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Research Article

Spatial Analysis of NO_2 and PM_{10} Concentrations with the Incidence of Acute Respiratory Tract Infection (ARI) in Toddlers in Bandung City

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SUMMARY

Introduction: The attention paid to the health risks associated with urban air pollution has grown in recent times. Several epidemiological studies have revealed a significant relationship between the air quality in urban regions and the incidence of respiratory issues. This study aims to analyze the spatial distribution of NO_2 and PM_{10} in Bandung City, and to propose measures to decrease the occurrence of ARI disease in Bandung City based on the findings of the spatial analysis.

Methods: In 2010, a cross-sectional study was undertaken in five health centers situated in the Bandung region. This study aimed to measure the levels of NO_2 and PM_{10} in the air, as well as the incidence of respiratory illnesses in infants. The data collected from this study were assessed and depicted using the ArcView GIS software.

Results: The research findings revealed that the levels of NO_2 varied between PKM Ujungberung and PKM Kiaracondong, with an average of 0.07 mg/m^3, while the PM_{10} levels ranged from 0.20 µg/m^3 at PKM Caringin to 0.43 µg/m^3 at PKM Puter, with a mean content of 0.342 µg/m^3. The second parameter PM_{10} demonstrated its efficacy at PKM Ujungberung. Out of the sample of 350 respondents 166 (47.4%) reported experiencing Acute Respiratory Infections (ARI), while 168 (52.6%) did not. The Chi-square test indicated no significant correlation between the high levels of NO_2 and the incidence of respiratory diseases in infants ($p = 0.144$), or between the PM_{10} levels and the occurrence of respiratory diseases in infants ($p = 0.132$).

Conclusion: The findings from the Chi-square test suggest no substantial correlation between the concentrations of NO_2 and the incidence of respiratory diseases in children in Bandung. Additionally, no significant relationship was observed between the levels of PM_{10} in the air and the occurrence of respiratory diseases in children. Nevertheless, it can be concluded that both NO_2 and PM_{10} in Bandung City have the potential to be significant variables that affect the prevalence of ARI in children.

Keywords: spatial analysis, NO_2, PM_{10}, ARI

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INTRODUCTION

Urban regions significantly contribute to air pollution and significantly aggravate air pollution problems. These areas are home to a multitude of pollution sources, including transportation, industrial activities, household pollution, and stationary and mobile sources. Health risks associated with urban air pollution have received considerable attention in recent years. The role of urban areas in exacerbating air pollution is substantial, and various sources contribute to this issue. These sources include transportation, industry, domestic pollution, and stationary and mobile sources. Over the past several decades, the health risks associated with urban air pollution have garnered significant attention. Multiple epidemiological investigations have consistently uncovered a

robust connection between elevated urban air pollution levels and the prevalence of respiratory disorders. Air pollutants typically exist in the form of gases and particles, which can lead to various health problems, including those affecting the respiratory system, cardiovascular system, and irritation to the eyes and skin.

Acute Respiratory Infection (ARI) is an acute infectious process that lasts for two weeks. This condition is caused by microorganisms and affects one or more parts of the airway, including the nose, sinuses, middle ear cavity, and pleura. ARI often occurs in children due to their undeveloped immune system. The incidence of cough and cold in toddlers in Indonesia is estimated to be 3 to 6 times per year, which means that an average toddler experiences a cough and cold attack 3 to 6 times annually. The respiratory tract, from the nose to the bronchi, is lined with a ciliated mucous membrane that filters, warms, and moisturizes the air entering through the nasal cavity. The hair in the nose can filter out coarse dust particles, while fine dust particles become entangled in the mucosal layer. The movement of cilia pushes the mucosal layer posteriorly into the nasal cavity and superiorly towards the pharynx. However, air pollution can cause the movement of nasal cilia to slow down or even stop, leading to irritation and difficulty in cleaning the respiratory tract. This increase in mucus production can cause the respiratory tract to narrow and destroy bacteria-killing cells, resulting in difficulty breathing and attracting foreign objects. This can facilitate the occurrence of respiratory infections.

