

Exposure to Industrial Air Pollutants and Respiratory Health School and Home Exposure among Primary School Children in Kemaman, Terengganu.

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Abstract--- Exposure to air pollution leads to a wide range of acute and chronic airways effects. Compared adults, children are particularly at risk due to the immaturity of their respiratory organ systems. This study is intended to determine the exposure of Industrial Air Pollutants (PM₁₀, PM_{2.5}, NO₂, SO₂ and VOCs) and its association with respiratory symptoms among Primary School Children in industrial and non-industrial area at Kemaman, Terengganu. A cross-sectional comparative study was carried out among Malay primary school children in Kemaman, Terengganu. A standardized set of questionnaire are adapted from the American Thoracic Society (ATS) and International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire were used to obtain the background information, exposure history and respiratory symptoms of the respondents. Indoor air quality assessments were conducted in each primary school and homes using several indoor air monitoring instruments includes DustTrak DRX Aerosol Monitor 8534, Air Sampling Pump, PbbRAE Portable VOC Monitor (pbbRAE 3000), LaMotte Air Sampling Pump, Q-TrakPlus Model 8554 Monitor and TSI VelocicalcPlus Model 8386. The median and interquartile range of concentration of PM₁₀, PM_{2.5}, NO₂, SO₂ and VOCs in classrooms and homes of exposed group was higher than the values in comparative group at $p < 0.001$. Respiratory symptoms show a significant difference between exposed and comparative group at $p < 0.001$. The reported respiratory symptoms were based on the questionnaire that fulfil by their parents. Data collected was analysed using Statistical Package for Science (SPSS) Version 21. This study showed that the exposure to industrial air pollutants increased the risk of getting respiratory tract symptoms among primary school children living near industry area.

Keywords: Industrial Air Pollutants, PM₁₀, PM_{2.5}, NO₂, SO₂, VOCs, Primary School Children, Respiratory Symptoms

Introduction

Nowadays the abrupt growth of factories and facilities in Malaysia is a key to a growing and profitable economy, but it is also bringing up a health issue regarding adverse health effects through the release of malodorous air pollutants and other environmental pollution. Industrial emission which is a stationary source of air pollution is the second largest (20-25%) contributor of air pollution in Malaysia, which includes factories and energy plants [1]. Exposures to industrial air pollutants have been associated with respiratory symptoms and asthma exacerbations in children. Many health effects due to air pollution have been reported in various research studies over the past 30 years [2,3]. Short term exposure to these pollutants may cause respiratory problems such as cough and chest tightness. On the other hand, long term exposure to these pollutants remains largely unknown and thus, leaving a gap for more studies to be conducted on this matter.

Primary school children were chosen as study subjects in order to focus more towards early disease prevention. It is because of most of the times school children are resided in the same area in which they are attended their primary school all day, five days a week attending their curriculum and cocurriculum activities.

Children are particularly vulnerable due to their respiratory organ systems that are still growing, despite inhaling a larger volume of air per body weight. Children

are at risk of exposure because there are residential areas and schools near the industrial areas. Children might be

more likely to be affected by air pollutants, as their airways are smaller in diameter [4].

The purpose of this study is to determine association between PM₁₀, PM_{2.5}, NO₂, SO₂ and VOCs with respiratory tract symptoms among primary school children at industrial area in Kemaman, Terengganu for some reasons of significant findings of association between industrial air pollutants with prevalence of respiratory health symptoms by previous studies [2, 3]. The importance of this study will either indirectly or directly help to increase the awareness of the community regarding the risk of exposure towards industrial air pollutants which can later cause many respiratory health symptoms and illnesses. This later is also expected to provide supportive information or data to help developers or any related agencies to prepare a better development plan or control measures if there is a threat towards people nearby the area of petrochemical industries area.

Materials and Methods

Study Design

The cross sectional comparative study was carried out among male and female primary school children with the aim to determine the respiratory tract symptoms among primary school children in primary schools located near industrial area under the exposures of Particulate Matter less than 10 micrometers (PM₁₀) and 2.5 micrometers (PM_{2.5}), Sulphur Dioxide (SO₂), Nitrogen Dioxide (NO₂) and Volatile Organic Compounds (VOCs).

