health centre was 622 toddlers (sample 86) and Singgani health center was 1,167 toddlers (sample 93), samples were taken by Proportional Stratified Random Sampling based on the number of cases in each urban village in the study area. The results showed both of Talise and Singgani health centers the physical aspect of the houses was not associated with the incidence of ARI in children under five. Ventilation area with ρ-values 0.77 and 1.00, density with ρ-values 0.77 and 1.00, floor types with ρ-values 0.33 and 0.37, and wall types with ρ-values 0.75 and 1.00. Based on the results of the mapping at the two locations, it was found that the most vulnerable locations to ARI in infants with the highest number of vulnerable from all aspects of the physical condition of the house including ventilation area, occupancy density, type of floor, and type of wall were in the working area of the Singgani Health Center.

Keywords: Acute Respiratory Infection (ARI), Mapping, Vulnerability, Geographic Information System (GIS)

Key Messages:

• Eenvironmental factors greatly influence the incidence of infectious diseases, a possible explanation for this condition is that disease is always multicausal

1. Introduction

Acute Respiratory Infection (ARI) is still a cause of morbidity and mortality, especially in children under five[1]. Deaths from ARI in the world are estimated to be ten to fifty times in developing countries compared to developed countries[2]. ARI causes almost ±13 million children under five die every year with the majority of deaths in Asia and Africa such as India (48%), Indonesia (38%), Ethiopia (4.4%), Pakistan (4.3%), China (3.5%), Sudan (1.5%), and Nepal (0.3%)[3]. WHO estimates, in developing countries the under-five mortality rate due to ARI is 40 per 1000 live births with a percentage of 15% - 20% per year[4]. ARI is still a health problem in

Indonesia, including in the city of Palu.

The prevalence of ARI in Central Sulawesi province reaches 2.5%, this disease is the 4 largest disease in 2020, with a total of 49.513 cases(5). The Central Sulawesi Provincial Health Office Annual Report showed in 2019 the number of ARI in children under five in the city of Palu reached 83.7%(6), and the data from the Palu City Health Office showed in 2020, ARI in infants was 70 cases and children under five was 501 cases(7). Geographical conditions in a region can trigger an increase in cases and deaths due to ARI(2). Based on data from the Meteorology, Climatology and Geophysics Agency of Palu City (2020), the geographical conditions in Palu City have an alluvial soil structure that is prone to causing dust, especially during the dry season, with wind speeds of 5 km/hour so it has the potential to carry a lot of dust(8). This condition is associated with the potential for an increase in the incidence of ARI in people of all age groups.

Hendrik L. Bloom (1974) stated that environmental factors (45%) are the main factors that influence the health status of the community followed by behavior (30%), health services (20%), and heredity (5%)(9). The physical condition of the house as environmental factor is also closely related to the incidence of ARI, especially in children under five, considering that they spend almost all of their time in the house. The physical conditions of the house that can be related to ARI include ventilation area, density, floor and wall type, and house ceiling. This has been stated in previous studies that these variables have a close relationship with the susceptibility of it. The ventilation area that does not meet the requirements is < 10% of the floor area, the indoor air exchange is not working properly(1,2). Houses with high occupancy density if < 9 m2/person(10). The type of floor and wall that does not meet the requirements will result in ARI from dust exposure, such as the type of ground floor and wall made of wood or bamboo will make it easier for dust or microorganisms from outside the house to enter from the gaps of wall(11,12). The house without ceiling that does not meet the requirements so that dust easily exposed(11).

Based on the annual report of Palu City Health Office, the highest cases of ARI disease among children under five in 2020 were found in working areas of Talise and Singgani Health Center, respectively is 622 and 1,167 cases(7). In addition, the data on the incidence of ARI are still processed manually with a simple presentation in the form of tables and graphs, so that mapping related to Geographic Information Systems has not been done at all. Basically, the existence of a mapping the spread of a disease can be an important tool to support epidemiological investigations and routine monitoring certain areas that are at risk of exposure to disease.