The World Health Organization (WHO) reports that acute respiratory infections (ARI) affect approximately 15-20% of children under five years old in developing countries where the under-five mortality rate surpasses 40 per 1,000 live births annually (WHO, n.d.). It is estimated that around 13 million children under five die each year, with the majority of these deaths occurring in developing countries where pneumonia is a leading cause of death, taking the lives of about 4 million children under five each year (Depkes, 2000; Asrun, 2006). In Indonesia, the Basic Health Research (Riskesdas) conducted in 2007 revealed a national prevalence of ARI at 25.5% (with 16 provinces having rates above the national average), a pneumonia morbidity rate of 2.2% for infants and 3% for toddlers, an infant mortality rate of 23.8%, and a toddler mortality rate of 15.5%. The prevalence of ARI among children under five in Bandung City was 20.3% according to the Bandung City Health Profile 2007.

The Spatial Analysis Technique is a research method that generates a map as a model to represent the real world and serves as an analysis medium for obtaining results with spatial attributes. This method is crucial for gaining insight into the complex interactions among regions within the study area. The Spatial Analysis Technique was employed to investigate the air pollution resulting from NO_2 and PM_{10} in Bandung City. The aim of this research is to examine the spatial distribution of NO_2 and PM_{10} in Bandung City, and to formulate suggestions for preventive measures to reduce the occurrence of ARI disease in Bandung City based on the outcomes of the spatial analysis.

METHODS

This study is a cross-sectional analysis that was carried out in Bandung City. Data was collected by measuring the concentrations of NO_2 and PM_{10} in the ambient air. The test method for determining NO_2 gas in ambient air is specified by SNI 7119-2: 2017, which involves the Griess-Saltzman method using a Spectrophotometer at a wavelength of 550 nm. Analyses of PM_{10} air ambient samples were conducted using the Digital Dust Indicator (DDI). The prevalence of ARI in children at various locations in the area.

The study's minimum sample size was fixed at 61 individuals. However, the final tally of participants reached 70. Utilizing an area-based sampling methodology (cluster sampling) in combination with quota sampling, the study selected 70 participants from each location. To be eligible for inclusion, respondents had to be toddlers who were either male or female, aged between 2 and 5 years, present at the health center during sampling, and their parents or guardians were permanent residents of the sampling area.

The 5 (five) most representative locations were chosen based on the location of the Puskesmas. These locations were Puskesmas Kiaracondong, Puskesmas Ujungberung Indah, Puskesmas Puter, Puskesmas Riung Bandung, and Puskesmas Caringin. To be included in the study, participants had to be infants aged 2 to 5 years, male or female, visiting a health center at the time of sampling, and permanent residents of the sampling area. The independent variables in this study were the NO_2 and PM_{10} levels, and the dependent variable was the incidence of acute respiratory infections (ARI) in toddlers in Bandung City. The statistical analysis of data used in this study was the Chi-Square test to determine whether there was a relationship between NO_2 and PM_{10} concentrations and the incidence of ARI disease in Bandung City.