Study Location

The study location was the schools located within zone of impact of 5 km radius [5] from centre of industrial area in Kemaman, Terengganu. For the comparative group, schools located outside 5 km radius from centre of industrial area were chosen.

Sampling Technique

A total of 204 male and female primary school children aged 11 years old were randomly selected from schools in Kemaman, Terengganu. Random sampling method was used to select the respondents with inclusion criteria of; healthy from asthma and any upper respiratory illness and Malay ethnicity. Exclusion criteria were also considered; primary school children who did not get the approval or consent letters from parents.

Instruments and Procedures

The standard established questionnaire adapted from American Thoracic Society, "Questionnaire ATS-DLD-C WHO" for children [6] were used in order to determine the socio-demographic, respiratory health symptoms and history of exposure. The pre-test of questionnaires of 10% out of sample size was done prior to data collection.

Period of 5 hours sampling time during school session were used to measure the concentration of the indoor PM_{2.5}, NO₂, SO₂, and VOCs in selected school and houses. The indoor air quality monitoring instruments used in this study includes TSI8520 DustTrak Airborne Particles Monitor for PM_{2.5}, PbbRAE Portable VOC Monitor (PbbRAE 3000) for VOCs, and LaMotte Portable Air Sampling Pump for NO₂, and SO₂. The instruments were placed at a height of 1.0 m above the floor [7], approximately to the children breathing zone level. A distance of at least 1 metre away from any active heating system, wall, doors, and windows were ensured.

All the instruments, whenever possible were placed at the back of the classroom to avoid distraction of learning session and to lessen attraction of the students so that the result is reliable. The measurement of air velocity, temperature and humidity were taken periodically and spread throughout many points within the classrooms to ensure even distribution. The measurement of indoor air pollutants at homes was carried out under consideration of voluntary basis. The principle of sampling method was the same as the measurement in school.

Statistical analysis

Comparison between groups of study for the concentration of air pollutants, prevalence of respiratory symptoms and association between the concentration of air pollutants and respiratory symptoms was tested with Mann-Whitney U, Chi- Square and Fisher's Exact Test. The p-value of less than 0.05 was considered

statistically significant and all analyses were carried out using Statistical Package of Social Sciences (SPSS) version 21.

Results

Comparison of Air Pollutants at Schools and Homes

Exposure monitoring of air pollutants inside children's classrooms in their schools was done using specific equipment during school session. The parameters for air pollutants were PM₁₀, PM_{2.5}, NO₂, SO₂ and VOCs. The data were not normally distributed, thus the results were compared using Mann-Whitney U test. The results are tabulated in Table 1 and it was found that the concentration of air pollutants were higher among the exposed group for each pollutant compared to the comparative group at p < 0.001. For homes measurements, results in Table 2 show that the concentration of air pollutants were higher among the exposed group for each pollutant compared to the comparative group at p < 0.001.

Table 1: Concentration of Air Pollutants in Schools

| Variables | Exposed Group | Comparative Group | z | p |
|---|-----------------|-------------------|---------|---------|
| | Median (IQR) | Median (IQR) | | |
| PM ₁₀ (µg/m ³) | 116.00 (39.00) | 53.00 (24.00) | -11.333 | <0.001* |
| PM _{2.5} (µg/m ³) | 94.00 (39.00) | 48.00 (22.00) | -11.762 | <0.001* |
| SO ₂ (µg/m ³) | 331.46 (100.49) | 123.79 (129.60) | -12.344 | <0.001* |
| NO ₂ (µg/m ³) | 220.04 (56.61) | 22.60 (22.45) | -12.357 | <0.001* |
| VOCs (ppm) | 0.25 (0.53) | 0.07 (0.32) | -3.168 | <0.001* |
| N = 204, Significant at p<0.05* | | | | |

Table 2: Concentration of Air Pollutants in Homes

| Variables | Exposed Group | Comparative Group | z | p |
|---|----------------|-------------------|---------|---------|
| | Median (IQR) | Median (IQR) | | |
| PM ₁₀ (µg/m ³) | 90.00 (55.00) | 63.00 (25.00) | -4.870 | <0.001* |
| PM _{2.5} (µg/m ³) | 70.00 (36.00) | 51.00 (16.00) | -4.455 | <0.001* |
| SO ₂ (µg/m ³) | 165.14 (83.12) | 41.95 (83.00) | -10.223 | <0.001* |
| NO ₂ (µg/m ³) | 165.50 (39.66) | 57.60 (57.80) | -10.109 | <0.001* |
| VOCs (ppm) | 0.71 (4.21) | 0.04 (0.58) | -3.840 | <0.001* |
| N = 204, Significant at p<0.05* | | | | |

Prevalence of Respiratory Health Symptoms

Respiratory symptoms in this study were reported by parents or guardians using the standardised questionnaire adapted from ATS and ISAAC. The parameters for respiratory symptoms were cough, phlegm, wheezing and chest tightness.