Field observations and data collection in this study were conducted in order to obtain an overview of the relationship between the physical condition of the house and the incidence of ARI in this area. The study results can be used as initial data for mapping the ARI vulnerability of children under five in this area, and can be used as a reference for estimating the vulnerability of other areas in Palu City which have similar characteristics of the community. It is hoped that this environmental-based disease incident mapping will assist the relevant agencies.

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2. Methods

This research is analytical with a Geographic Information System (GIS) approach. The population of the study were children under five with ARI that carried out in Talise and Singgani Health Center in 2021. The number of populatin each of study site is 622 and 1,167 children under five. The sampling was done by proportional stratified random sampling, where the area was divided based on the urban village in the working area both of the health centre Talise and Singgani so we have a sample each area is 86 and 92 that calculated uses the Slovin formula.

Data collection related to the physical condition of the house using the healthy home assessment form by the ministry of health. The determination of the ventilation area is calculated toward comparing the total houses area with the ventilation holes area that measured using a tensile meter by the researcher himself. The ventilation area is considered eligible if it is ≥ 10% of the houses area, it refer to Regulation of the Minister of Health of R.I Number 1077/Menkes/Per/V/2011 concerning Guidelines for Air Sanitization in the Home Room). While the determination of dwelling density by comparing the area of the house with the number of occupants, and is deemed eligible if each occupant has a minimum space of 9 m²/people, it refer to Decree of the Minister of Settlement and Regional Infrastructure Number 403 in 2002. Meanwhile, the ceiling, floor and wall type parameters were assigned values based on the conditions found during interviews and field observations. the

standard of scoring according to the health ministry's home assessment form. The correlation of physical house condition with ARI incidence identified using Chi-square analysis and presented in table and narration. Determination of the coordinates of the patient's house using Timestamp Camera Enterprise, spatial data analysis with Arc GIS 10.8 application.

3. Results

The data collection was conducted for 2 months on 179 families in the working area of the Singgani and Talise health centers. The results analysis of the relationship between the physical conditions of the house and the incidence of ARI are presented in Table 1.

Table 1. Vulnerability of ARI Incidence in Children Under Five in Palu City in 2022