RESULTS

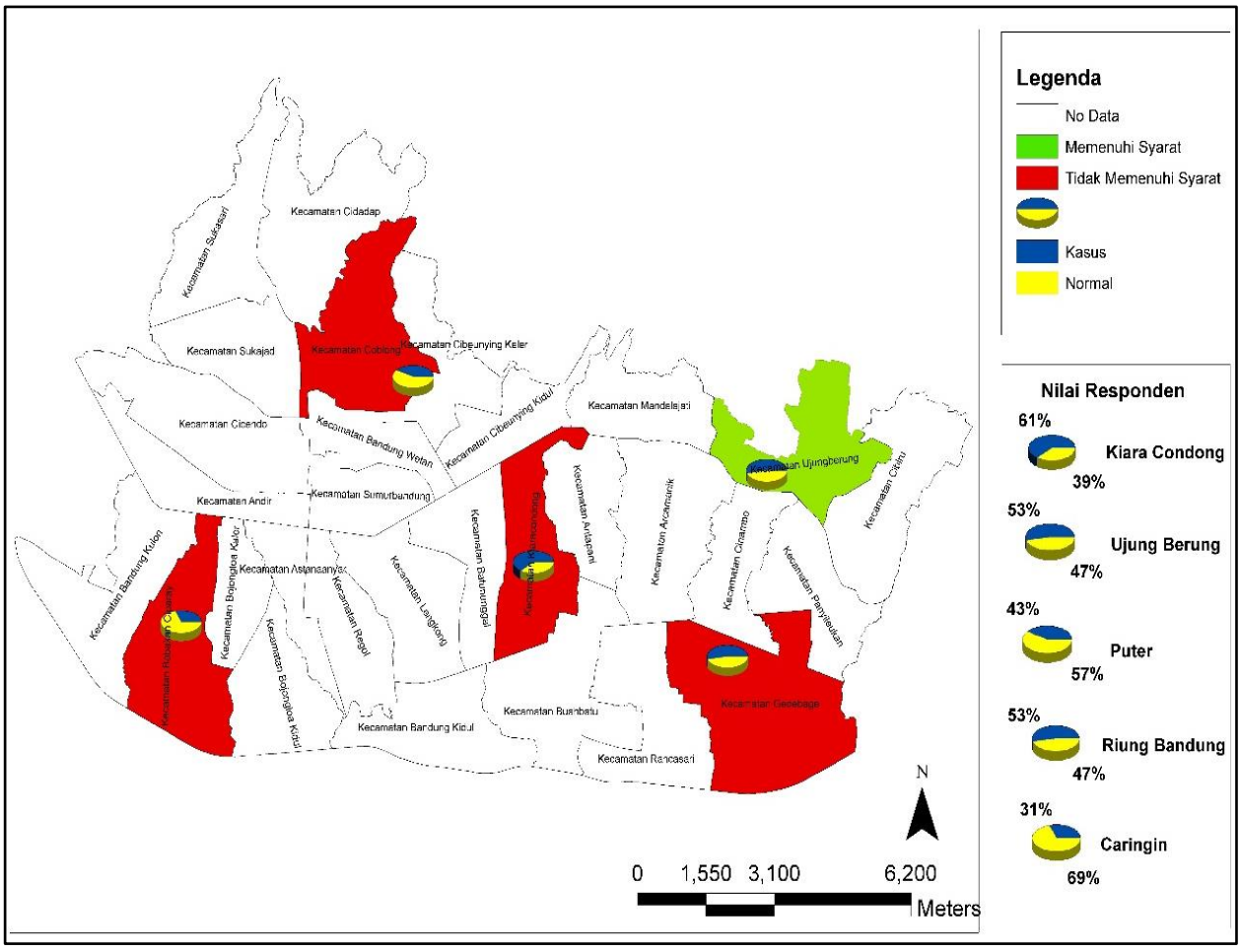
The analysis of air parameters revealed NO_2 levels ranging from 0.038 mg/m^3 at PKM Ujungberung to 0.127 mg/m^3 at PKM Kiaracondong, with an average of 0.07 mg/m^3. The PM_{10} levels, the range was between 0.20 µg/m^3 at PKM Caringin and 0.43 µg/m^3 at PKM Puter, with an average of 0.342 µg/m^3. The health center that met the requirements was PKM Ujungberung. The incidence of ARI was determined by the examination/diagnosis of doctors at 5 Puskesmas in Bandung city. Out of 350 respondents, 166 (47.4%) were sick with ARI and 168 (52.6%) were not sick with ARI.

Table 1. below displays the connection between levels of NO_2 and PM_{10} and the occurrence of ARI in toddlers. Of the 182 respondents, 79 (43.4%) were affected by ARI at locations with air quality exceeding the Threshold Value for NO_2, while 103 (56.6%) were not sick. The Chi-square test yielded a p-value of 0.144, indicating no association between NO_2 levels and ARI incidence in toddlers in Bandung City. Among the 182 respondents, 107 (64.5%) were affected by ARI at locations with air quality exceeding the threshold value for PM_{10}, while 59 (35.5%) were not sick. The Chi-square test produced a p-value of 0.132, indicating no relationship between PM_{10} levels and ARI incidence in toddlers in Bandung City.