Prevalence of cough was found among 57 respondents from exposed and 31 respondents from comparative group. Chi-Square test was performed to evaluate whether the difference in cough has a relationship with the respondents. It is shown that there was a significant difference in reported cough for both groups at $p=0.035$, $p<0.05$, $PR=1.712$ (95% $CI=1.04-2.83$). Prevalence of phlegm was found among 31 respondents from exposed and 13 respondents from comparative group. Chi-Square test was performed to evaluate whether the difference in phlegm has a relationship with the respondents. It is shown that there was a significant difference in reported phlegm for both groups at $p=0.029$, $p<0.05$, $PR=2.126$ (95% $CI=1.07-4.23$).

Prevalence of wheezing was found among 25 respondents from exposed and 10 respondents from comparative group. Chi-Square test was performed to evaluate whether the difference in wheezing has a relationship with the respondents. It is shown that there was a significant difference in reported wheezing for both groups at $p=0.041$, $p<0.05$, $PR=2.193$ (95% $CI=1.02-4.72$). Prevalence of chest tightness was found among 8 respondents from exposed and 3 respondents from comparative group. Fisher's Exact test was performed to evaluate whether the difference in chest tightness has a relationship with the respondents. It is shown that there was no significant difference in chest tightness for both groups at $p<0.05$.

Association between Concentration of Air Pollutants and Respiratory Symptoms

The association between concentration of PM_{10} at schools with respiratory symptoms among studied respondents for cough ($p=0.010$, $PR=2.33$, 95% $CI=1.21-4.94$) and wheezing ($p=0.019$, $PR=3.345$, 95% $CI=1.17-9.58$). Chi-square and Fisher's Exact test show significant association between cough and wheezing with the concentration of PM_{10} at schools.

The association between concentration of $PM_{2.5}$ at schools with respiratory symptoms among studied respondents for cough ($p=0.008$, $PR=2.435$, 95% $CI=1.25-4.76$). Chi-square and Fisher's Exact test show significant association between cough with the concentration of $PM_{2.5}$ at schools.

The association between concentration of SO_2 at schools with respiratory symptoms among studied respondents for cough ($p=0.010$, $PR=2.333$, 95% $CI=1.21-4.49$); wheezing ($p=0.005$, $PR=4.558$, 95% $CI=1.47-14.16$) and phlegm ($p=0.021$, $PR=2.530$, 95% $CI=1.13-5.66$). Chi-square and Fisher's Exact test show significant association between cough, wheezing and phlegm with the concentration of SO_2 at schools.

The association between concentration of NO_2 at schools with respiratory symptoms among studied respondents for cough ($p=0.010$, $PR=2.333$, 95% $CI=1.21-4.49$) and wheezing ($p=0.005$, $PR=4.558$, 95% $CI=1.47-14.16$). Chi-square and Fisher's Exact test show significant association between cough and wheezing with the concentration of NO_2 at schools. There was no

significant difference in reported phlegm and chest tightness with NO_2 in schools.

The association between concentration of SO_2 at home with respiratory symptoms among studied respondents for cough ($p=0.029$, $PR=2.262$, 95% $CI=1.08-4.75$). Chi-square and Fisher's Exact test show significant association between cough with the concentration of SO_2 at home.

The association between concentration of NO_2 at schools with respiratory symptoms among studied respondents for cough ($p=0.018$, $PR=2.400$, 95% $CI=1.15-5.00$). Chi-square and Fisher's Exact test show significant association between cough with the concentration of NO_2 at home. There was no significant difference in reported wheezing, phlegm and chest tightness with NO_2 in home.