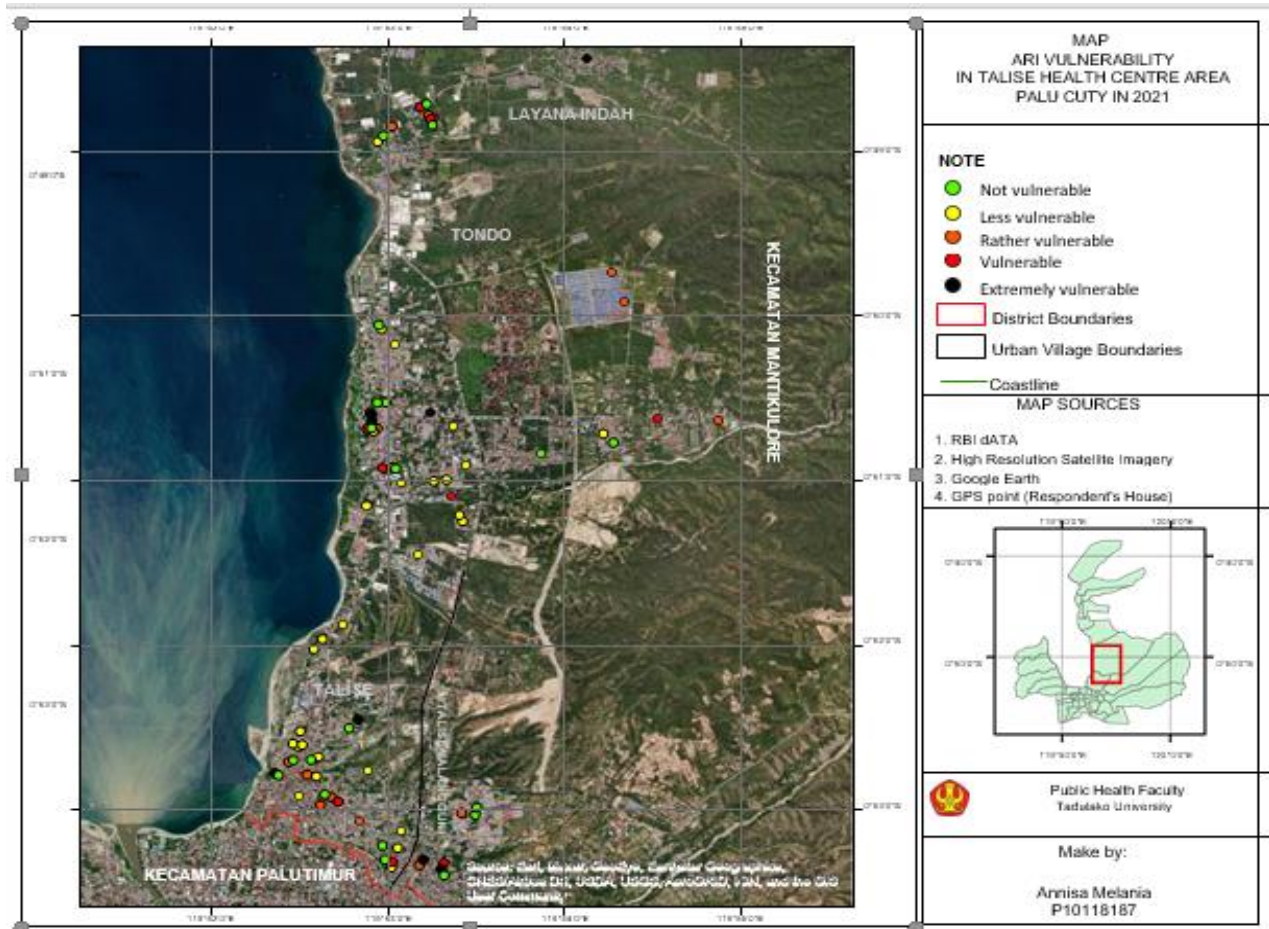| House Condition	Talise Health Centre Area			Singgani Health Centre Area		
	Susceptible	Not Susceptible	ρ-value	Susceptible	Not Susceptible	ρ-value
Ventilation Not eligible	14	59	1.00	19	62	1.00
Eligible	2	11		3	9	
House Density Not eligible	4	21	0.77	10	33	1.00
Eligible	12	49		12	38	
Ceiling Not eligible	2	19	0.34	5	17	1.00
Eligible	14	51		17	54	
Floor Type Not eligible	7	25	0.76	6	29	0.37
Eligible	9	45		16	42	
Wall Type Not eligible	6	24	0.75	6	28	0.37
Eligible	10	46		16	43	

