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Indoor Air Quality and Its Impact on Stunting Risk in Children

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ABSTRACT

Indoor air quality is an important factor that needs attention in everyday life because it has a significant impact on health, especially for children under 5 years who spend almost 90% of their time indoors. Pollutants that pollute indoor air can increase the risk of infection in children, which can stunt their growth and cause stunting. Indonesia is one of the countries with the highest prevalence of stunting. Therefore, this study aims to analyze indoor air quality which can be a risk factor for stunting. This research was cross-sectional research. The research results showed that the concentration of Volatile Organic Compounds (VoC), CO (Carbon Monoxide), CO_2 (Carbon Dioxide), and the number of microbes in the air exceeded the quality standard values permitted for the air where stunted children live. Meanwhile, for home air for children who are not stunted, it does not exceed the quality standard value. This shows that the air quality in the homes of children who are pregnant is in the bad category with high levels of pollutants present. The bad effects of these pollutants can result in recurring infectious diseases in children, which can cause children to become malnourished, which can ultimately lead to stunting. The results of statistical testing using the Independent Sample T-Test for each parameter show a p value of 0.005, which is smaller than alpha, meaning there is a significant difference between the air quality in the room where stunted and non-stunting children live. This means that there is a relationship between air quality and the incidence of stunting in children.

Keywords: Indoor air quality (IAQ), Stunting, Air pollutants

INTRODUCTION

currently the center of world attention, and many scientific research teams are currently studying all aspects related to IAQ and outdoor air, especially health aspects (Ostro et al., 2018; Saini and Dutta, 2020). This is because indoor air quality greatly affects health, especially for children, and because a person can spend 90% of their time indoors (Saini, Dutta and Marques, 2020).

According to the World Health Organization (WHO), indoor air pollution (IAP) is responsible for the deaths of 3.8 million people each year (WHO, 2020). Dangerous indoor pollution includes carbon monoxide (CO), volatile organic compounds (VOC), particulates (PM), aerosols, biological pollutants, and others that can disrupt the body's immune system, increase allergies, asthma and asthma exacerbations, and chronic lung disease (Schraufnagel et al., 2018; Chojer et al., 2020; Glencross et al., 2020; Saini, Dutta and Marques, 2020).

Humans have a relatively high level of exposure due to the length of time they are exposed when they are in the room (Kar, Zhang and Pinkerton, 2016). So, children should be a concern because children aged 0-5 years old do a lot of their activities indoors, it is even very possible that they stay indoors for 1x24 hours, especially children

Indoor Air Quality (IAQ), is

under 5 years old are very susceptible to diseases that can be transmitted through the air such as pneumonia and other respiratory tract infections. And it is known that pneumonia kills more children worldwide than any other disease (Chojer et al., 2020).

Bioaerosol is also a very important factor because pathogenic bacteria have the same effect on infectious disease such as tuberculosis, Legionella pneumophilacan can cause severe pneumonia especially Legionnaires' disease, Staphylococcus aureus causes abscesses and Clostridium difficile causes inflammation (Liu et al., 2018; Yang et al., 2018).

Infectious diseases are closely related to nutrition. Children who suffer from infectious diseases are at higher risk of malnutrition (Mbuya and Humphrey, 2016). And one of the diseases caused by malnutrition is stunting. A child can be said to be stunted if there is a failure to grow and develop. Stunting affects morbidity and mortality, reduces cognitive development, reproductive and physical work capacity which will later affect the quality of a nation (Jonah, Sambu and May, 2018).

Environmental hygiene and sanitation are considered to be the main causes of stunting because they

can cause recurrent diarrhea in children (Sinharoy, Clasen and Martorell, 2020). This can happen because of environmental enteropathy. When pathogenic bacteria enter the intestines, the intestines work harder to remove toxins and kill bacteria even without diarrhea. However, this can reduce the intestines' ability to absorb nutrients (Badriyah and Syafiq, 2017).

Worldwide, 155 million children under the age of 5 (toddlers) experience stunting (Batiro et al., 2017; Vonaesch et al., 2018). And WHO data (2018) shows that Indonesia is ranked third in the country with the highest stunting rate in Southeast Asia, reaching 36.4% in 2005-2017 (Kemenkes RI, 2018). So, this article will evaluate the difference in indoor air quality between the residences of children who experience stunting and children who do not experience stunting. This is considered important because IAQ can be used as an indicator of environmental sanitation in residences that can affect the level of public health, especially in children.