Discussion

Comparison of Air Pollutants at Schools and Homes

The distance of primary schools' location from the industrial area might have contributed to the higher concentration of the particulates and gases as there was a significant difference in concentration of PM_{10} , $PM_{2.5}$, NO_2 , SO_2 and VOCs inside the different classrooms of selected schools of exposed and comparative group.

The median and interquartile range of PM_{10} in classrooms for exposed and comparative group was (116.00 ± 39.0) $\mu\text{g}/\text{m}^3$ and (53.00 ± 24.0) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 81.0 to 163.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 39.0 to 90.0 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of PM_{10} in classrooms was significantly different for both groups at $p<0.001$ with $z = -11.333$. The concentration of PM_{10} was referred to the national standard set by the Malaysian Ambient Air Quality Standard [8] for 24- hours ($150 \mu\text{g}/\text{m}^3$) and annual ($50 \mu\text{g}/\text{m}^3$). It was suggested that the exposure of the exposed group towards the concentration of PM_{10} was higher as compared to comparative and standards mentioned above.

The median and interquartile range of $PM_{2.5}$ in classrooms for exposed and comparative group was (94.00 ± 39.0) $\mu\text{g}/\text{m}^3$ and (48.00 ± 22.0) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 76.0 to 129.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 35.0 to 81.0 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of $PM_{2.5}$ in classrooms was significantly different for both groups at $p<0.001$ with $z = -11.762$. Since there was no national standard established for indoor $PM_{2.5}$, the concentration of indoor $PM_{2.5}$ was referred to the international standard set by the US Environmental Protection Agency [9] for 24-hours ($35 \mu\text{g}/\text{m}^3$) and annual ($12 \mu\text{g}/\text{m}^3$). It was suggested that the exposure of the exposed group towards the concentration of $PM_{2.5}$ was higher as compared to comparative and standards mentioned above.

The median and interquartile range of SO_2 in classrooms for exposed and comparative group was (331.46 ± 100.5) $\mu\text{g}/\text{m}^3$ and (123.79 ± 129.6) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 250.9 to 497.4 $\mu\text{g}/\text{m}^3$ for exposed group, and 0.0 to 234.4 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of SO_2 in classrooms was significantly different for both groups at $p<0.001$ with $z = -12.344$. According to national standard of Malaysian Air Quality

Guidelines for 1-hour exposure (350 $\mu\text{g}/\text{m}^3$) and 24-hours (105 $\mu\text{g}/\text{m}^3$) [8], it was suggested that the exposed group was exposed to higher concentration of indoor SO_2 as compared to comparative group and Malaysian Air Quality Guidelines.

The median and interquartile range of NO_2 in classrooms for exposed and comparative group was (220.04 \pm 56.6) $\mu\text{g}/\text{m}^3$ and (22.60 \pm 22.5) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 185.8 to 384.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 0.0 to 155.1 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of NO_2 in classrooms was significantly different for both groups at $p < 0.001$ with $z = -12.357$. According to national standard of Malaysian Air Quality Guidelines for 1-hour exposure (320 $\mu\text{g}/\text{m}^3$) and 24-hours (75 $\mu\text{g}/\text{m}^3$) [8], it was suggested that the exposed group was exposed to higher concentration of indoor SO_2 as compared to comparative group and Malaysian Air Quality Guidelines.

Other than that, the measured data of VOCs concentration shows significantly higher concentration in exposed group (0.200 ppm) as compared to comparative group (0.080 ppm). Those statistical data reported above suggested that the concentration of PM_{10} , $\text{PM}_{2.5}$, SO_2 , NO_2 , and VOCs were significantly higher in school of exposed group which was located near industrial area as compared to school of comparative group.

Exposure monitoring of air pollutants inside children's residences was done using specific equipment outside school session. The parameters for air pollutants were PM_{10} , $\text{PM}_{2.5}$, SO_2 , NO_2 and VOCs. The data were not normally distributed, thus the results were compared using Mann-Whitney U test. It was found that the concentration of air pollutants were higher among the exposed group for each pollutant compared to the comparative group.

The median and interquartile range of PM_{10} in residences for exposed and comparative group was (90.00 \pm 55.0) $\mu\text{g}/\text{m}^3$ and (63.00 \pm 25.0) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 42.0 to 180.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 34.0 to 170.0 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of PM_{10} in residences was significantly different for both groups at $p < 0.001$ with $z = -4.870$.

