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Upper respiratory infection (URI) symptom prevalence corresponds with air pollution and physical activity

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Abstract

Air pollution is often associated with Upper Respiratory Infection (URI), and children are generally the most susceptible to URI. Although physical activity has a positive impact on health, it should be remembered that unhealthy pollution concentrations can eliminate the positive effects of physical activity. Thus, this research aimed to map the concentration of air pollution associated with the prevalence of URI symptoms and the level of physical activity in children throughout Java Island. This research uses a multicenter design, a descriptive quantitative method with a cross-sectional approach, within every six big cities on Java Island, Indonesia. The total subjects in this research were 1,216 male and female elementary school students from six provinces throughout Java Island (Banten, n=200), (Jakarta, n=200), (Bandung, n=202), (Semarang, n =210), (Yogyakarta, n=201), (Surabaya, n=203). Data was collected offline using the physical activity and URI questionnaires, accompanied directly by the original teacher. The research results indicated that unhealthy air pollution quality (> 35 µg/m³) was associated with the prevalence of URI symptoms (Jakarta 18.9% and Semarang 21.6%). Data analysis using ANOVA to see the interaction between 6 big cities and investigate within each city using paired t-test. Students' level of physical activity was related to air pollution, which could negatively impact the respiratory system. Therefore, these findings can be of particular concern to city governments and school teachers not to rule out the dangers of air pollution and the benefits of physical activity in schools.

Keywords: $PM_{2.5}$, physical activity, upper respiratory infection.

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INTRODUCTION

The benefits of outdoor physical activity and the adverse effects caused by air pollution are still interesting topics for deeper study. Research results showed that the benefits of doing physical activity for 30 minutes, which is performed 3-5 times a week, can reduce the risk of heart attack, respiratory system, type-II diabetes, and certain types of cancer to reduce the risk of death (Wagner & Clark, 2018). However, although previous research has provided relevant information about the benefits of physical activity in improving human health, it is essential to note that some environmental characteristics can modulate the benefits of exercise, such as air pollution (Si & Cardinal, 2017).

WHO reports that air pollution caused 4.1 million deaths in 2016. On the other side, physical inactivity is also a risk factor for NCDs, with an estimated cause of 3.2 million deaths in the same year (WHO, 2018; World Health Organization, 2020). The high air pollution in Indonesia correlates with the number of motorized vehicles, which is estimated to total more than 140 million (Yudison et al., 2017). From 2001 to 2011, the transportation sector's share of the total national consumption of fossil fuels almost doubled from 45% to 80% (Agustian et al., 2020). It will be a significant source of emissions apart from pollution caused by industry. Thus the condition of air pollution, especially in big cities on the island of Java (Banten, Jakarta, Bandung, Yogyakarta, Semarang and Surabaya), continues to increase every year, so that it makes several locations close to sources of energy use and dense areas of motorized vehicles, such as school areas located in urban areas having high levels of air pollution which can harm children's and adolescent’s health.

One of the effects of air pollution, especially on human health, is Upper Respiratory Infection (URI), which is characterized by reducing the vital capacity of individual lungs (Sinharay et al., 2018). Due to air pollution, URI significantly impacts vulnerable groups, including children and adolescents (Ozlem Kar Kurt et al., 2017). Children and adolescents in Indonesia tend to do physical activity in the morning and afternoon in the

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school environment. High activity can also increase the rate of respiratory ventilation so that the possibility of inhaled air pollution is even more significant and can harm the bodies of children and adolescents (Thompson Coon et al., 2011). However, some research revealed that high activity could minimize the adverse effects caused by air pollution (Giorgini et al., 2016). In contrast, someone with low physical activity tends to be at increased risk of air pollution (Tainio et al., 2021). Thus, it creates the effect of school environmental conditions on the level of physical activity in schools with the incidence of URI in children and adolescents.

The condition of air pollution in the school environment and the level of physical activity of children and adolescents is a concern that must be discussed. Mapping the condition of air pollution in the school environment, the level of physical activity, and the incidence of URI in students must be carried out properly. This can help governments and schools provide physical activity recommendations based on environmental conditions to effectively reduce the risk of air pollution and improve the physical health of children and adolescents. Based on our knowledge, there has not been much research related to the impact of air pollution on respiratory system disorders in elementary school children, and recent research has only focused on the effect of air pollution on the health of adults (Abdullah et al., 2021; Agustian et al., 2020; Bahri et al., 2021; Nurrohman et al., 2014; Samsul Bahri et al., 2019). Thus, this research aims to see how much the impact of air pollution is associated with the level of physical activity of elementary school-age children with the incidence of URI. It is expected that the results of this service can provide an overview for relevant stakeholders in policies, especially the use of energy that is not environmentally friendly, as well as the management of the school area to minimize air pollution from outside.