METHOD

This research is a type of analytical descriptive research, namely research that describes, records, and analyzes the differences between the air quality in the homes of children who are stunted and those who are not stunted using the Cross-Sectional method. This research was conducted in the integrated laboratory of UIN Raden Fatah Palembang.

The total sample in this study was 60 residential houses consisting of 2 sample groups. The first group is the residence of children who experience stunting as many as 30 and the second group is the residence of children who are not stunted as many as 30 samples as a comparison. The criteria for the selected samples are children aged 2-5 years with the same economic conditions and the same educational background of their parents. The flow of this study is:

1. Observation and Observation of Respondents' Homes
   Observation of the respondent's residence location was carried out by observation and interviewing the respondent's parents to find out birth weight, mother's age of marriage, parents' occupation, education, parents, and parents' income. This interview was conducted to achieve a high level of sample homogeneity and screening for a history of diseases that are often suffered by children.
2. Measurement of concentrations of VoC, CO, Co2, and Air Bacterial Count
   To analyze or assess the Indoor Air Quality of the respondent's house, VoC, CO, and Co2 tests were carried out using an Air quality detector that was installed for 24 hours in the respondent's house. To examine the number of air germs using the plate count method or Total Plate Count (TPC) which was then calculated using the following air germ number formula: $\frac{CFU}{m3} = \frac{Nx10.000}{A\ x\ T\ x\ 1/5}$
   This examination aims to assess the number of bacteria in the air. Where N is the number of colonies on the media in the Petri dish, A is the surface area of the media in the Petri dish (cm2), and t is the exposure time of the media to air (minutes). The results of the CFU/m3 conversion are described using descriptive statistics to see the size of the diversity or variation of statistical data and the description of the data that was carried out.
3. Analysis
   The research data were analyzed using SPSS and tested using the Independent Sample T-Test for normally distributed groups and Mann Whitney to determine the differences between the two sample groups.

RESULT AND DISCUSSION

From the examination carried out directly using an Air quality detector for IAQ parameters (VOC, CO, CO_2) in the room or house, it is known that the residences of stunted children have very high concentrations of VOC, CO, CO_2 exceeding the quality standards set according to the Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023. The average concentration of VOC in the homes of stunted children is at 4.7 Ppm, CO is at 224 Ppm, CO2 is at 4707 Ppm and the number of air germs is at 10287 CFU/m3. These values indicate that the rooms where stunted children live have been contaminated by high levels of PM_{10} and $PM_{2.5}$ pollutants.

Table 1
Concentration of VOC, CO, CO_2 and Bacterial Numbers in Living Rooms

Sample Group	Sample Code	VOC Concentration (Ppm)		CO Concentration (Ppm)		CO_2 Concentration (Ppm)		Airborne Germ Number (CFU/m^3)	
		Concentration	Average	Concentration	Average	Concentration	Average	Concentration	Average
Residence of Stunting Children	S1	4	4,7 (> 3 Ppm/ More standard quality) (Regulation of the Minister of Health	120	224 (>9Ppm/ More than the quality standard) (Regulation of the	4176	4707 (> 1000 Ppm/ More standard quality) (Regulation of the Minister	11759	10287 (> 1000 CFU/m^3/ More standard quality) (Regulation of the Minister
	S2	1.6		48		4288		6667	
	S3	3.2		56		4488		8889	
	S4	4.8		256		4752		7037	
	S5	4.8		256		4752		11481	
	S6	2.4		56		4240		10741	
	S7	79.2		4912		15536		5370	
	S8	2.4		56		4368		4259	
	S9	2.4		48		4360		6759	

