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ARTICLE REVIEW

# Students Views and Perceptions on Outdoor Air Pollution in Iskandar Puteri, Malaysia

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## ABSTRACT

**Introduction** Air pollution and air quality are growing concerns among urban citizens of Southeast Asia, especially the University students who devote most of their days to the vicinity of campus. However, there is limited data available on the extent of the problem, as well as an understanding of the knowledge of and perceptions of people who may be exposed to poor air quality.

**Methods** This focused study evaluated University students' opinions, perceptions, and behavioral responses to local air quality in the Iskandar Puteri, Johor region of Malaysia using an online questionnaire, and measurements of $NO_2$, $SO_2$, formaldehyde, and particulate matter levels in the area using diffusion tubes. All air quality parameters were within the standards recommended by the local environmental authority, however, $NO_2$ levels exceeded the recommended World Health Organization (WHO) standards at all sites.

**Results** Questionnaire findings indicate that students most commonly suffered from respiratory diseases, and were very concerned about air pollution and its impacts. Respondents perceived the situation to be worse in the afternoons and weekends, corroborated by the PM2.5 readings in the area. Preferred preventive measures included wearing masks and limiting active time outdoors.

**Conclusions** The evidence from this study highlighted the need to improve air quality in Iskandar Puteri as the $NO_2$ level exceeded international standards for human health at all study sites. This could be supported by educational programs for industry, limitations on traffic emissions, and general awareness of air quality issues present locally.

**Keywords** Air pollution; Air quality; Respiratory disease; Preventive measures

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# INTRODUCTION

Malaysia is one of the most urbanized countries in Southeast Asia[1] and currently undergoing rapid development resulting in major changes to land use, and growth in motorization and industrialization.[2] In the southern Peninsular Malaysia, Iskandar Puteri has been identified as a conurbation for prime development that will contribute to regional population and economic growth due to its strategic location, close to Singapore. To achieve this vision, The Comprehensive Development Plan II (2014 – 2025) Iskandar Malaysia was introduced with blueprints for a long-term urbanization project to develop the region.[3]

Construction, industrialization and population mobility are associated with higher air pollution, and this has been previously demonstrated in the Klang Valley, Selangor, Malaysia, where the area's high volume of traffic and high density of industrialization frequently results in poor air quality.[4,5] Poor air quality presents a serious threat to human health and welfare.[6] According to World Health Organization (WHO), ambient air pollution accounts for an estimated 4.2 million deaths per year leading to acute and chronic respiratory diseases, heart disease, lung cancer and stroke; Southeast Asia is among the most heavily burdened region by this phenomenon.[7] Malaysia frequently experiences transboundary haze episodes, defined as a complex process with high levels of fine particulate matter smaller than PM2.5.[8] Between August and November in South East Asia, these are often caused by seasonal forest fires often originating in Indonesia; previous studies have shown that these disrupt breathing and wellbeing of the urban population living in Southern Malaysia and Indonesia with people avoiding going outside and undertaking outdoor exercise through fear of adverse health effects[9,10] especially those affecting the respiratory system.[11] Despite the evidence correlating air pollution to various negative effects, the issue tends to be overlooked by the general public in Malaysia because it is norm at a particular time of year and seems to be forgotten about after the haze episodes has subsided.[4] During the COVID-19 pandemic, there were fewer forest fires creating haze in Southern Malaysia, but air pollution was still evident from construction and traffic.

Educity, Iskandar is a complex, housing university students, surrounded by areas of residential (Eco Botanic City, Nusa Sentral), commercial (Medini), and industrial (Nusa Cemerlang) establishments. University students are potentially vulnerable to inconsistent air quality due to their unique time-activity pattern that includes attending lectures on campus and various outdoor activities.[12] Due to the high temperatures in the day times, students frequently spend evenings outdoors. Student accommodation contains air conditioning units, but outdoors there is little provision for ensuring good air quality. The impact of air pollution on health and behaviors of students has not been investigated to date in this area. An area that is undergoing increasing development through construction and will continue to do so over the next 10-20 years. Anecdotal complaints of respiratory difficulties highlighted concerns from students on air quality issues. Previous studies around educational establishments conducted in Malaysia on air pollution have mainly focused on quantifying the severity and sources of pollutants,[13] but there has been less research on social attitudes and awareness or behaviors. Various factors such as age, gender, education background, lifestyle may affect an individual's thoughts on air quality. The majority of respondents in one Malaysian study of graduates who had completed tertiary education, found no significant correlation between education level and awareness of air quality issues,[14] but in another study conducted in Kuala Lumpur, respondents who regularly practiced outdoor sports showed more concern towards air quality than a control group who did not participate in outdoor sports.[9] Contrary to these results, studies conducted in other low and middle-income countries such as in China[15] and in India[16] where university students and medical students were recruited as respondents, respectively, indicated high awareness towards air pollution and the adverse health impacts. The limited studies conducted and the inconsistency in findings, highlights the need for more comprehensive studies in Malaysia to understand perception of different groups towards air quality in the regions of rapid urbanization.

This study therefore aimed to evaluate perceptions towards local outdoor air quality, related health impacts and behavioral responses among university students in Educity, Iskandar Puteri, Johor.

# METHODS

Following ethical approval (Newcastle University Ethics Committee, reference: 16196/2021), higher education students living in Educity, Iskandar were invited to participate in the study via social media platforms and electronic messaging groups among students in each of three campuses (Newcastle University Medicine Malaysia, Southampton University Malaysia and Reading University Malaysia). Participants were included on the basis of being enrolled at a University in Educity and living in Iskandar Puteri. Respondents that did not fully complete the electronic questionnaire were excluded from this study. A link to complete an ArcGIS Survey123® questionnaire was given to participants, which comprised questions on basic demographics, time spent outside during weekdays/weekends measures to evaluate air quality and combat the effects of poor air quality on health. Data was collected for one month during November 2021.

Diffusion tubes were used to measure nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$) levels (Gradko International Limited, Hampshire, United Kingdom). They were set up according to the manufacturer's protocol and placed at 35 locations within Educity and the wider Iskandar Puteri area. The tubes were then collected and sent to the manufacturer's accredited laboratory for analysis of $NO_2$ and $SO_2$ using UV spectrophotometry and ion chromatography, respectively. Measurements of weekday and Saturday through to Sunday 11:59pm, particulate matter (PM2.5 and PM10), carbon dioxide ($CO_2$) and formaldehyde (HCHO) were also taken using Temptop® M2000C second generation air quality monitor (Elitech Limited, London, United Kingdom) every three hours at each sampling location for one week during the monitoring period.