The median and interquartile range of $\text{PM}_{2.5}$ in residences for exposed and comparative group was (70.00 \pm 36.0) $\mu\text{g}/\text{m}^3$ and (51.00 \pm 16.0) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 31.0 to 180.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 27.0 to 121.0 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of $\text{PM}_{2.5}$ in residences was significantly different for both groups at $p < 0.001$ with $z = -4.455$.

The median and interquartile range of SO_2 in residences for exposed and comparative group was (165.14 \pm 83.1) $\mu\text{g}/\text{m}^3$ and (41.95 \pm 83.0) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 0.0 to 254.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 0.0 to 124.5 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median concentration of SO_2 in residences was significantly different for both groups at $p < 0.001$ with $z = -10.223$.

The median and interquartile range of NO_2 in residences for exposed and comparative group was (165.50 \pm 39.7) $\mu\text{g}/\text{m}^3$ and (57.60 \pm 57.8) $\mu\text{g}/\text{m}^3$ respectively. The concentration ranged between 0.0 to 188.0 $\mu\text{g}/\text{m}^3$ for exposed group, and 0.0 to 145.2 $\mu\text{g}/\text{m}^3$ for comparative group. In addition, distribution of median

concentration of NO_2 in residences was significantly different for both groups at $p < 0.001$ with $z = -10.109$.

Other than that, the measured data of VOCs concentration shows significantly higher concentration in exposed group (0.610 ppm) as compared to comparative group (0.040 ppm). Those statistical data reported above suggested that the concentration of PM_{10} , $\text{PM}_{2.5}$, SO_2 , NO_2 , and VOCs were significantly higher in residences of exposed group which was located near industrial area as compared to residences of comparative group.

Previous study by Tezara et al. [10] also found that the concentration of indoor PM_{10} in day care centers was almost similar to the mean concentration of indoor PM_{10} in areas near the main road and industrial area (69.8 $\mu\text{g}/\text{m}^3$ and 68.8 $\mu\text{g}/\text{m}^3$, respectively) and slightly lower in day care centers in residential area. A study done by Ayuni et al. [3] found out that the concentration of indoor $\text{PM}_{2.5}$ and NO_2 in primary schools located in industrial area (79.00 $\mu\text{g}/\text{m}^3$ and 3.730 ppm respectively) were higher than comparative area (49.00 $\mu\text{g}/\text{m}^3$ and 0.140 ppm respectively).

Another study conducted by Noor Hisyam and Juliana [2] found higher median (IQR) concentration of indoor $\text{PM}_{2.5}$ at 75.00(47.00) $\mu\text{g}/\text{m}^3$ and NO_2 at 0.140(0.140) ppm in preschools at industrial area as compared to sub-urban area 65.00(84.00) $\mu\text{g}/\text{m}^3$ and 0.000(0.000) ppm respectively and the study conducted by Anis Syafiqah et al., [11] also revealed that the mean of indoor PM_{10} and VOCs in the exposed area was higher (325.6 \pm 4.3) and (0.11 \pm 0.001) compared to the comparative group (123.7 \pm 3.9) and (0.07 \pm 0.002). Mann-Whitney U Test found a significant difference between the levels of indoor PM_{10} and VOCs in both study areas ($Z = -8.861$, $p < 0.001$) and ($Z = -8.915$, $p < 0.001$).

A study done by ArasyiYahya and Juliana Jalaludin also [12] also revealed that indoor PM_{10} level at home is higher in urban area with mean (76.61 \pm 17.53 $\mu\text{g}/\text{m}^3$) compared to rural area (48.37 \pm 8.33 $\mu\text{g}/\text{m}^3$). Indoor concentration of VOC indicates a significant difference ($p < 0.001$) between urban 0.083 ppm and rural area 0.035 ppm.

All those studies mentioned above are consistent with the findings and hypothesis of this study that the location of primary schools or schools contributes to the concentration of the indoor PM_{10} , $\text{PM}_{2.5}$, NO_2 , SO_2 , and VOCs.