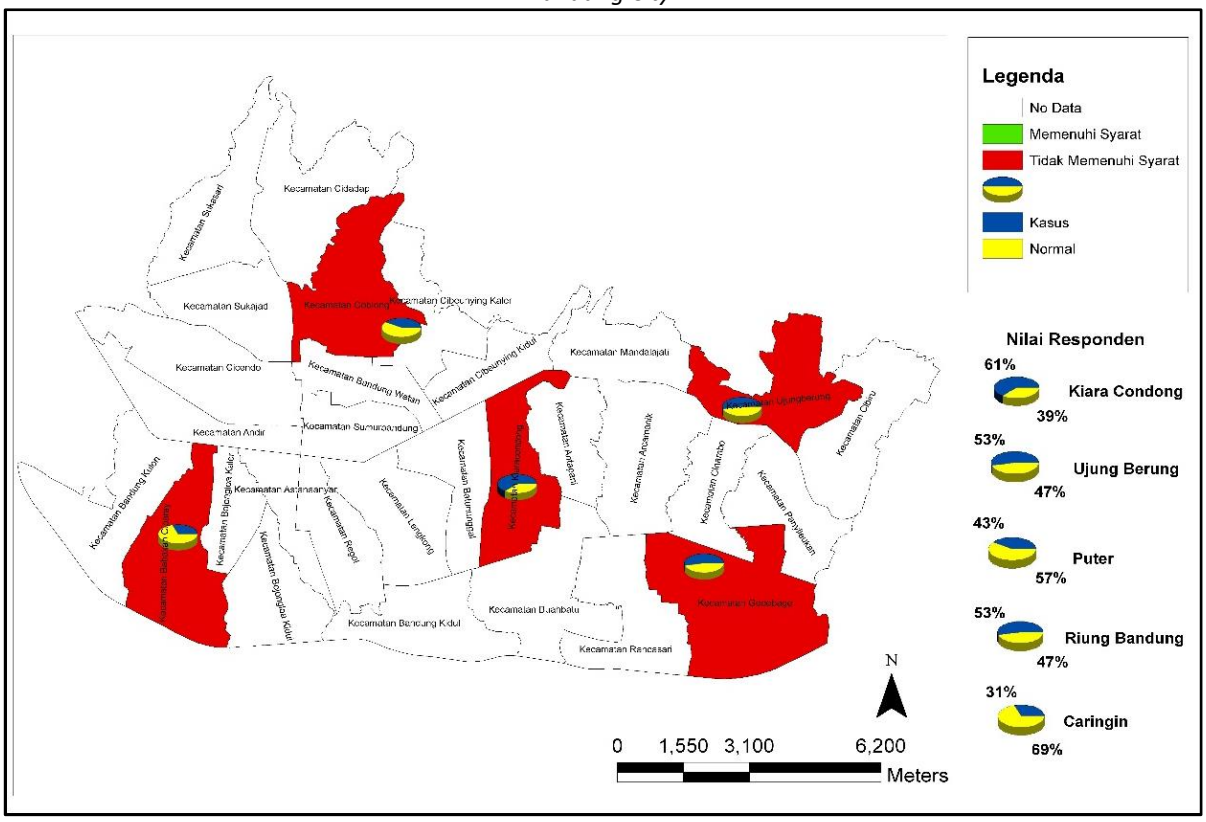
Table Relationship between NO_2 and PM_{10} Levels and the Incidence of ARI Disease in Toddlers in Bandung City

Parameter Analysis		ARI Screening Results				Chi-Square Analysis
		ARI	%	No ARI	%	
NO_2	Not eligible	79	43.4	103	56.6	$X^2 = 2.462$ and p = 0.144
	Eligible	87	51.8	81	48.2	RP (95% CI) = 0,714 (0,469 – 1,088)
PM_{10}	Not eligible	107	64.5	59	35.5	$X^2 = 2.273$ and p = 0.132
	Eligible	103	56.0	81	44.0	RP (95% CI) = 1.426 (0.927 – 2.195)

The spatial analysis reveals an uneven distribution of NO_2 levels across the city. Although the air quality for NO_2 levels in the Ujungberung Health Center working area meets the requirements, the incidence of ARI disease in children under five in this area (53%) exceeds that of the Puskesmas Puter (43%) and Caringin (31%) working areas. The distribution of PM_{10} levels is uniform throughout Bandung City, with the highest incidence of ARI among children under five in the Kiara Condong Health Center working area (61%) and the lowest in the Caringin Health Center working area (31%). As a result, there is no significant relationship between the presence of PM_{10} and NO_2 in the air and the incidence of ARI disease in toddlers in the Bandung City area. The findings of the spatial analysis are illustrated in Figure 1 and Figure 2.