Figure 1 Distribution of ARI vulnerability Talise Health Centre Area

Figure 1 described that from 86 respondents, 8 of them have a house physical condition is very vulnerable to the ARI incidence, 9 respondents are vulnerable, 17 respondents are rather vulnerable, 32 respondents are less vulnerable and 20 of them not susceptible to the ARI incidence. Mapping of the distribution of ARI vulnerability in terms of the physical condition of the respondent's house in the Singgani health centre area is shown in Figure 2.
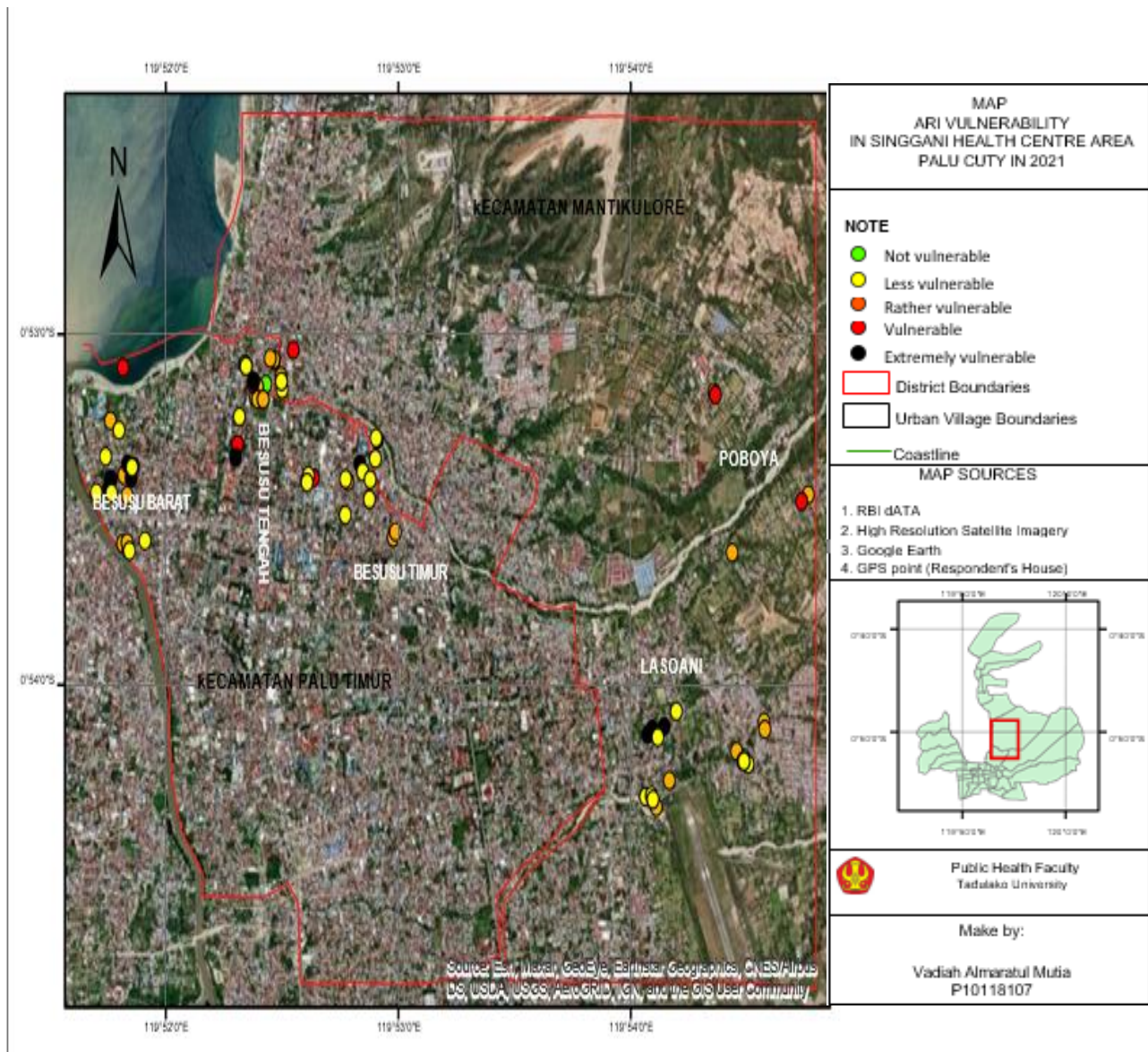
Figure 2 Distribution of ARI vulnerability Singgani Health Centre Area

Figure 2 described that from 93 respondents, 12 of them have the house's physical condition is extremely vulnerable to the ARI incidence, 37 respondents are vulnerable, 13 respondents rather vulnerable, 28 respondents less vulnerable, and 3 respondents not susceptible to the ARI incidence.

4. Discussion

Environmental-based diseases, one of which is ARI, can arise due to poor sanitation of the living environment(13), for example, the physical condition of a house that does not match the healthy home category has the potential to cause disease in its inhabitants. The physical condition of the house in this study is the ventilation area, the density of the house, the type of floor, and the type of wall. The ventilation has an important role in indoor air exchange. Poor ventilation causes oxygen in the house not to be properly available and carbon dioxide levels may arise. The ventilation area is considered to meet the requirements if it is at least 5-20% of the floor area of the house (Regulation of the Minister of Health of the Republic of Indonesia Number 1077/Menkes/Per/V/2011 concerning Guidelines for Air Sanitization in the Home Room)(10).