Descriptive statistics, Pearson correlation coefficients, Chi square and Fishers exact Tests were used for data analysis of questionnaire responses and air quality measures were undertaken using SPSS (IBM® SPSS 27®) statistical software. Results were considered significant when $p$ value ≤ 0.050, and very significant when $p$ value ≤ 0.005. Mapping of air quality data was undertaken using Esri ArcGIS® Mapping Software.

# RESULTS

Air Quality Measurements

Table 1a shows the results of average air quality measurements on weekdays and weekends in a 24-hour period. Sampling locations were identified based on buildings/infrastructure/industry and road networks in the study area. An industrial estate adjacent to the educational establishments and retail area had the highest daily total particulate matter (5147.8 ± 2070.0 particles/L on weekdays and 6049.9 ± 4041.1 particles/L on weekends). At all study sites, the level of PM2.5 was alarmingly close to the standard recommended by the 2021 WHO Air Quality Guidelines[7] of 15 ug/m$^3$ in a 24-hours period. For PM10, the recommended standard was a maximum PM10 of 45 ug/m$^3$ in a 24-hours period. From the results (Table 1a), none of the sites selected for this study exceeded the PM10 recommended levels.

On weekdays and weekends, recordings from the industrial estate for PM2.5 (11.38 ± 3.47 µg/m$^3$ and 11.52 ± 7.18 respectively) and PM10 (15.45 ± 7.10 µg/m$^3$ and 15.47 ± 9.27) suggesting that PM10 values were within acceptable limits, but PM2.5 was relatively higher than other locations. The retail area had the higher PM2.5 (9.42 ± 3.41 µg/m$^3$) and PM10 (13.52 ± 7.28 µg/m$^3$) readings on weekends than weekdays, as did Educity situated adjacent to it. For $CO_2$, residential zones had the highest readings (1269.93 ± 221.10 ppm) on weekdays, while the industrial area had the highest readings (1700.28 ± 1527.70 ppm) on weekends. During weekdays, residential areas had the highest formaldehyde readings (0.1011 ± 0.1209 mg/m$^3$), and educational establishments had higher readings during the weekends (0.1239 ± 0.1993 mg/m$^3$) (Table 1a). From the analysis of $SO_2$ diffusion over four weeks, surprisingly, the highest values were recorded at educational establishments (4.98 µg/m$^3$), followed a retail area (3.335 ± 1.135 µg/m$^3$), and then the industrial area which recorded a value of 2.47 µg/m$^3$. Samples from other diffusion locations showed values below the threshold reporting limit. All $SO_2$ levels fell well below the maximum WHO air quality guideline maximum of 40 ug/m$^3$ in 24 hours. Measurement of $NO_2$ diffusion tubes showed $NO_2$ at its highest level in an industrial estate (33.02 ± 4.05 µg/m$^3$), followed by the highway (32.44 ± 9.90 µg/m$^3$), retail outlet (31.83 ± 3.35 µg/m$^3$), education establishments (28.31 ± 3.10 µg/m$^3$) and residential areas (26.34 ± 2.40 µg/m$^3$). Since the WHO air quality guidelines suggest a maximum 25 ug/m$^3$, $NO_2$ levels exceeded the maximum values defined by WHO at all these sites.[7]

In this study, air temperature did not vary through the course of the study more than 1 °C per day and there were no significant correlations between individual air quality measures.

When asked whether they were concerned about air pollution in Iskandar Puteri, 52.7% of students expressed concern, 15.0% were neutral in their response and 32.2% were less concerned (Fig. 1). The courses students were studying (medicine, engineering and business/management) were recorded along with year of study, but results showed that concerns were not significantly related to university course ($p$ = 0.328). The students in this study felt that the biggest pollutants were coming from construction work (49.1%) and traffic emissions (36.4%). Fewer students were concerned about the factory industry (8.9%), pollen (5.0%) and wood or forest fire burning (5.1%).

When asked at what time of day, students felt the air quality was poorest, they felt that air pollution was most evident in the afternoon (39.3%). While 43% students didn't know what time of year the air pollution was most problematic, 25.2% felt it was the same all the time. Interestingly, 67.8% students felt that the smell of the air was the feature that alerted them most to poor air quality. Other attributes such as stinging eyes (8.4%), shortness of breath (7.0%), cough (6.1%) and headache (1.9%) featured less commonly among the respondents (Fig. 1).

**Table 1a** Daily trends (mean ± SD) of PM2.5, PM10, $CO_2$ and HCHO at selected locations surrounding university campuses and Iskandar Puteri. Pearson test on values between weekday and weekend; *: $0.68 \leq r^2 \leq 0.89$, **: $0.90 \leq r^2$; *: $p \leq 0.050$, **: $p \leq 0.005$.