	S10	1.6	of the Republic of Indonesia No. 2 of 2023)	56	Minister of Health of the Republic of Indonesia No. 2 of 2023)	4112	of Health of the Republic of Indonesia No. 2 of 2023)	10926	of Health of the Republic of Indonesia No. 2 of 2023)
	S11	0		16		4112		11944	
	S12	0.8		48		4160		7130	
	S13	0.8		48		4168		9815	
	S14	0.8		24		4232		7685	
	S15	1.6		48		4296		11852	
	S16	0.8		16		4224		9259	
	S17	0.8		48		3984		5278	
	S18	0.8		16		4112		4627	
	S19	0.8		48		4224		7407	
	S20	0.8		24		4048		11852	
	S21	6.4		352		5056		11667	
	S22	0.8		24		4048		8148	
	S23	3.2		48		4432		10093	
	S24	2.4		104		4472		12500	
	S25	2.4		56		4240		8056	
	S26	0		16		4048		8519	
	S27	4		336		4816		10370	
	S28	4		120		4624		8333	
	S29	0		16		4048		11111	
	S30	5.6		56		4800		10278	
Places of Residence for Children Who Are Not Stunted	K1	0.5	0,6 (< 3 Ppm/ Less than the quality standard) (Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023)	15	30,5 (>9Ppm/ More than the quality standard) (Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023)	522	592 (< 1000 Ppm/ Less than the quality standard) (Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023)	556	525 (< 1000 CFU/m^3/ Less than the quality standard) (Regulation of the Minister of Health of the Republic of Indonesia No. 2 of 2023)
	K2	0.2		6		536		463	
	K3	0.4		7		561		556	
	K4	0.6		32		594		648	
	K5	0.6		32		594		463	
	K6	0.3		7		530		556	
	K7	9.9		614		2067		370	
	K8	0.3		7		546		463	
	K9	0.3		6		545		648	
	K10	0.2		7		514		463	
	K11	0		2		514		556	
	K12	0.1		6		520		556	
	K13	0.1		6		521		370	
	K14	0.1		3		529		556	
	K15	0.2		6		537		463	
	K16	0.1		2		528		648	
	K17	0.1		6		498		556	
	K18	0.1		2		514		648	
	K19	0.1		6		528		556	
	K20	0.1		3		506		648	
	K21	0.8		44		632		556	
	K22	0.1		3		506		463	
	K23	0.4		6		554		556	
	K24	0.3		13		559		370	
	K25	0.3		7		530		556	
	K26	0		2		506		648	
	K27	0.5		42		602		463	
	K28	0.5		15		578		463	
	K29	0		2		506		463	
	K30	0,7		7		600		463	

Table 2
Statistical Test Analysis of Indoor Air Quality (IAQ) Between Sample Groups

Test Group	P Value (Sig 2 – tailed)				Information
	VOC	CO	CO_2	Airborne Germ Number	
IAQ Place of residence for children experiencing stunting and children not experiencing stunting	0.000	0.000	0.000	0.000	The Asymp sig value (2-tailed) is 0.000, which is less than 0.05, which means there is a significant difference.

Table 1 has provided a clear picture that the parameters examined as indicators of indoor air pollution for children who suffer from stunting live, all parameters exceed the threshold values permitted in PKM No. 2 of 2023. For air germ numbers, the environmental health quality standards are permitted. is 700 CFU/m^3, CO is 9 ppm, CO_2 is 1000 Ppm and VOC is 3 Ppm.

From the Simple T Test presented in table 2, it is known that there is a positive relationship or correlation between indoor air quality and the incidence of stunting as seen from the p value of 0.000 which is smaller than alpha 5% (0.05). Correlation II illustrates that the higher the pollutant substances in the air, especially VOC, CO, CO_2 and bacteria, the higher the risk of stunting in children.

Based on the normality of the sample, the Independent Simple T-Test and Mann Whitney tests were used to see whether there were significant differences in the concentrations of VOC, CO, CO_2 and germ numbers between the residences of children who experienced stunting and those who did not experience stunting as seen from the P Value (Sig 2-tailed).

Significant differences in the quality of residential air between stunted and non-stunted children can occur due to differences in parental behavior in implementing a healthy lifestyle and creating a healthy home environment. From the results of the interview, one of the known facts is the knowledge of parents about the importance of good ventilation at home, sufficient lighting, and the habit of not smoking inside the house which are the dominant factors that differentiate the air quality of the two groups. The residences of children who experience stunting have poor ventilation and the habit of fathers who actively smoke room (Salthammer et al., 2016; Chojer et al., 2020; Marques et al., 2020).

inside the house. While the group of children who do not experience stunting have good ventilation and low smoking activity inside the house.

Ventilation plays an important role in measuring indoor air quality (IAQ). Several studies have shown that if ventilation is not properly arranged in a building, IAQ will decrease and the building will become unhealthy to live in.

Other studies also reveal that IAQ is an important parameter to observe as one of the main factors in increasing health problems due to a lack of room ventilation (Parajuli, Lee and Raj, 2016).

Damp house conditions, poor lighting, and inadequate ventilation in almost all houses where stunted children lived as samples were the main factors in low indoor air quality. In addition to poor ventilation, household activities including cooking are carried out in narrow houses without a place to exhaust smoke.