Prevalence of Respiratory Health Symptoms

The prevalence of respiratory health symptoms among respondents for each exposed and comparative group was assessed using standardized questionnaire adapted from American Thoracic Society Questionnaire ATS-DLC-78-C and International Study of Asthma and Allergies in childhood (ISAAC) questionnaires. Respondents' parents were required fill in the questionnaires for the respondents. Prevalence of respiratory health symptoms was then assessed from the returned questionnaires.

Prevalence of cough was found among 57 respondents (30.3%) from exposed and 31 respondents (20.3%) from comparative group. Chi-Square test was performed to evaluate whether the difference in cough has a relationship with the respondents. It is shown that there was a significant difference in reported cough for both groups at $p = 0.035$, $p < 0.05$, $PR = 1.712$ (95% $CI = 1.04-2.83$). Prevalence of phlegm was found among

31 respondents (16.5%) from exposed and 13 respondents (8.5%) from comparative group. Chi-Square test was performed to evaluate whether the difference in phlegm has a relationship with the respondents. It is shown that there was a significant difference in reported phlegm for both groups at $p=0.029$, $p<0.05$, $PR=2.126$ (95% $CI=1.07-4.23$).

Prevalence of wheezing was found among 25 respondents (13.3%) from exposed and 10 respondents (6.5%) from comparative group. Chi-Square test was performed to evaluate whether the difference in wheezing has a relationship with the respondents. It is shown that there was a significant difference in reported wheezing for both groups at $p=0.041$, $p<0.05$, $PR=2.193$ (95% $CI=1.02-4.72$). Prevalence of chest tightness was found among 8 respondents (4.3%) from exposed and 3 respondents (2.0%) from comparative group. Fisher's Exact test was performed to evaluate whether the difference in chest tightness has a relationship with the respondents. It is shown that there was no significant difference in chest tightness for both groups at $p<0.05$.

Study by Ayuni et al. [3] revealed that reported respiratory health symptoms were significantly higher among the exposed children, which were 5 times more likely to get cough ($PR = 5.09$, 95% $CI = 2.23-11.65$), and 9 times more likely to get phlegm ($PR = 9.66$, 95% $CI = 2.10-44.46$), chest tightness ($PR = 9.08$, 95% $CI = 1.09-75.0$) and wheezing ($PR = 9.07$, 95% $CI = 1.89-25.2$) compared to comparative group. Other than that, study by Aida et al. [4] stated that, the self-reported numbers of respiratory symptoms (cough, phlegm, and chest tightness) were higher among urban area children compared to rural area children. Only wheezing was reported to be higher among rural area children compared to urban area children. Even though the data collected were only based on questionnaire feedbacks without further carrying out clinical test, parents and teachers were given instructions on how to complete the questionnaire before filling them in. Next, a study done by ArasyiYahya and Juliana Jalaludin also showed that respiratory symptoms which include cough ($p<0.001$), phlegm ($p<0.001$) and wheezing ($p<0.001$) were significantly higher among children in urban area compared to those in the rural area [12].

Association between Concentration of Air Pollutants and Respiratory Symptoms

PM_{10} concentration in schools were categorised into high for $87 \mu\text{g}/\text{m}^3$ and above, and low for less than $87 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with PM_{10} concentration in schools. It is shown that there was no significant association in reported respiratory symptoms for PM_{10} in schools except for cough at $p=0.010$, $p<0.05$, $PR=2.333$ (95% $CI=1.21-4.49$) and wheezing at $p=0.019$, $p<0.05$, $PR=3.345$ (95% $CI=1.17-9.58$) suggested that the prevalence of children who were exposed to high level of PM_{10} having cough and wheezing was 2 times and three times higher than those who were less exposed.

$PM_{2.5}$ concentration in schools were categorised into high for $81 \mu\text{g}/\text{m}^3$ and above, and low for less than $81 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with $PM_{2.5}$ concentration in schools. It is shown that there was no significant association in reported respiratory symptoms

for $PM_{2.5}$ in schools except for cough at $p=0.008$, $p<0.05$, $PR=2.435$ (95% $CI=1.25-4.76$) suggested that the prevalence of children who were exposed to high level of $PM_{2.5}$ having cough was two times higher than those who were less exposed.