Picture 1. Map of NO_2 Concentration Distribution in Bandung City Area



Picture 1. Map of PM_{10} Concentration Distribution in Bandung City Area

DISCUSSION

The one-sample Kolmogorov-Smirnov test results for NO_2 revealed a p-value of 0.948, which is greater than the significance level of 0.05, indicating that the distribution of data on NO_2 levels is normal or that air pollution caused by NO_2 is evenly distributed throughout the city of Bandung. The p-value for PM_{10} was 0.680, which is also greater than 0.05, suggesting the same conclusion. These findings are partly influenced by the local meteorological, climatic, and weather conditions. The chi-square test results for meteorological factors showed that temperature, air humidity, air pressure, and wind speed were all significant at $p < 0.05$. The geographical, topographical, and stratigraphic conditions of the Bandung Basin, which is surrounded by mountains and mountain ranges, play a unique role in the accumulation of exhaust gases from pollution sources in the area. The unique climate and atmospheric dynamics in the Bandung Basin contribute to the buildup of air pollution and impact air quality in general. Locations with air pollution concentrations that exceed the established threshold values can also have significant impacts on public health and other living things.

The swift growth of Bandung City has led to a transformation in urban land use and a blending of urban space utilization. The size of green land in the city center has decreased significantly, being replaced by building land. According to Driejana's (1990) research, transport processes have a substantial impact on particulate concentrations in Bandung. The detection of certain particulate fractions suggests that transport processes are involved. These particles often accumulate in poorly ventilated airspaces, such as mountains, backflow, and inverse temperature, indicating a potential for pollutant accumulation.

The study found that among the 179 respondents who were affected by ARI disease at the location of the Puskesmas, 79 (43.4%) had air quality with NO_2 levels exceeding the threshold value, while 103 (56.6%) were not sick with ARIs. The chi-square test yielded a p-value of 0.144, indicating that there was no significant relationship between NO_2 levels and the incidence of ARI in toddlers in Bandung City. This finding contrasts with the research conducted by Wahyono B. (2007), which found that PM_{10} ($p = 0.000$) and NO_2 ($p = 0.000$) were associated with the incidence of ARI disease in toddlers. However, the study suggests that NO_2 in the air may still have a potential influence on the incidence of ARI disease in toddlers in Bandung City ($p < 0.25$).

NO_2 is particularly harmful to the respiratory system, and exposure to levels higher than 100 parts per million (ppm) can result in fatal consequences. Animal studies have demonstrated that concentrations above 800 ppm can cause 100% mortality within 29 minutes or less. Exposure to 5 ppm for 10 minutes can cause breathing difficulties, while concentrations between 50 and 100 ppm can lead to lung inflammation within a few minutes of exposure. The severity of the effects depends on the dose and duration of exposure, as noted by Slamet (2000). Concentrations of 150 to 200 ppm can cause bronchiolitis fibrosis obliterans, which can be fatal within 3 to 5 weeks of exposure, while concentrations over 500 ppm can be lethal within 2 to 10 days.

The findings indicate that among the 107 respondents who did not suffer from ARI, 59 of them had been exposed to PM_{10} levels exceeding the Threshold Value at Puskesmas locations.

Conversely, 64.5% of the respondents who were affected by ARI had been exposed to such air quality conditions. The chi-square test yielded a p-value of 0.132, suggesting that there was no significant relationship between PM10 levels and the incidence of ARI in toddlers in Bandung City.

The findings of Wahyono B.'s (2007) research suggest that the concentration of air parameters associated with the incidence of ARI disease in toddlers in Bandung Wetan is PM_{10} ($p = 0.000$) and NO_2 ($p = 0.000$). However, it is possible to infer that PM_{10} in the air has the potential to influence the incidence of ARI disease in toddlers in Bandung City ($p < 0.25$).