METHOD

This research used a multicenter design, a descriptive quantitative method with a *cross-sectional* approach within every six big cities on Java Island, Indonesia. Data collection was carried out *face-to-face*, beginning

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with anthropometric measurements such as age, weight, height and BMI. A questionnaire was conducted to measure the level of physical activity and the incidence of URI prevalence. The total subjects in this research were 1,216 male and female elementary school students from six big cities that represent java island consisting of (Banten, n=200), (Jakarta, n=200), (Bandung, n=202), (Semarang, n =210), (Yogyakarta, n=201), (Surabaya, n=203). Six large cities were confirmed by the Ministry of Environment and Forestry as the six largest cities on Java Island are used for factory land, and the traffic was so terrible. Hence, six big data represent the entire data for the province, which was correlated with ambient air pollution. Inclusion criteria in this research included active male and female students in grades 5-6 and between 10-14 years.

Measurement and Research Procedures

Anthropometry

Data collection on the age of students was carried out using a questionnaire accompanied by the homeroom teacher/sports teacher during class hours (08.00 – 09.00 WIB). Furthermore, the *Gea HT721 Digital Stature Meter* was used for height in this research. It used a distance meter with ultrasonic technology, where the subject stands near a wall and then places the device on the upper limit of the subject's head. The sensor will read the head height limit to the ground level. While for body weight and BMI, it used the *OMRON Karada Scan Body Fat* measuring tool (HBF-375). The data collection procedure was carried out using the subject standing upright on the unit by placing his feet on the electrodes barefoot, then positioning both hands straight ahead to form 90° by holding the display; After the results of the weight measurement appeared, it will blink twice, wait for it until the sensor stop working; Then, when the sensor stops, the measurement results for weight and body composition will appear on the monitor.

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URI (**Upper Respiratory Infection**)

URI measurement was carried out using a questionnaire directly assisted by the health team. This URI questionnaire has been validated and is often used to see the prevalence of URI by doctors. The prevalence of URI according to the history of diagnosis was measured through the question: "In the last 1 month, has the respondent ever been diagnosed with URI by a health professional (doctor/nurse/midwife)?" If the answer is no, then a history of experiencing URI symptoms is asked through questions asking about fever, cough for less than two weeks, runny nose/nasal congestion, and sore throat. If the respondent answered that he had experienced symptoms of fever, cough for less than two weeks, runny nose/stuffy nose, or sore throat, then the respondent was considered to have a URI. The prevalence of URI was calculated using the following formula:

$$\text{URI prevalence} = \frac{\Sigma \text{ URI case diagnostic history (D) or Symptom (DG)}}{\Sigma \text{ ART All age categories}}$$

Physical Activity

Physical activity data were collected after anthropometric measurements; the physical activity level measuring tool employed the Physical Activity Questionnaire for Older Children (PAQ-C) questionnaire. Filling out the questionnaire accompanied by the homeroom teacher/sports teacher while in class consists of 10 questions. In general, the calculation of the PAQ-C questionnaire score begins by giving each activity a score of 1 to 5 for each item (except question number 10). Question number (1) will be given a score of 1 when the participant answers "no", a score of 2 when the participant answers "1-2", a score of 3 when the participant answers "3-4", a score of 4 when the participant answers "5-6", and a score of 5 when the participant answered "7 times or more". After obtaining the score for each item in questions 1 and 9, calculate the mean value of question 1; thus, you get a composite score from questions number (1) and number (9). Then, the calculation for questions number (2) to (8) is carried out by giving a score of 1 if the participant chooses the lowest level of activity and gives a score

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of 5 if he chooses the most strenuous activity. The final calculation for the PAQ-C questionnaire is carried out by adding the scores of the 9 questions (numbers 1-9). Then, after adding them up, the mean value of the 9 questions is taken. The score obtained is then classified, including the score (1) "very low", score (2) "low", score (3) "moderate", score (4) "high", and score (5) "very high".

The procedures in this study included, in the early stages, the researcher recording which schools were involved and determining which origin teachers from each school representative were responsible for data collection accompanied by 1 member of the researcher. Secondly, all participants took anthropometric measurements (age, weight, height and BMI). All three participants were explained to fill out the physical activity questionnaire and the URI prevalence questionnaire and were directly guided in class to fill out the questionnaire. All data collection was carried out face-to-face in class and an orderly manner according to research procedures.