SO_2 concentration in schools were categorised into high for $243 \mu\text{g}/\text{m}^3$ and above, and low for less than $243 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with SO_2 concentration in schools. There were significant associations in reported respiratory symptoms for SO_2 in schools except chest tightness. Cough was significantly associated at $p=0.010$, $p<0.05$, $PR=2.333$ (95% $CI=1.21-4.49$). Phlegm was significantly associated at $p=0.021$, $p<0.05$, $PR=2.530$ (95% $CI=1.13-5.66$). Wheezing was significantly associated at $p=0.005$, $p<0.05$, $PR=4.558$ (95% $CI=1.47-14.16$) suggested that the prevalence of children who were exposed to high level of SO_2 having cough, phlegm and wheezing was two times and four times higher than those who were less exposed.

NO_2 concentration in schools were categorised into high for $170 \mu\text{g}/\text{m}^3$ and above, and low for less than $170 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with NO_2 concentration in schools. There was a significant difference in cough with NO_2 in schools at $p=0.010$, $p<0.05$, $PR=2.333$ (95% $CI=1.21-4.49$). Also, wheezing was significantly different with NO_2 in schools at $p=0.005$, $p<0.05$, $PR=4.558$ (95% $CI=1.47-14.16$) suggested that the prevalence of children who were exposed to high level of NO_2 having cough and wheezing was two times and four times higher than those who were less exposed. There was no significant difference in reported phlegm and chest tightness with NO_2 in schools.

For the residential area, SO_2 concentration were categorised into high for $84 \mu\text{g}/\text{m}^3$ and above, and low for less than $84 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with SO_2 concentration in residences. It is reported that there was no significant association in respiratory symptoms for SO_2 in residences except for cough at $p=0.029$, $p<0.05$, $PR=2.262$ (95% $CI=1.08-4.75$) suggested that the prevalence of children who were exposed to high level of SO_2 having cough was two times higher than those who were less exposed.

NO_2 concentration in residences were categorised into high for $59 \mu\text{g}/\text{m}^3$ and above, and low for less than $59 \mu\text{g}/\text{m}^3$. Chi-Square and Fisher's Exact test were performed to evaluate whether the difference in respiratory symptoms has a relationship with NO_2 concentration in residences. It is reported that there was no significant difference in respiratory symptoms for NO_2 in residences except for cough at $p=0.018$, $p<0.05$, $PR=2.400$ (95% $CI=1.15-5.00$) suggested that the prevalence of children who were exposed to high level of NO_2 having cough was two times higher than those who were less exposed.

According to Chua et al. [13], there were strong associations were reported between risk factors (particulate matter and volatile organic compounds) and respiratory effects among school children. A study done by Nazariah et al. [14] also showed a significant association between indoor PM_{10} and reported respiratory symptoms in urban area for cough ($OR=1.81$, CI

95%=1.18-2.79), phlegm (OR=2.45, CI 95%=1.42-4.24) and wheezing (OR=5.43, CI 95%=2.21-13.37).

A study done by Anis Syafiqah et al. [11] showed that results from statistical analysis show significant associations between PM₁₀ with cough, phlegm and chest tightness. Other than that, the results from statistical analysis also showed significant associations between VOCs with coughing and chest tightness. The children who are exposed to high indoor concentration of VOCs were 3 times more likely to get cough and 2 times more likely to get chest tightness. Study by Ayuni et al. [3] also revealed that reported respiratory health symptoms were significantly higher among the exposed children, which were 5 times more likely to get cough (PR = 5.09, 95% CI = 2.23-11.65), and 9 times more likely to get phlegm (PR = 9.66, 95% CI = 2.10-44.46), chest tightness (PR = 9.08, 95% CI = 1.09-75.0) and wheezing (PR = 9.07, 95% CI = 1.89-25.2) compared to comparative group.

Other than that, study by ArasyiYahya and Juliana Jalaludin proved that there was a significant association between PM₁₀ concentration with cough (p<0.033) and chest tightness (p<0.022) [12].

Conclusion

In summary, this study indicated that the exposure to industrial air pollutants might increase the risk of getting respiratory symptoms among primary school children living near industry area. This study suggests that knowledge should be given to the public, primary school managements and parents, specifically about the risk of getting respiratory problems due to poor air quality inside classrooms and residences. Further studies are needed to confirm the observed association between industrial air pollutant concentrations and respiratory health among primary school children in the industrial area and non-industrial area.

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