| Location | PM2.5 (µg/m³) | | PM10 (µg/m³) | | Particles (/L) | | $CO_2$ (ppm) | | HCHO (mg/m³) | | $NO_2$ (µg/m³) | $SO_2$ (µg/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend | Weekday | Weekend | | |
| Residential area | 8.33 ± 2.93 | 7.01 ± 3.71 | 8.31 ± 1.54 | 8.47 ± 4.07 | 4455.07 ± 1054.30 | 3980.07 ± 1423.09 | 1269.93 ± 221.10 | 1324.14 ± 400.79 | 0.1011 ± 0.1209 | 0.0451 ± 0.0131 | 26.34 ± 2.40 | ≤ 2.45 |
| $r^2$ | 0.666 | | - 0.145 | | 0.857* | | 0.423 | | - 0.516 | | | |
| *p-value* | 0.149 | | 0.785 | | 0.029* | | 0.404 | | 0.294 | | | |
| Retail area | 9.42 ± 3.41 | 13.52 ± 7.28 | 12.42 ± 4.84 | 18.43 ± 11.44 | 4522.30 ± 950.67 | 5802.40 ± 1934.75 | 1019.20 ± 480.60 | 834.60 ± 334.03 | 0.0493 ± 0.0592 | 0.0911 ± 0.0898 | 31.83 ± 3.35 | 2.70 ± 0.43 |
| $r^2$ | 0.868* | | 0.480 | | - 0.660 | | - 0.353 | | 0.739* | | | |
| *p-value* | 0.011* | | 0.276 | | 0.106 | | 0.437 | | 0.058 | | | |
| Educational area | 10.52 ± 2.81 | 11.75 ± 4.45 | 14.51 ± 3.83 | 17.14 ± 7.02 | 5035.81 ± 1487.90 | 4597.00 ± 1118.58 | 882.81 ± 336.84 | 751.00 ± 461.56 | 0.0713 ± 0.0636 | 0.1239 ± 0.1993 | 28.31 ± 3.10 | 2.62 ± 0.63 |
| $r^2$ | - 0.027 | | - 0.103 | | 0.159 | | - 0.391 | | 0.641 | | | |
| *p-value* | 0.924 | | 0.645 | | 0.570 | | 0.150 | | 0.010* | | | |
| Industrial area | 11.38 ± 3.47 | 11.52 ± 7.18 | 15.45 ± 7.10 | 15.47 ± 9.27 | 5147.78 ± 2070.20 | 6049.89 ± 4041.00 | 1111.33 ± 294.29 | 1700.28 ± 1527.70 | 0.0689 ± 0.0303 | 0.0806 ± 0.0699 | 33.02 ± 4.05 | 2.45 ± 0.01 |
| $r^2$ | - 0.003 | | - 0.431 | | - 0.156 | | - 0.099 | | - 0.023 | | | |
| *p-value* | 0.996 | | 0.469 | | 0.803 | | 0.874 | | 0.971 | | | |
| Highway | 9.79 ± 3.46 | 9.47 ± 4.68 | 13.77 ± 5.54 | 13.67 ± 7.46 | 4039.86 ± 898.84 | 4576.57 ± 1260.65 | 866.86 ± 518.61 | 1087.29 ± 355.48 | 0.0851 ± 0.0682 | 0.1036 ± 0.0988 | 32.44 ± 9.90 | 2.46 ± 0.01 |
| $r^2$ | 0.960 | | 0.964 | | 0.987 | | - 0.602 | | - 0.750 | | | |
| *p-value* | 0.182 | | 0.172 | | 0.105 | | 0.589 | | 0.460 | | | |

**Table 1b** Pearson correlation test on air quality data at selected locations; moderate correlation was marked with *: $0.68 \leq r^2 \leq 0.89$, strong correlation was marked with **: $0.90 \leq r^2$; *: $p \leq 0.050$, **: $p \leq 0.005$.