Data Analysis

The data presented in this research is the main score and standard deviation. The anthropometric data such as age, weight, height, and BMI were tested using one-way analysis or *one-way ANOVA* to compare differences between provinces. Furthermore, concerning the incidence of URI, the level of physical activity and air pollution were tested using a correlation test, which aimed to see whether there was a correlation between variables in each province. All statistical analyses used the SPSS version 22 application with a significance level of $p<0.05$.

RESULTS

The research results showed that in anthropometric data from the six major cities in Java, there were significant differences in body weight, height, and BMI; where the highest value of weight comes from Jakarta (p=0.001), the height in Bandung (p=0.001), and the mean height in Surabaya (p=0.001) that is superior when compared to the cities of Banten,

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Jakarta, Semarang, and Yogyakarta. Then, the mean value of BMI with the highest score comes from Jakarta (p=0.001) (see Table 1).

Table 1. Anthropometric data of elementary school students in six major cities throughout Java Island

Variable	Group					
	Banten (n=200)	Jakarta (n=200)	Bandung (n=202)	Semarang (n=210)	Yogyakarta (n=201)	Surabaya (n=203)
Age (years)	10.29 ± 0.78	10.31 ± 0.93	11.34 ± 0.61	10.62 ± 0.92	11.04 ± 0.95	10.94 ± 0.88
Weight (kg)	31.40 ± 7.88	39.59 ± 11.58*	36.20 ± 10.67	36.34 ± 11.02	38.53 ± 10.48	37.77 ± 11.75
Height (cm)	137.49 ± 8.24	139.22 ± 8.97	142.24 ± 8.37*	139.09 ± 9.78	140.39 ± 11.30	143.53 ± 9.14*
BMI (kg/m^2)	16.61 ± 3.98	20.25 ± 5.14*	17.64 ± 3.93	18.54 ± 4.18	19.44 ± 4.17	18.13 ± 4.50

Result of repeated measures one-way ANOVA analysis. *p<0.05;

Table 2. Correlation of air pollution on prevalence uri and physical activity

City	Air Pollution (PM2.5) (µg/m³)	URI (%)	Physical Activity (METs)	Air Pollution & PA		Air Pollution & URI	
				Pearson Correlation	Sig	Pearson Correlation	Sig
Banten (n=200)	27.90 ± 13.44	22 (11.6)	2.64 ± 0.52	0.196**	0.005*	0.075*	0.025
Jakarta (n=200)	36.22 ± 7.94	36 (18.9)	2.51 ± 0.61	0.016	0.817	0.049*	0.028*
Bandung (n=202)	14.56 ± 2.35	27 (14.2)	2.41 ± 0.52	0.013	0.850	0.026	0.282
Semarang (n=210)	39.20 ± 7.81	41 (21.6)	2.74 ± 0.88	0.143**	0.039*	0.062*	0.048*
Yogyakarta (n=201)	20.63 ± 3.66	28 (14.7)	2.59 ± 0.57	0.008	0.912	0.070*	0.025
Surabaya (n=203)	29.11 ± 7.29	36 (18.9)	2.89 ± 0.59	0.124**	0.007*	0.073*	0.003

The results in Table 2 showed significant differences in the average exposure to air pollution, the level of physical activity, and the incidence of URI. Based on the six major cities from every province in Java Island, it showed that the high pollutant is in Semarang with a mean value of 39.56 µg/m³. In second place is occupied by Jakarta with a value of 36.28 µg/m³, Surabaya 30.70 µg/m³, Yogyakarta 20.63 µg/m³, Banten 27.90 µg/m³, and Bandung occupies last position at 14.56 µg/m³. Statistical test results indicated that high air pollution correlates with levels of physical activity, especially in Banten (2.64 METs), Semarang (2.74 METs), and Surabaya (2.89 METs). Furthermore, high air pollution is also related to the prevalence of URI symptoms, with the mean value in Banten (11.6%), Jakarta (18.9%), Bandung (14.2%), Semarang (21.6%), Yogyakarta (14.7%), and Surabaya (18.9%) (See Table 2).