The results of burning biomass fuels in poorly ventilated home stoves will result in increased carbon monoxide (CO), particulate matter (PM), formaldehyde, nitrogen oxides (NOx), polycyclic aromatic hydrocarbons, benzene, and other toxic organic compounds, which will then lead to chronic health problems (Garcia, 2017; Saini and Dutta, 2020). The use of chemical products and synthetic materials in the home can also increase the concentration of Volatile Organic Compounds (VOC). VOCs can cause hypersensitivity when exposed to humans (Saini, Dutta and Marques, 2020). High CO2 concentrations in a room are caused by poor ventilation. And this also indicates the accumulation of pollutants in the

Table 3
Analysis of the Relationship Test of Indoor Air Quality (IAQ) with Disease Incidence (ARI and Diarrhea)

Test Group	P Value (Sig 2 – tailed)				Information
	VOC	CO	CO_2	Angka Kuman Udara	
Incidence of Diseases in Children Who Experience Stunting and Children Who Do Not Experience Stunting	0.000	0.000	0.000	0.000	The Asymp sig value (2-tailed) is 0.000, which is less than 0.05, which means there is a significant difference.

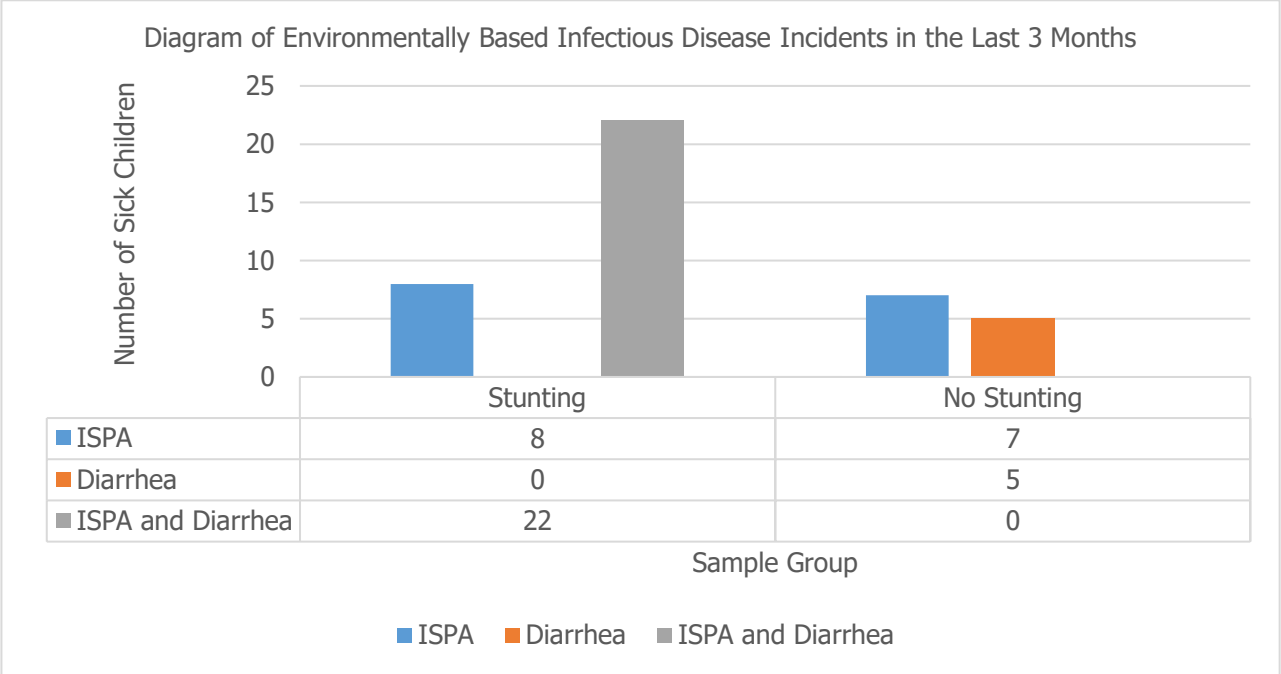

Figure 1. Distribution of the Highest Infectious Disease Incidents Based on the Environment in Each Sample Group

The figure 1 shows that in the group of stunted children, all children experienced ARI and diarrhea in the last 3 months, even out of 30 samples, 22 samples experienced diarrhea and ARI. While in the group of children who did not experience stunting, only 7 cases of ARI and 5 cases of diarrhea were found. The Independent Simple T Test and Mann Whitney Test in table 3 were used to see whether the disease incidence variable was related to the number or concentration of indoor air quality in the sample's residence. A p value of 0.000 was obtained from each test of indoor air quality parameters on disease incidence. This shows a relationship between the number of germs, CO, CO2, and VOC values in the air and the incidence of disease. Where the worse the indoor air quality of the residence, the higher the risk of environmental-based diseases. In this study, the categories of illness studied in this study were Upper respiratory tract infectionand diarrhea. Where if the sample group one of these diseases or both were included in the disease category.