| Location | $NO_2$ | | $SO_2$ | | PM2.5 | | PM10 | | Particles | | $CO_2$ | | HCHO | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $r^2$ | *p-value* | $r^2$ | *p-value* | $r^2$ | *p-value* | $r^2$ | *p-value* | $r^2$ | *p-value* | $r^2$ | *p-value* | $r^2$ | *p-value* |
| **Residential area** | | | | | | | | | | | | | | |
| $NO_2$ | | | NA# | | - 0.412 | 0.416 | 0.462 | 0.356 | - 0.012 | 0.982 | 0.669 | 0.146 | - 0.283 | 0.586 |
| $SO_2$ | | | | | | | NA# | | | | | | | |
| PM2.5 | -0.412 | 0.416 | NA# | | | | 0.401 | 0.430 | 0.582 | 0.226 | 0.010 | 0.986 | 0.441 | 0.381 |
| PM10 | 0.462 | 0.356 | NA# | | 0.401 | 0.430 | | | 0.169 | 0.748 | 0.226 | 0.667 | - 0.121 | 0.820 |
| Particles | - 0.012 | 0.982 | NA# | | 0.582 | 0.226 | 0.169 | 0.748 | | | 0.349 | 0.497 | - 0.167 | 0.751 |
| $CO_2$ | 0.669 | 0.146 | NA# | | 0.010 | 0.986 | 0.226 | 0.667 | 0.349 | 0.497 | | | 0.163 | 0.757 |
| HCHO | - 0.283 | 0.586 | NA# | | 0.441 | 0.381 | - 0.121 | 0.820 | - 0.167 | 0.751 | 0.163 | 0.757 | | |
| **Retail area** | | | | | | | | | | | | | | |
| $NO_2$ | | | 0.730* | 0.063 | -0.398 | 0.377 | 0.068 | 0.884 | - 0.029 | 0.950 | 0.205 | 0.659 | - 0.033 | 0.944 |
| $SO_2$ | 0.730* | 0.063 | | | -0.823* | 0.023* | - 0.331 | 0.469 | 0.413 | 0.357 | 0.055 | 0.907 | - 0.173 | 0.711 |
| PM2.5 | - 0.398 | 0.377 | -0.823* | 0.023* | | | 0.723* | 0.067 | - 0.660 | 0.107 | - 0.398 | 0.376 | - 0.067 | 0.887 |
| PM10 | 0.068 | 0.884 | - 0.331 | 0.469 | 0.723* | 0.067 | | | - 0.269 | 0.560 | - 0.437 | 0.326 | 0.084 | 0.859 |
| Particles | - 0.029 | 0.950 | 0.413 | 0.357 | - 0.660 | 0.107 | - 0.269 | 0.560 | | | 0.223 | 0.630 | 0.515 | 0.237 |
| $CO_2$ | 0.205 | 0.659 | 0.055 | 0.907 | - 0.398 | 0.376 | - 0.437 | 0.326 | 0.223 | 0.630 | | | 0.297 | 0.518 |
| HCHO | - 0.033 | 0.944 | - 0.173 | 0.711 | - 0.067 | 0.887 | 0.084 | 0.859 | 0.515 | 0.237 | 0.297 | 0.518 | | |
| **Educational area** | | | | | | | | | | | | | | |
| $NO_2$ | | | - 0.187 | 0.504 | 0.414 | 0.125 | 0.224 | 0.423 | 0.717* | 0.003** | - 0.044 | 0.876 | 0.659 | 0.007* |
| $SO_2$ | - 0.187 | 0.504 | | | - 0.061 | 0.828 | 0.098 | 0.727 | - 0.057 | 0.839 | - 0.210 | 0.453 | 0.310 | 0.261 |
| PM2.5 | 0.414 | 0.125 | - 0.061 | 0.828 | | | 0.716* | 0.003** | 0.648 | 0.009* | - 0.328 | 0.233 | - 0.023 | 0.934 |
| PM10 | 0.224 | 0.423 | 0.098 | 0.727 | 0.716* | 0.003** | | | 0.492 | 0.063 | - 0.449 | 0.093 | - 0.028 | 0.922 |
| Particles | 0.717* | 0.003** | - 0.057 | 0.839 | 0.648 | 0.009* | 0.492 | 0.063 | | | - 0.036 | 0.900 | 0.518 | 0.048* |
| $CO_2$ | - 0.044 | 0.876 | - 0.210 | 0.453 | - 0.328 | 0.233 | - 0.449 | 0.093 | - 0.036 | 0.900 | | | 0.200 | 0.475 |
| HCHO | 0.659 | 0.007* | 0.310 | 0.261 | - 0.023 | 0.934 | - 0.028 | 0.922 | 0.518 | 0.048* | 0.200 | 0.475 | | |
| **Industrial area** | | | | | | | | | | | | | | |
| $NO_2$ | | | -0.800* | 0.104 | - 0.626 | 0.259 | - 0.724 | 0.167 | 0.696* | 0.192 | 0.433 | 0.467 | - 0.321 | 0.599 |
| $SO_2$ | - 0.800* | 0.104 | | | 0.749* | 0.145 | 0.915** | 0.029* | - 0.302 | 0.622 | - 0.397 | 0.509 | - 0.102 | 0.870 |
| PM2.5 | - 0.626 | 0.259 | 0.749 | 0.145 | | | 0.950** | 0.014* | 0.005 | 0.994 | - 0.184 | 0.767 | 0.198 | 0.749 |
| PM10 | - 0.724 | 0.167 | 0.915** | 0.029* | 0.950** | 0.014* | | | - 0.125 | 0.841 | - 0.245 | 0.692 | 0.075 | 0.904 |
| Particles | 0.696 | 0.192 | - 0.302 | 0.622 | 0.005 | 0.994 | - 0.125 | 0.841 | | | - 0.030 | 0.962 | - 0.595 | 0.290 |
| $CO_2$ | 0.433 | 0.467 | - 0.397 | 0.509 | - 0.184 | 0.767 | - 0.245 | 0.692 | - 0.030 | 0.962 | | | - 0.152 | 0.903 |
| HCHO | - 0.321 | 0.599 | - 0.102 | 0.870 | 0.198 | 0.749 | 0.075 | 0.904 | - 0.595 | 0.290 | - 0.152 | 0.903 | | |
| **Highway** | | | | | | | | | | | | | | |
| $NO_2$ | | | - 0.332 | 0.785 | 0.953** | 0.196 | 0.056 | 0.964 | 0.923** | 0.251 | 0.964** | 0.172 | - 0.513 | 0.657 |
| $SO_2$ | - 0.332 | 0.785 | | | - 0.030 | 0.981 | 0.923** | 0.251 | 0.056 | 0.964 | - 0.068 | 0.957 | 0.980** | 0.128 |
| PM2.5 | 0.953** | 0.196 | - 0.030 | 0.981 | | | 0.357 | 0.768 | 0.996** | 0.055 | 0.999** | 0.024* | - 0.228 | 0.853 |
| PM10 | 0.056 | 0.964 | 0.923** | 0.251 | 0.357 | 0.768 | | | 0.436 | 0.713 | 0.321 | 0.792 | 0.828* | 0.379 |
| Particles | 0.923** | 0.251 | 0.056 | 0.964 | 0.996** | 0.055 | 0.436 | 0.713 | | | 0.992** | 0.079 | - 0.144 | 0.908 |
| $CO_2$ | 0.964** | 0.172 | - 0.068 | 0.957 | 0.999** | 0.024* | 0.321 | 0.792 | 0.992** | 0.079 | | | - 0.265 | 0.829 |
| HCHO | - 0.513 | 0.657 | 0.980** | 0.128 | - 0.228 | 0.853 | 0.828* | 0.379 | - 0.144 | 0.908 | - 0.265 | 0.829 | | |

*#: Results below reporting limit. Unable to perform correlation test.*

**Table 2** Demographic of questionnaire respondents.

| | Frequency (n) | Percentage (%) |
|---|---|---|
| Respondents | 214 | 100 |
| | | |
| Age | | |
| 18 – 21 | 102 | 47.7 |
| 21 – 24 | 69 | 32.2 |
| 25 – 28 | 16 | 7.5 |
| 29 – 32 | 8 | 3.7 |
| 33 – 36 | 2 | 0.9 |
| 36 – 39 | 2 | 0.9 |
| > 40 | 15 | 7.0 |
| | | |
| Gender | | |
| Female | 146 | 68.2 |
| Male | 68 | 31.8 |
| | | |
| History of Asthma or allergy with respiratory symptoms. | | |
| Yes | 42 | 19.6 |
| No | 172 | 80.4 |
| | | |
| Students | | |
| Medical students Medicine Malaysia (NUMed) | 169 | 79.0 |
| Management/Business | 32 | 15.0 |
| Engineering | 13 | 6.1 |

In total, 214 students voluntarily completed the questionnaire; 68.2% respondents were female (n = 146). In this study, 47.7% students were in the 18 – 21 years old age group and 32.2% were in the 25 – 28 years old age group (Table 2).

When students were asked who they felt were the most vulnerable to air quality issues, 36.4% felt that everyone was equally vulnerable, 33.6% felt that those with pre-existing chest problems were most vulnerable, followed by the elderly (11.2%) (Fig. 1).

In terms of behavioral adaptations to poor air quality, 29.9% students said they avoided the area they felt had poor air quality if they could; 33.6% would stay indoors and 25.7% would wear a mask (Table 3). The behavioral change was not significantly related to the amount of time spent outdoor during weekdays ($p = 0.586$) and weekends ($p = 0.462$). In this study, 19.6% respondents (n = 42) said that they had pre-existing respiratory disease such as asthma. When asked about spending time outside, 50.4% students said they spent 1 – 3 hours outdoors and 14.5% spent 3 – 4 hours' outdoors on weekdays. At the weekends however, there was less time spent outside and 29.0% spent 1 – 2 hours versus 25.2% spending 2 – 3 hours.