Based on the results of the study, it was found that there was no relationship between the area of ventilation and the susceptibility of the incidence of ARI in both of areas, Talise and Singgani health centre. The average ventilation houses are 0.72 m² to 18.4 m² with an average floor area of 20 m² to 200 m², and the majority use the single-sided ventilation type. Theoretically, the area of ventilation that does not meet the requirements

may lead on the susceptibility of ARI. However, researchers have found the opposite, but we need to consider that disease is always multicausal(14).

The house wide that does not match the number of residents can cause overcrowding, this becomes unhealthy and facilitates the transmission of disease between family members, low privacy and a sense of tightness resulting in lack of oxygen in the room[14]. Dwelling density is calculated by dividing the house wide by the number of occupants and is deemed eligible if each occupant has a minimum space of 9 m²/people (Decree of the Minister of Settlement and Regional Infrastructure Number 403 in 2002)**(15)**.   Based on the results of the study, it was found that there was no relationship between dwelling density and the susceptibility of the incidence of ARI in the research site. Theoretically, the density that do not meet the requirements has an effect of ARI susceptibility. According to Saparina et all, dense housing causes a lack of oxygen in the room and if one of the family members is exposed to an infectious disease, for example ARI, it will easily spread, including to toddlers**(16)**. The researcher's findings contradict the general theory, so we need to consider other variables as causes of ARI in the community in the study site. Based on the researcher's observations, the pattern of respondent activity can be the cause of the absence of a relationship between density and the ARI incidence. Most of the respondents work as traders, so they often spend longer in their business place than at home so that family activities in the house are reduced. Another condition that also inhibits disease transmission between family members in the research area is due to roomization, almost all houses are good in this roomization. The houses without roomization with family members suffered of ARI, it will be easily transmitted to other residents**(17)**.

The type of floor and wall is suspected as a risk factor for ARI, especially in infants. If floor and wall is waterproof and difficult to clean will be a favorites place of microorganism growth**(18)**. Toddlers spend a lot of time doing activities like playing on the floor, so they are likely to be inhaled dust and microorganism on the floor, which can cause ARI**(9,18)**. Based on the Decree of the Minister of Settlement and Regional Infrastructure Number 403 of 2002, the type of floor and wall that meets the requirements if not waterproof, easy to clean, brightly colored and does not produce a lot of dust residue, for example floor made of tiles or ceramics and wall make of brick with plastered on surface. In this study, the types of floors and walls were not associated with the incidence of ARI, where almost all respondents with ARI cases lived in houses with ceramic floors and walls made of brick plastered, so it is necessary to consider other factors as risk factors for ARI here, for example exposure to cigarette smoke in housing and cooking fuel which are also often associated with ARI incidence.   This is in line with the opinion by Lalu et al that the type of floor and wall that has meet the healthy standard may to prevent dust from sticking and also minimize the risk of ARI up to 2,15 times compared to the floor and wall type does not meet the standard**(19)**, in addition the walls that are in accordance with health standards will keep the room temperature keep stable for residents, especially toddlers. It is protected from a cold and make the resident comfortable, this can also reduce the risk of ARI susceptibility**(18)**. The physical condition of the house which is theoretically also associated with the incidence of ARI in this study is the ceiling and its condition. A healthy house ideally has a ceiling with strong and sturdy materials, not moldy and damp, easy to clean and brightly colored**(15)**.