Inhalation is the sole exposure route of concern in the link between PM_{10} and health issues, including ARI, in toddlers. However, other hazardous compounds, such as Pb, are attached to particulates. Particulates larger than 5 µm are primarily trapped in the nose and throat, with some entering the lungs but never progressing past the air sacs or bronchi and being expelled by cilia vibrations. Particles ranging from 0.5 to 5 µm in size can be collected in the lungs up to the bronchioli, and a small portion reaches the alveoli. Most of the particles collected in the bronchioli are expelled by cilia within 2 hours. Particles smaller than 0.5 µm in diameter can reach and remain in the alveoli.

CONCLUSIONS

The findings from the examination of NO_2 and PM_{10} air parameters at five public health centers in Bandung City reveal a range in NO_2 levels from 0.038 mg/m^3 at PKM Ujungberung to 0.127 mg/m^3 at PKM Kiaracondong, with an average of 0.07 mg/m^3. Similarly, the PM_{10} levels exhibit a range from 0.20 µg/m^3 at PKM Caringin to 0.43 µg/m^3 at PKM Puter, with an average level of 0.342 µg/m^3. It should be noted that PKM Ujungberung is the only health center that meets the requirements for both parameters.

The prevalence of ARI among 350 toddlers with ARI status was discovered to be 166 (47.4%), while the remaining 168 (52.6%) were unaffected. It was observed that there was no correlation between PM_{10} levels and the incidence of ARI in children under five years of age in Bandung City, as indicated by the Chi-square test's p-value of 0.132. Additionally, there was no relationship found between NO_2 levels and the occurrence of ARI among children under five years of age in Bandung City, as demonstrated by the Chi-square test's p-value of 0.144.

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REFERENCES

A.W. Gertler, J. A. Gillies and W. R. Pierson. An Assessment of The Mobile Source Contribution to PM10 and PM2.5 In The United States. Water, Air, and Soil Pollution Journal Kluwer Academic Publishers 2000; 123:203–214.

Caroline Meyer, Daniel Gilbert, André Gaudry at all. Relationship of Atmospheric Pollution Characterized by Gas (NO_2) and particles (PM_{10}) with microbial communities living in bryophytes at three different polluted sites (Rural, Urban, and Industrial, Microbiology Ecology Springer Science Journal 2010; 59:324–334.

Chang Keung, Chan Hoi Ho, Ro Kjun at all. Spatial and Seasonal Variations of Surface PM_{10} Concentration and MODIS Aerosol Optical Depth Over China., Asia Pacific Journal of Atmospheric Science 2009; 45:33 – 43.

Christer Johansson, Michael Norman, Lars Gidhagen. Spatial and Temporal Variations of PM_{10} and Particle Number Concentrations in Urban Air. Environmental Monitoring Assessment Springer Science Journal 2007; 127:477–487.

Fran, Te, Effect Temperature and Pollution on Cardiovascular and Respiratory Disease for Males and Females Older than 65 Years of Age in

Tokyo July and August 1980-1995, Environmental Health Perspective Journal of the National Institute of Environmental Health Sciences. USA 2001; 109 (4) : 335 - 361.

Dinas Kesehatan Kota Bandung. Profil Kesehatan Kota Bandung Tahun 2009.

Depkes R.I., Pedoman Pemberantasan Penyakit Infeksi Saluran Pernafasan Akut Untuk Penanggulangan Pneumonia Pada Balita, Ditjen PPM-PLP Jakarta 2002.

Driejana, Pencemaran Udara di Kota Bandung Mencemaskan, Jurnal Informasi Lingkungan, BPLHD Jabar, 2003.

Fardiaz S. Polusi Air dan Udara, Kanisius Yoyakarta 1992.

Hamzah Hasyim. Manajemen Penyakit Lingkungan Berbasis Wilayah. Jurnal Manajemen Pelayanan Kesehatan, 2008; Volume II, No. 2 Juni : 72 – 76.

Soedomo Moestikahadi. Kumpulan Karya Ilmiah Mengenai Pencemaran Udara. Penerbit ITB Bandung 2001.

Murti B., Prinsip dan Metode Riset Epidemiologi. Gajah Mada University Press, Yogyakarta 2003.

Soemirat, Juli. Epidemiologi Lingkungan. Gajah Mada University Press, 2000.

Wakhyono B., Analisis Hubungan Kualitas Udara Ambien dengan Kejadian Penyakit ISPA (Tesis). UI 2008.