In this study, there were significant differences between those with pre-existing respiratory disease and those without with regards to concern about air pollution ($p < 0.001$) (Table 4), time of the day that they felt had worse air pollution ($p = 0.039$), time of the year with most noticeable air pollution ($p = 0.002$), as well as how they recognized poor air quality ($p = 0.001$). Those with a respiratory disease felt that shortness of breath was an important indicator (23.8%) compared to stinging eyes which was the second highest indicator for those without respiratory disease (9.3%). A significant amount of those with respiratory disease ($p = 0.021$) felt that they were the most vulnerable to the effects of declined air quality. In terms of behavioral adaptations, there were significant differences in adaptations between non-respiratory disease students and those with respiratory disease as the majority of those without respiratory disease felt they would avoid the area, but the majority of the respiratory-diseased would wear a mask (35.7%) or stay indoors (23.8%).

There were significant differences in the amount of time students spent outside in this study with 66.3% of medical students (n = 162) spending less than 3 hours per weekday outdoors, and 33.1% spent more than 3 hours per weekday outdoors. The students from the management University (n = 32) spent a similar amount of time on weekdays outdoors (65.7% less than 3 hours, 34.4% more than 3 hours). However, engineering students (n = 13), spent more time per weekday outdoors with 77.0% spending more than 3 hours' outdoors on weekdays and 23.1% less than 3 hours ($p = 0.006$). This difference was also significant with time spent outside at the weekend ($p < 0.001$).

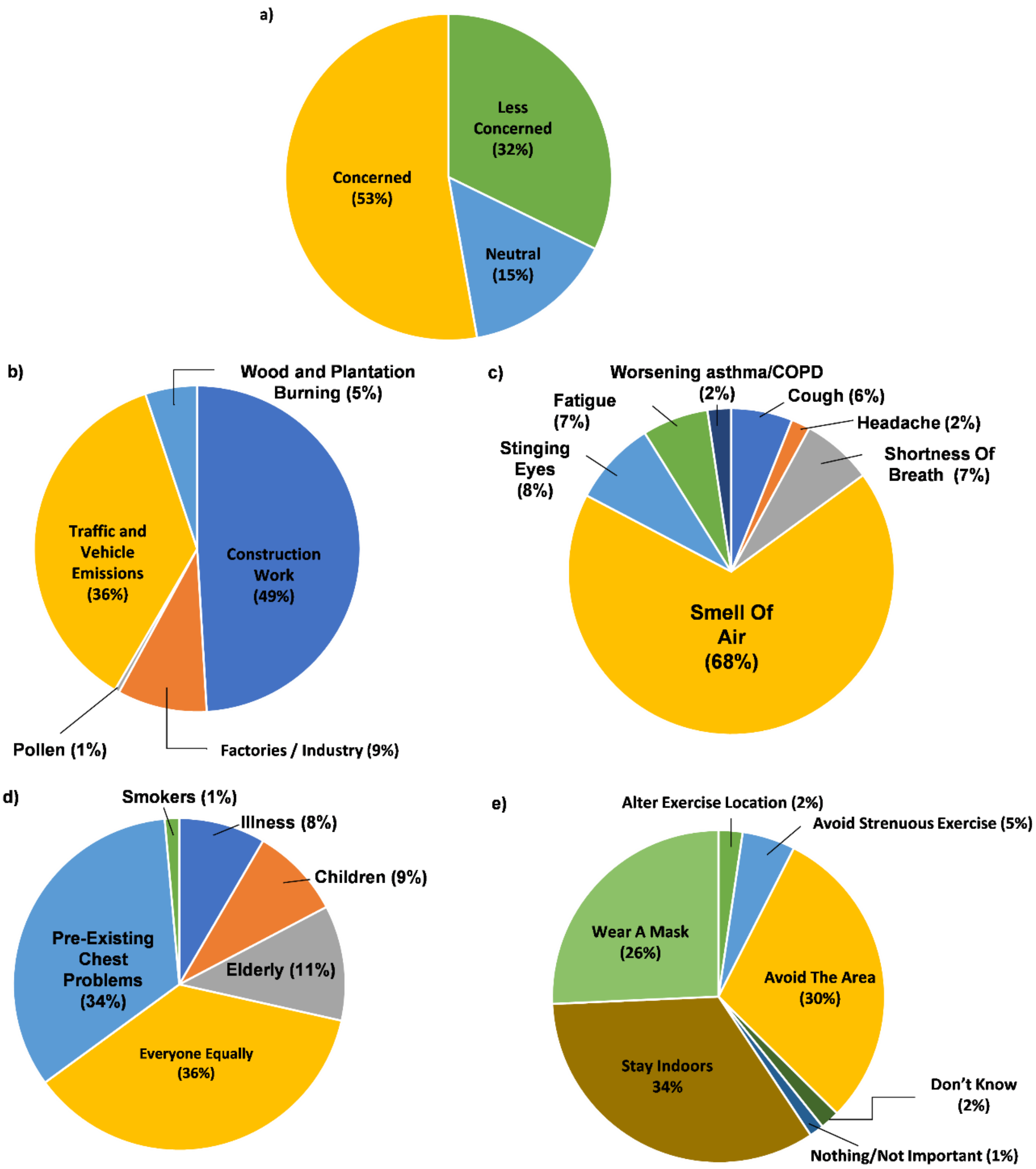


**Figure 1** Responses on concerns and awareness towards air quality and related questions. a) Concern towards air quality in Educity. b) Perceived greatest air pollutants. c) Feature that indicates decline in air quality. d) Perceived most vulnerable group of people towards bad air quality. e) Action in response to decline in air quality.