Although statistically the houses physical condition (ventilation, density, floor and wall type, ceiling) in the table 1 is not related to the ARI incidence, theoretically it is explained that there are 4 factors related to the public health, one of which is environmental factors, even in theory proposed by H.L Bloom (1972), the environment as a major component of determining public health. Umar Fachmi (2008) in his book on environmental-based diseases, also emphasizes that all diseases are related to environmental conditions where the environment is not only limited to biotic and abiotic, but also includes components of the social, cultural and human resilience (psychological conditions) which are influenced by the environment**(13)**. In Figures 1 and 2, it can be seen the distribution of the respondent's place of residence based on the level of vulnerability to the ARI incidence, where their vulnerability is described by color gradations. The color determination is based on the provisions of not vulnerable if 0-1 the variable does not eligible which is symbolized in green. In this condition, the physical condition of the respondent's house is considered not to cause the resident to be vulnerable to ARI. Less vulnerable if 2 variables are not eligible symbolized in yellow, rather vulnerable if 3 variables are not eligible symbolized by orange, (4) vulnerable if 4 variables are not eligible symbolized by red, and (5) extremely vulnerable if all variables are not eligible symbolized by black color.

Based on the distribution of points in Figure 1, it is dominated by yellow, where 47.1% of the respondent's houses in the Talise PKM area are considered to have low susceptibility to the ARI incidence. the map also shows the color gradations are evenly distributed in each area, this condition illustrates that the respondent's house has the same characteristics, this can be related to their position in the same economy class. The design of the house is also similar, namely minimalist with the condition of the building attached. While in Figure 2 it is dominated by orange color, where 39.8% of the respondent's houses in the Singgani PKM area are considered rather vulnerable to the ARI incidence even though the statistical test does not showed a significant relationship. In addition, on this map the distribution of color gradations is uneven, the Poboya sub-district is dominated by red and orange dots, while in other areas it is dominated by orange and yellow dots. This indicates that there are differences of the houses characteristics in this area. This caused this site placed in the center of Palu City, where

is dominated by old buildings which is used for two functions, as a residence house as well as a business place. The people here come from diverse economic classes.

Seeing the differences in the characteristics of the people in these two regions, it is necessary to take a different approach in dealing with disease incidence. As explained in the concept of the health belief model that health behavior at the community level needs to take into account the characteristics of the community, this can be in the form of their knowledge, economic level or other characteristics. These community characteristics will also affect their ability to obtain and process information related to health**(2,20)**.

Further research is needed to comprehensively look at the determinants of the incidence of ARI in this region, in addition to environmental aspects, the condition of the host itself is also very influential on the incidence of disease, for example in ARI, the immunization status of children under five greatly affects their susceptibility. Environmental aspects related to exposure to cigarette smoke and the type of fuel used for cooking also need to be investigated**.**

5. Conclusion

Statistically the houses physical condition (ventilation, density, floor and wall type, ceiling) is not related to the ARI incidence in both of Talise and Singgani health center area. However, the vulnerability maps showed that there are more houses in the Singgani health center area which are categorized as rather vulnerable than in the Talise health center area. The characteristics of the community houses in both of these sites are also different, so that disease prevention efforts require a different approach.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. B. Gobel, G. D. Kandou, and A. Asrifuddin, "Faktor-Faktor Yang Mempengaruhi Kejadian ISPA Pada Balita Di Desa Ratatotok Timur," Jurnal Kesehatan Masyarakat, 2021, vol. 10, no. 5, pp. 62–67.
2. D. Irfi Jayanti, T. Ashar, D. Aulia, M. S, "Pengaruh Lingkungan Rumah Terhadap ISPA Balita Di Wilayah Kerja Puskesmas Tanjung Haloban Kabupaten Labuhan Batu Tahun 2017,". *JUMANTIK*, 2018. vol. 3, no. 2, pp. 63–77.
3. R. Jalil, Yasnani, and L. O. M. Sety, "Faktor-Faktor Yang Berhubungan Dengan Kejadian ISPA Pada Balita Di Wilayah Kerja Puskesmas Kabangka Kecamatan Kabangka Kabupaten Muna," FKM-Uho, 2018. vol. 3, no. 4, pp. 1–8.
4. T. Ratnaningsih and E. Lusiana, "Relationship Between Cleanliness of the Home Environment with Incidence of Acute Respiratory Infections among Children Under Five," *Int. J. Nurs. Heal. Serv.*, 2020. vol. 3, no. 2, pp. 316–325, , doi: 10.35654/ijnhs.v3i2.335
5. Kementerian Kesehatan RI. Hasil Utama Riset Kesehatan Dasar (RISKESDAS). Badan Libatbengkes RI, 2018.
6. Dinas Kesehatan Provinsi Sulawesi Tengah, *Profil Kesehatan Provinsi Sulawesi Tengah Tahun 2019*.
7. Dinas Kesehatan Kota Palu, *Data Laporan ISPA Tahun 2020*.
8. Badan Meteriologi, Klimatology dan Geofisika. 2020. Laporan Tahunan: Analisis, Monitoring dan Prakiraan Iklim Kota Palu.
9. Pitriani dan Herawanto. 2019. Buku Ajar: Epidemiology Lingkungan. Nasmedia: Makassar
10. Peraturan Mentri Kesehatan Indonesia No 1077/Menkes/PER/2011 Tentang Pedoman Penyehatan Udara dalam Ruang Rumah.
11. W. Yuslinda, Y. Yasnani, and R. Ardiansyah, "Hubungan Kondisi Lingkungan Dalam Rumah Dengan Kejadian Penyakit Infeksi Saluranpernafasan Akut pada Masyarakat di Kelurahan Ranomeeto Kecamatan Ranomeeto Tahun 2017," *J. Ilm. Mhs. Kesehat. Masy. Unsyiah*, vol. 2, no. 6, pp. 1–9, 2017, doi: 10.37887/jimkesmas
12. S. Safrizal, "Hubungan Ventilasi, Lantai, Dinding, dan Atap dengan Kejadian ISPA pada Balita di Blang Muko," *Pros. Semin. Nas. IKAKESMADA "Peran Tenaga Kesehatan dalam Pelaksanaan SDGs,"* 2017. vol. 1, no. 1, pp. 41–48.