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DISCUSSION

The results showed that high air pollution is associated with the prevalence of URI symptoms. The level of physical activity of elementary school students is related to air pollution, which can negatively impact the respiratory system. If you are in an area contaminated by unhealthy air pollution (judging by the air quality index: > 35 μg/m^3), such as Jakarta (pollution quality: 36.22 μg/m^3) and Semarang (pollution quality: 39.20 μg/m^3), while other major cities still have good or healthy air quality, such as Bandung (pollution quality: 14.56 μg/m^3), Yogyakarta (pollution quality: 20.63 μg/m^3), and Banten (pollution quality: 27.90 μg/m^3). Meanwhile, for Surabaya, the physical activity of elementary school children is in the high category (2.89 METs), although the air quality is in the bad category (29.11 μg/m^3), where the air quality value in the bad category is >35 μg/m^3, the moderate category of 12-34.5 μg/m^3 and good category < 11.9 μg/m^3. Especially for the Surabaya area, the high physical activity of children can reduce the potential for URI symptoms compared to other areas.

PM (Particular Matter) is the main indicator, which is very complex and solid, and sends a lot of accumulated toxic substances (Kim et al., 2015; Losacco & Perillo, 2018). Exposure to PM will impact and maintain the inflammatory process of the airways in the body; thus, it will interfere with respiratory function (Losacco & Perillo, 2018). Epidemiologically, the impact of air pollution will be associated with more frequent respiratory system symptoms and impaired lung function, although the magnitude of the reduction in inhaled air is still relatively small and highly dependent on exposure to surrounding air pollution (Kocot, 2020).

As a result of the effect that occurred from the air that was inhaled depending on the level of air pollution, it was feared that it could also interfere with people who wanted to do physical activity or exercise. Air pollution during moderate-intensity exercise in a relatively short time does not negatively affect young boys' respiratory system and cardiovascular function (Kocot, 2020). The effect of exposure to increasing levels of air pollution has recently attracted more and more attention because of the

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habit that is gaining popularity and is continuing through recreational physical activity. Outdoor activities such as jogging or cycling increase ventilation rates and can cause increased deposition of air pollutants in the respiratory tract (Bahri et al., 2020; Giles & Koehle, 2014; Giorgini et al., 2016). Some research has shown that air pollution could impair exercise performance and reduce the positive effects of physical activity on respiratory and cardiovascular function (Kargarfard et al., 2011, 2015; Laeremans et al., 2018). However, the results obtained in the young adult age group indicate that by increasing the level of physical activity, negative physiological changes caused by air pollution can be reduced (Chen et al., 2018; Kubesch et al., 2015). This research statement is in line with the results of this research regarding the Surabaya area, with a high level of physical activity in elementary school children, even though the pollutant level was high, it did not have a significant impact on the development of URI symptoms.

The lack of air pollution stations in various city centres on the island of Java and schools that are dense with traffic is a weakness in this study, so air pollution data cannot be obtained in the area around schools. This will be of particular concern to researchers to recommend to the local government to create a health monitoring program and monitor air pollution conditions in the area around the school. Such health monitoring can be carried out by recording students who are absent due to illness caused by air quality, besides that, the findings in the study can provide recommendations regarding recommendations for carrying out the physical activity for children at school in order to minimize the negative impacts caused by air pollution.

The results of this study provide evidence that routine and increasing physical activity progress can suppress the bad effects of pollutants. Based on the intensity recommendations recommended by WHO, it was at moderate intensity. Every physical activity and sport that involves moderate intensity has been proven to have a positive impact on the body (World Health Organization, 2020), without exception the effects of pollutants on

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the respiratory system (Losacco & Perillo, 2018), and cardiovascular (Kocot, 2020), which play a significant role in movement during physical activity. Recommendations for increasing physical activity need to be added; hence, it is still within the early childhood recommendations (World Health Organization, 2020). Moreover, it was added to changes in behaviour during the Covid-19 pandemic, especially in the Java regions, there was a decrease in playing activity and sleeping quality (D. A. Fauziah et al., 2017; P. Y. Fauziah et al., 2022). Therefore, it is hoped that the results of these findings can be used as an effort to make a policy for the local government or a program to prevent the high incidence of URI and the low physical activity of students in school environments that have high levels of pollution so that the health conditions of students in each can be maintained and improved properly.

CONCLUSION

These findings provided evidence that unhealthy air pollution quality (>35 µg/m³) is associated with the prevalence of URI symptoms in children, especially in the cities of Semarang and Jakarta, which have the highest URI scores. The second finding shows that the level of physical activity of elementary school students is also related to air pollution and the prevalence of URI, i.e., when students actively exercise in unhealthy air pollution conditions, it can negatively impact the respiratory system. Thus, these findings can be used as education for elementary school students, especially those who attend schools in polluted areas, to always pay attention to the environmental conditions around the school from air pollution, e.g., planting trees that can absorb CO2, wearing masks, using bicycles at school, staying active in sports, and taking into account the surrounding air pollution.

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