**Table 3** Perception towards daily and annual air quality, and daily time spent outdoor by the respondents.

| | Frequency (n) | Percentage (%) |
|---|---|---|
| Time of The Day with Worst Air Quality | | |
| Afternoon | 84 | 39.3 |
| Don't know | 52 | 24.3 |
| Morning | 47 | 22.0 |
| Same all day | 23 | 10.7 |
| Night | 8 | 3.7 |
| | | |
| Time of The Year with Worst Air Quality | | |
| Don't know | 92 | 43.0 |
| Same throughout the year | 54 | 25.2 |
| October – December | 38 | 17.8 |

| | | |
|---|---|---|
| July – September | 18 | 8.4 |
| April – June | 7 | 3.3 |
| January – March | 5 | 2.3 |
| | | |
| Outdoor Time Per Weekday (hours) | | |
| > 5 | 28 | 13.1 |
| 4 – 5 | 18 | 8.4 |
| 3 – 4 | 31 | 14.5 |
| 2 – 3 | 54 | 25.2 |
| 1 – 2 | 54 | 25.2 |
| 0 – 1 | 28 | 13.1 |
| 0 | 1 | 0.5 |
| | | |
| Daily Outdoor Time Per Weekend (hours) | | |
| > 5 | 24 | 11.2 |
| 4 – 5 | 17 | 7.9 |
| 3 – 4 | 28 | 13.1 |
| 2 – 3 | 54 | 25.2 |
| 1 – 2 | 62 | 29.0 |
| 0 – 1 | 26 | 12.1 |
| 0 | 3 | 1.4 |

**Table 4** Comparison of responses between respondents with pre-existing respiratory disease and respondents without pre-existing respiratory disease. *: $p < 0.050$; **: $p < 0.005$.

| | With Respiratory Disease | | Without Respiratory Disease | | *Statistics* | *df* | *p-value* |
|---|---|---|---|---|---|---|---|
| | n | % | n | % | | | |
| Age | | | | | $x^2 = 23.104$ | 6 | <0.005 |
| 18 – 21 | 14 | 33.3 | 88 | 51.2 | | | |
| 21 – 24 | 13 | 31.0 | 56 | 32.6 | | | |
| 25 – 28 | 10 | 23.8 | 6 | 3.5 | | | |
| 29 – 32 | 2 | 4.8 | 6 | 3.5 | | | |
| 33 – 36 | 1 | 2.4 | 1 | 0.6 | | | |
| 36 – 39 | 0 | 0.0 | 2 | 1.2 | | | |
| > 40 | 2 | 4.8 | 13 | 7.6 | | | |
| | | | | | | | |
| Concern towards air pollution | | | | | $x^2 = 29.196$ | 9 | <0.005 |
| Concerned | 35 | 83.3 | 78 | 45.3 | | | |
| Neutral | 2 | 4.8 | 30 | 17.4 | | | |
| Less Concerned | 5 | 11.9 | 64 | 37.2 | | | |
| | | | | | | | |
| Perceived greatest air pollutant | | | | | $x^2 = 3.167$ | 4 | 0.530 |
| Construction work | 18 | 42.9 | 87 | 50.6 | | | |
| Factories/Industry | 2 | 4.8 | 17 | 9.9 | | | |
| Pollen | 0 | 0.0 | 1 | 0.6 | | | |
| Traffic and vehicle emissions | 19 | 45.2 | 59 | 34.3 | | | |
| Wood and plantation burning | 3 | 7.1 | 8 | 4.7 | | | |
| | | | | | | | |
| Time of the day with worst air quality | | | | | $x^2 = 10.116$ | 4 | <0.05 |
| Morning | 15 | 35.7 | 32 | 18.6 | | | |
| Afternoon | 15 | 35.7 | 69 | 40.1 | | | |
| Night | 2 | 4.8 | 6 | 3.5 | | | |
| Same all day | 6 | 14.3 | 17 | 9.9 | | | |
| Don't know | 4 | 9.5 | 48 | 27.9 | | | |
| | | | | | | | |
| Time of the year with worst air quality | | | | | $x^2 = 19.177$ | 5 | <0.005 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| January – March | 1 | 2.4 | 4 | 2.33 | | | |
| April – June | 1 | 2.4 | 6 | 3.49 | | | |
| July – September | 0 | 0.0 | 18 | 10.47 | | | |
| October – December | 16 | 38.1 | 22 | 12.79 | | | |
| Same all year | 6 | 14.3 | 48 | 27.91 | | | |
| Don't know | 18 | 42.9 | 74 | 43.02 | | | |
| Feature of worse air quality | | | | | $x^2$ = 31.949 | 6 | <0.005 |
| Cough | 3 | 7.1 | 10 | 5.8 | | | |
| Headache | 0 | 0.0 | 4 | 2.3 | | | |
| Shortness of breath | 10 | 23.8 | 5 | 2.9 | | | |
| Smell of air | 20 | 47.6 | 125 | 72.7 | | | |
| Stinging eyes | 2 | 4.8 | 16 | 9.3 | | | |
| Tired all the time | 4 | 9.5 | 10 | 5.8 | | | |
| Worsening asthma/ chronic obstructive pulmonary disease (COPD) | 3 | 7.1 | 2 | 1.2 | | | |
| Perceived most vulnerable people | | | | | $x^2$ = 13.309 | 5 | <0.05 |
| People with illness | 4 | 9.5 | 14 | 8.1 | | | |
| Children | 6 | 14.3 | 13 | 7.6 | | | |
| Elderly | 9 | 21.4 | 15 | 8.7 | | | |
| Everyone equally | 7 | 16.7 | 71 | 41.3 | | | |
| People with pre-existing chest problems | 16 | 38.1 | 56 | 32.6 | | | |
| Smokers | 0 | 0.0 | 3 | 1.7 | | | |
| Action in response to air quality | | | | | $x^2$ = 20.013 | 6 | <0.005 |
| Alter exercise location | 1 | 2.4 | 4 | 2.3 | | | |
| Avoid strenuous exercise | 7 | 16.7 | 4 | 2.3 | | | |
| Avoid the area | 9 | 21.4 | 55 | 32.0 | | | |
| Stay indoors | 10 | 23.8 | 62 | 36.0 | | | |
| Wear a mask | 15 | 35.7 | 40 | 23.3 | | | |
| Nothing / not important to self | 0 | 0.0 | 3 | 1.7 | | | |
| Don't know | 0 | 0.0 | 4 | 2.3 | | | |
| Time spent outdoors per weekday | | | | | $x^2$ = 10.086 | 6 | 0.121 |
| 0 | 0 | 0.0 | 1 | 0.6 | | | |
| 0 – 1 | 10 | 23.8 | 18 | 10.5 | | | |
| 1 – 2 | 12 | 28.6 | 42 | 24.4 | | | |
| 2 – 3 | 9 | 21.4 | 45 | 26.2 | | | |
| 3 – 4 | 3 | 7.1 | 28 | 16.3 | | | |
| 4 – 5 | 1 | 2.4 | 17 | 9.9 | | | |
| > 5 | 7 | 16.7 | 21 | 12.2 | | | |
| Time spent outdoors per day on weekend | | | | | $x^2$ = 6.093 | 6 | 0.413 |
| 0 | 1 | 2.4 | 2 | 1.2 | | | |
| 0 – 1 | 7 | 16.7 | 19 | 11.0 | | | |
| 1 – 2 | 16 | 38.1 | 46 | 26.7 | | | |
| 2 – 3 | 10 | 23.8 | 44 | 25.6 | | | |
| 3 – 4 | 4 | 9.5 | 24 | 14.0 | | | |
| 4 – 5 | 1 | 2.4 | 16 | 9.3 | | | |
| > 5 | 3 | 7.1 | 21 | 12.2 | | | |

# DISCUSSION

This cross-sectional study undertaken over weeks has provided an insight into air quality in Iskandar. It is by no means a comprehensive detailed study of the area but has allowed comparisons to be made between student perception and objective measures of air quality. A more in-depth qualitative study on perceptions of air quality is currently underway.