13. Pitriani dan Sanjaya. 2020. Buku Ajar: Dasar Kesehatan Lingkungan. Nasmedia: Makassar

14. S. Wahyuningsih, S. Raodhah, and S. Basri, "Infeksi Saluran Pernafasan Akut (ISPA) pada Balita di Wilayah Pesisir Desa Kore Kecamatan Sanggar Kabupaten Bima," *Hig.   J. Kesehat. Lingkung.*, 2017. vol. 3, no. 2, pp. 97–105,.

15. Keputusan Menteri Pekerjaan Umum dan Perumahan Rakyat Nomor 403 Tahun 2002 Tentang Panduang Teknis Rumah Sehat Sederhana

16. T. Saparina, Noviati, and S. Husnia, "Hubungan Kondisi Lingkungan Dengan Kejadian Penyakit ISPA pada Balita Di Kelurahan Wasolangka Wilayah Kerja Puskesmas Parigi Kabupaten Muna," *MIRACLE J. Public Heal.*, 2020. vol. 3, no. 2, pp. 133–141.

17. Nenitriana, Miswan, and Z. Tasya, "Hubungan Kondisi Fisik Rumah dengan Kejadian ISPA pada Anak Balita di Desa Taopa Wilayah Kerja Puskesmas Taopa Kabupaten Parigi Moutong," *J. Kolaboratif Sains*, 2018. vol. 1, no. 1, pp. 898–906.

18. W. K. Sari.AZ and M. Audia, "Hubungan Jenis Lantai, Jenis Dinding, dan Jenis Atap Rumah dengan Kejadian ISPA di Desa Mekar Jaya Kecamatan Bayung Lincir," *Sci. J.*, 2021. vol. 10, no. 2, pp. 34–39.

19. S. T. Lalu, R. H. Akili, and S. S. Maddusa, "Gambaran Faktor Kesehatan Lingkungan pada Balita 12 - 59 Bulan dengan Penyakit ISPA di Wilayah Kerja Puskesmas Kema Tahun 2020," *Kesmas*, 2020. vol. 9, no. 7, pp. 190–199.

20. Rosmalia D dan Sriani Y. 2017. Bahan Ajar: Sosiologi Kesehatan. Kementerian Kesehatan R.I. Pusat Pendidikan Sumber Daya Manusia Kesehatan. Jakarta