When viewed from the incidence of disease, children who live in homes that have high levels of air germs, CO, CO_2 and VoC have experienced Upper respiratory tract infection in the last two months and even had repeated infections in one month. Bacteria enter the bioaerosol indoors and outdoors which are included in the category of particulate matter that can cause pneumonia Staphylococcus aureus in the air can also cause abscesses and Clostridium difficile causes inflammation which is also transmitted through the air (Liu et al., 2018; Yang et al., 2018). High levels of VOC, CO, and CO_2 in the home will increase the severity of the disease. Pollutants in the air can also interfere with the body's immune system. Pollutants in the air such as VOC, CO, and CO_2, can increase T helper lymphocytes type 2 (Th2) and T helper lymphocytes type 17 (Th17) so that an adaptive immune response will occur so that allergies, asthma and exacerbations of asthma and chronic obstructive pulmonary disease can occur (Glencross et al., 2020). High VOCs in indoor air can irritate the skin, irritate or inflame the throat, nose, and eyes. Even medical health experts have reported many more serious illnesses resulting from high VOC exposure such as headaches, respiratory symptoms, fatigue (Saini, Dutta and Marques, 2020).

This condition was found by researchers when conducting observations in the field. The sanitation of the houses where children with stunting live is much worse than the houses where children who do not experience stunting live. Economic problems cannot be the main reason in this case. Because the control group is also in the same economy but they practice clean and healthy living behavior. Small houses are well arranged and always cleaned and have sufficient ventilation so that the temperature and humidity of the indoor air remain stable in the residences of normal children or those who do not experience stunting. However, in the residences of children who experience stunting, this was not found by researchers in the field. So this makes it very possible that there will be an increase in VOC, CO2, and CO levels due to household activities and make air quality poor.

In children who are still under 5 years old are susceptible to diseases that can be transmitted through the air such as pneumonia and other respiratory infections. And it is known that pneumonia kills more children worldwide than any other disease (Chojer et al., 2020). Therefore, children must be given attention because children aged 0-5 years do most of their activities indoors, and it is very possible that they spend 24 hours indoors,

especially children under 5 years old who are very susceptible to diseases that can be transmitted through the air, such as pneumonia and other respiratory tract infections.

Infectious diseases are closely related to nutrition. Children who suffer from infectious diseases are at higher risk of malnutrition (Mbuya and Humphrey, 2016). The quality of the living environment during early life has an impact on a child's development. Exposure to toxic air pollutants such as lead can lead to malnutrition and increased stress levels because a child's brain is very sensitive to exposure to these toxins (Claire and Chase, 2020).

Conditions like this can eventually cause infants or children to be malnourished. The frequency of diarrhea, as a syndrome, regardless of its cause, is strongly correlated with growth faltering. So from several studies also say that repeated diarrhea can increase the risk of stunting in children (Cumming and Cairncross, 2016; Torlesse et al., 2016). Furthermore, it is currently estimated that 25 to 43 percent of global stunting rates are associated with enteric infections in early childhood, with or without symptoms of diarrhea (Guerrant et al., 2012)

CONCLUSION AND SUGGESTIONS

Poor indoor air quality conditions in homes where stunted children live cause a greater risk of infectious diseases such as acute respiratory infections and diarrhea. This can worsen the condition of children who have experienced stunting because they will experience more nutritional deficits, thus inhibiting their growth and development. Even indoor air quality must be considered carefully so as not to interfere with children's health because it can be a risk factor for stunting due to repeated infections that occur in children and cause children to experience malnutrition.

Differences in air quality affect the incidence of ARI and diarrhea. This is illustrated by the results of the study that the group of stunted children experienced repeated ARI and diarrhea in the last two months, while the group of children who did not experience stunting mostly did not experience illness. Where it is known that the Indoor Air Quality of the residence of stunted children is worse than the group of children who did not experience stunting. For this reason, one solution that can be done to prevent infectious diseases in children is to maintain the indoor air quality of the child's residence so that the child is not infected with infectious diseases or diseases caused by bad air. Thus, nutrients will be maximally used by the child's body for growth and development.

Finally, this research can provide recommendations to heads of families so that they can pay attention to environmental sanitation hygiene and behave in a healthy way according to standards. Apart from that, it can be used as a reference for policy makers, in this case the government, in determining the next work program to reduce stunting rates so that they also focus on sanitation because it is one of the important risk factors for overcoming stunting.

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