While the majority of students who completed questionnaires in this study were undergraduates, there was a general level concern about air quality from both undergraduate and postgraduate students in Iskandar. The data was collected following the COVID-19 pandemic and as such, students may have had a level of concern about air quality that they might not have exhibited prior to the pandemic. Previous study demonstrated higher concerns towards local air quality among people with experience of large scaled air pollution and the COVID-19 pandemic.[17]

Particulate matter was more problematic on weekdays in general and highest levels were present in the industrial estate immediately behind the educational institutions, where manufacturing industry such as chemical and wood chip factories are located. At the weekends when the factories were closed, particulate matter was higher in the mixed area of commercial and residential of many students, likely related to traffic caused by increased numbers of people visiting the area, as suggested by similar studies in busy urban commercial areas.[18,19] Although both particulate levels did not exceed local standards as recommended by the Department of Environment,[20] low level of particulate matter in the air would cause irritated responses in human body, therefore it was important to be attentive to such pollutants. While levels of $SO_2$ were higher in educational establishments and residential areas, no apparent direct sources of $SO_2$ were found in these areas. Levels of $NO_2$ were also found in industrial and adjacent retail areas. Deteriorated air quality had become a concerning environmental consequences of rapid urbanization and industrialization.[21,22] Both $NO_2$ and $SO_2$ are common by-products of industrial waste, combustion of fossil fuel, mainly by vehicles, and construction. All these sources of pollution are present in Iskandar, a region that is rapidly developing with both mature establishments and construction sites within close distance to one another. While construction work more or less ceased during the pandemic, production has been rapidly upscale after the pandemic, resulting in greater environmental pollution than had likely existed pre-pandemi.[23,24]

With construction work and vehicle emission most perceived as the biggest source of pollutants, students seemed to have relatively good knowledge about the potential causes of air pollution locally. Most respondents relied on smell of the air to inform them of air quality, which was an easy and straightforward method, but were limited by its subjectivity[25] and could potentially be inaccurate.

While vulnerability to poor air quality was considered to be a universal issue affecting all age groups,[26,27] some students felt that the elderly was more at risk. Those with pre-existing respiratory illness were concerned for themselves and other respiratory illness sufferers rather than the general population or elderly, similar to previous studies where perceptions of air quality strongly correlated with respiratory diseases.[28,29] At the time of the data collection, public health education initiatives in relation to COVID-19 were common to warn the population of the vulnerabilities of those with pre-existing respiratory illnesses, and the elderly, towards triggers for respiratory illness, as these groups of people were at higher risks of environment-induced health conditions.[30,31] Interestingly, protection measures for those with pre-existing respiratory disease differed from those without, with respiratory disease sufferers preferring to wear masks as a primary prevention strategy rather than avoiding an area. Since the pandemic, mask wearing has become a common strategy for avoiding viral illness, but the benefits of mask wearing to prevent respiratory illness caused by pollutants, depending on the type of mask, may not be ideal.[32,33] Instead, avoiding polluted areas maybe a more effective strategy.

It is not surprising that the warm climate in Iskandar significantly affected students' outdoors activity pattern.[34] The unique weather pattern in Malaysia might affect the level of ozone pollution.[35] and particulate pollution,[36,37] costing the population more risks of environmental hazards such as air pollution.

# CONCLUSION

This study showed that the residents of universities in this study were generally concerned about air pollution in the local area, with good awareness of the health consequences and preventative measures. Health conditions including respiratory diseases/chest problems significantly affected respondents' perceptions towards air pollution issues. Respondents also demonstrated adequate knowledge regarding the sources of air pollutants, as supported by the local air quality readings collected during the study period. Among the air parameters, it is important to recognize that $NO_2$ levels exceeded international health standard at all sites, increasing the risk of eye, nose and respiratory track irritation. With the continuing and possibly increasing regional development and construction work post pandemic, the situation is likely to get worse without further monitoring and action. In future studies, measuring indoor air quality may be of benefit as it is not known to what extent outside air quality is impacting on people in their workplaces and homes despite use of air conditioning units particularly during heavy pollution periods.

## REFERENCES


1 The World Bank. *Malaysia among Most Urbanized Countries in East Asia*; 2015. [cited April 5; 2022]. Available from https://www.worldbank.org/en/news/feature/2015/01/26/malaysia-among-most-urbanized-countries-in-east-asia.

2 Nourqolipour R, Shariff ARBM, Balasundram SK, et al. Predicting the effects of urban development on land transition and spatial patterns of land use in Western Peninsular Malaysia. *Appl Spat Anal Policy.* 2016; 9:1-19.

3 Iskandar Malaysia. *Comprehensive Development Plan (2014 - 2025)*; 2014. [cited April 5; 2022. Available from http://www.iskandarmalaysia.com.my/comprehensive-development-plan.

4 Chang F, Ashfold M. Public perceptions of air pollution and its health impacts in Greater Kuala Lumpur. *IOP Conf Ser Earth Environ Sci.* 2020; 012027.

5 Mabahwi NAB, Leh OLH, Omar D. Human health and wellbeing: Human health effect of air pollution. *Procedia Soc Behav Sci.* 2014; 153:221-9.

6 Usmani RSA, Saeed A, Abdullahi AM, et al. Air pollution and its health impacts in Malaysia: A review. *Air Qual Atmos Health.* 2020; 13:1093-118.

7 World Health Organization (WHO). WHO global air quality guidelines: particulate matter (PM2.5 and PM10) , ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide; 2021. [cited April 5; 2022]. Available from https://www.who.int/publications/i/item/9789240034228.

8 Hamid HA, Rahmat MH, Sapani SA. The classification of PM10 concentrations in Johor based on seasonal monsoons. *IOP Conf Ser Earth Environ Sci.* 2018; 012028.

9 De Pretto L, Acreman S, Ashfold MJ, et al. The link between knowledge, attitudes and practices in relation to atmospheric haze pollution in Peninsular Malaysia. *PloS One.* 2015;10(12): e0143655.

10 Hanafi NH, Hassim MH, Noor ZZ. Overview of health impacts due to haze pollution in Johor, Malaysia. *J Eng Technol Sci.* 2018;50(6).

11 Jaafar H, Azzeri A, Isahak M, et al. The impact of haze on healthcare utilizations for acute respiratory diseases: Evidence from Malaysia. *Front Ecol Evol.* 2021; 9:764300.

12 Zhou Y, Shao Y, Yuan Y, et al. Personal black carbon and ultrafine particles exposures among high school students in urban China. *Environ Pollut.* 2020;265: 114825.

13 Hanafi NH, Hassim MH, Noor ZZ, et al. Economic losses due to health hazards caused by haze event in Johor Bahru, Malaysia. *E3S Web Conf.* 2019; EDP Sciences: 01009.

14 Chin YSJ, De Pretto L, Thuppil V, et al. Public awareness and support for environmental protection — A focus on air pollution in Peninsular Malaysia. *PloS One.* 2019;14(3): e0212206.

15 Rajper SA, Ullah S, Li Z. Exposure to air pollution and self-reported effects on Chinese students: A case study of 13 megacities. *PloS One.* 2018;13(3): e0194364.

16 Butt M, Waseef R, Ahmed H. Perception about the factors associated with smog among medical students. *Biomed.* 2018;34(4):264.

17 Cobbold AT, Crane MA, Knibbs LD, et al. Perceptions of air quality and concern for health in relation to long-term air pollution exposure, bushfires, and COVID-19 lockdown: A before-and-after study. *J Clim Change Health.* 2022; 6:100137.

18 Rakowska A, Wong KC, Townsend T, et al. Impact of traffic volume and composition on the air quality and pedestrian exposure in urban street canyon. *Atmos Environ.* 2014; 98:260-70.

19 Moltchanov S, Levy I, Etzion Y, et al. On the feasibility of measuring urban air pollution by wireless distributed sensor networks. *Sci Total Environ.* 2015; 502:537-47.

20 Malaysian Department of Environment (DOE). *New Malaysia Ambient Air Quality Standard*; 2020. Available from https://environment.com.my/wp-content/uploads/2016/05/Ambient-Air.pdf

21 Jaén C, Villasclaras P, Fernández P, et al. Source apportionment and toxicity of PM in urban, sub-urban, and rural air quality network stations in Catalonia. *Atmos.* 2021;12(6):744.

22 Li C, Wang Z, Li B, et al. Investigating the relationship between air pollution variation and urban form. *Build Environ.* 2019; 147:559-68.

23 Bañuelos-Gimeno J, Sobrino N, Arce-Ruiz RM. Effects of mobility restrictions on air pollution in the Madrid region during the COVID-19 pandemic and post-pandemic periods. *Sustainability.* 2023;15(17):12702.

24 Bhatti UA, Zeeshan Z, Nizamani MM, et al. Assessing the change of ambient air quality patterns in Jiangsu Province of China pre-to post-COVID-19. *Chemosphere*. 2022;288: 132569.
25 Hsu YC, Cross J, Dille P, et al. Smell Pittsburgh: Engaging community citizen science for air quality. *ACM Trans Interact Intell Syst.* 2020;10(4): 32.
26 Cohen G, Gerber Y. Air pollution and successful aging: Recent evidence and new perspectives. *Curr Environ Health Rep*. 2017;4(1):1-11.
27 Lippmann M. Aging and vulnerability to ambient air pollution. *In: Aging and Vulnerability to Environmental Chemicals: Age-related Disorders and Their Origins in Enviromental Exposures*. Royal Society of Chemistry; 2012.
28 Götschke J, Mertsch P, Bischof M et al. Perception of climate change in patients with chronic lung disease. *PloS ONE*. 2017;12(10): e0186632.
29 Zakaria MF, Ezani E, Hassan N, et al. Traffic-related air pollution (TRAP), air quality perception and respiratory health symptoms of active commuters in a university outdoor environment. *IOP Conf Ser Earth Environ Sci.* 2019;228(1):012017.
30 Kangas T, Gadeyne S, Lefebvre W et al. Are air quality perception and PM2.5 exposures differently associated with cardiovascular and respiratory disease mortality in Brussels? Findings from a census-based study. *Environ Res.* 2023; 219:115180.
31 Park Y, Koo JH, Jeong H et al. Evaluation of an air quality warning system for vulnerable and susceptible individuals in Korea: An interrupted time series analysis. *Epidemiol Health.* 2023;45: e2023020.
32 Kodros JK, O'Dell K, Samet JM et al. Quantifying the health benefits of face masks and respirators to mitigate exposure to severe air pollution. *GEOHealth.* 2021;5(9): e2021GH000482.
33 Tultrairatana S, Phansuea P. Symptoms related to air pollution, mask-wearing and associated factors: A cross-sectional study among OPD pollution clinic patients in Bangkok, Thailand. *J Health Res.* 2022;36(6):1058-67.
34 Ahmad Termida N, Abang Ismail DEE, Rohani MM et al. The effects of weather on university students' activity-travel patterns: A case study in Batu Pahat, Johore. *IOP Conf Ser Earth Environ Sci.* 2020;498(1):012007.
35 Austin E, Zanobetti A, Coull B et al. Ozone trends and their relationship to characteristic weather patterns. *J Expo Sci Environ Epidemiol.* 2015;25(5):532-42.
36 Zhan CC, Xie M, Fang DX et al. Synoptic weather patterns and their impacts on regional particle pollution in the city cluster of the Sichuan Basin, China. *Atmos Environ.* 2019; 208:34-47.
37 Huszar P, Juda-Rezler K, Halenka T et al. Effects of climate change on ozone and -particulate matter over Central and Eastern Europe. *Clim Res.* 2011;50(1):51-68.