

School students' awareness on air pollution and its health effects in the Sultanate of Oman

Hilal K. Al-Shidi^{1*} , Abdullah K. Ambusaidi² , Moza A. Al-Moqbali² 

¹ Department of Educational Studies, University of Technology and Applied Sciences, Khasab, Musandam, OMAN

² Ministry of Education, OMAN

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Abstract

The current study aimed to investigate the level of Omani school students' awareness of air pollution and its health effects due to gender and grade variables. A study was conducted in four governorates in Oman, viz. Muscat, Al Dakhiliyah, north and south Al Batinah, in the 2022/2023 academic year. A closed online questionnaire was used with a total of 1,337 respondents from grades 9th, 10th, & 11th. The results of the study showed that the level of students' awareness regarding air pollution and its health effects was moderate. Significant differences in students' awareness of air pollution and its health effects due to gender and grade variables were obtained. Female students were more vulnerable than males to the effects of air pollution, hence they were significantly careful about air quality when doing outdoor sports activities. In contrast, male students' awareness of the schools' role regarding air pollution awareness and reduction actions was significantly higher than female students. Social media was a main source of access to information about air pollution. Inhaling contaminated air was the most common route of exposure to the toxic air pollutants reported by participants.

Keywords: air pollution, student awareness, health effects, behavior, curriculum

INTRODUCTION

Rapid and increasing industrialization, mechanized transportation, and population growth are significant causes of air pollution in big cities (Al-Shidi et al., 2020c). Air pollution is the consequence of a multitude of different biological materials, particulate matter, and chemicals that can cause harm or adversely affect human beings and other organisms (Ullah et al., 2021). The consequences of air pollution can seriously damage the environment and affect the atmosphere, which is a complex system of natural gases and significant for life. People can be exposed to different kinds of air pollutants either in the short-term or in the long-term exposure which leads to morbidity and mortality from respiratory and cardiovascular disease in addition to lung cancer (Cohen et al., 2005; Pope & Dockery, 2006). Studies show that the major anthropogenic sources of air pollution in developed cities are traffic emissions and industrial processes (Kamani et al., 2018; Rajaram et al., 2014). Hence, traffic emissions are responsible for considerable levels of particulate and gaseous air pollutants for

human exposure. According to WHO (2024), the estimated number of annual deaths attributed to outdoor air pollution exposure is 4.2 million.

Al-Shidi et al. (2020a) reported that humans can be exposed to air pollution via three main pathways: inhalation, ingestion, and dermal adsorption. Thus, air pollutants may pose a risk to public health including asthma, acute and chronic bronchitis, respiratory symptoms, and premature death (Hall et al., 2008). On the other hand, the public's understanding level and response to outdoor air pollution may be a key factor in protecting public health (Al-Shidi et al., 2021). Yazdanparast et al. (2013) defined environmental awareness as a complex of knowledge, values, and attitudes in interaction with environmental contribution. WHO (2013) indicated that the awareness of public people can play a substantial role in encouraging behavioral changes that could diminish personal exposure to air pollution and reduce individual emissions to improve air quality. For instance, public attitudes toward the risks of air pollution and related

Contribution to the literature

- The research contributions are related to identifying the level of awareness of public school students in the ninth, tenth, and eleventh grades about the issue of air pollution in the Sultanate of Oman.
- This contributes to enriching the Arab and international literature on this issue and the level of students' awareness of it, their behavior, and their attitudes towards it.
- This data can also be used to compare students' awareness of air pollution in the Sultanate of Oman with the awareness of students in the same category in other countries of the world.

actions could affect prevention and mitigation behaviors such as information-seeking behavior, avoidance of polluted roads along with acceptance of related air quality policies (Al-Shidi et al., 2021). Oltra and Sala. (2018) stated that improving public environmental awareness and knowledge is fundamental to the success of pollution prevention. People's beliefs particularly youths regarding nature and the causes of its destruction affect their subsequent choices and lifestyle that finally lead to protection or degradation of the environment (Yazdanparast et al., 2013).

Studies have shown that several ideas and beliefs about nature are formed through the early years of life or school period (Rajper et al., 2018; Yazdanparast et al., 2013). Thus, student's beliefs and thoughts might change their perceptions and reactions to air pollution. Hence the corresponding authorities should be aware of education, beliefs, and misconceptions that students have received either at or out of school to make a suitable opportunity for them to consider these views and attitudes in educational planning (Skamp et al., 2004). Elliott et al. (1999) found that age, gender, educational level, or respiratory symptoms have been correlated with perceptions and concerns about air pollution. A study conducted on primary school students in Turkey concluded that the students who received environmental education are more aware of the environment and are more willing to participate in environmental protection activities (Yeşilyurt et al., 2020). Bezuidenhout (2023) found that environmental education within the grade 5 curriculum was able to influence the awareness and perceptions of the students and their parents regarding air quality and other environmental issues in their community. Some school curricula in Oman addressed the issue of air pollution, particularly the science books for the sixth and seventh grades in the Cambridge series, where a special lesson has been devoted to the topic of air pollution (Ministry of Education, 2019, 2022). For many schools, curriculum-linked materials are significant to encourage the use of air quality monitoring in schools for health and education purposes as part of school lessons (Chatzidiakou et al., 2023). Thus, the current study aimed to evaluate the levels of school students' awareness (knowledge, behavior, and attitude) in four governorates in Oman. The study was directed at addressing the following research questions:

1. What is the level of Omani public school students' awareness of air pollution and its health effects?
2. Are there statistically significant differences at level of $\alpha \leq 0.05$ of Omani students' awareness of air pollution and its health effects due to gender and grade level?

METHODOLOGY

Research Design

The researchers in the current study used the descriptive approach to suit the nature of the study, as this approach is concerned with describing the various aspects of the study problem to arrive at results that reflect reality. It also targets students' awareness of the issue of air pollution by distributing a reviewed electronic questionnaire to the sample members of school students in the selected grades to measure the level of students' awareness of air pollution.

Instrument

A novel online closed questionnaire was used. It was designed as a "tool" for collecting and recording information and determining the basic awareness (knowledge, behaviors, and attitudes) of the students on air pollution and related issues. We made some modifications to the original questionnaire from the previous study by Al-Shidi et al. (2021), to suit school students. The original survey questions were written in English and then translated into Arabic before they were back-translated, independently, into English to check for the validity of the translation. In addition, the content of the questionnaire was validated by two academic staff and three schoolteachers with high qualifications. Variables were set by gender and grade to obtain a representative sample. Measures for key variables were adopted from previous studies (Chen et al., 2017; Larijani, 2010; Oltra & Sala, 2018). The questionnaire contained four main sections: sources of access to information on air pollution; knowledge about air pollution; risk perception of air pollution; and individuals' prevention and mitigation actions against air pollution. The questionnaire also included socio-demographic questions (gender and school grade). The final version of the questionnaire included 19 items. The questionnaire took approximately 7-10 minutes to answer all items.

Table 1. The distribution of the study sample according to variables (gender and grade)

| Variable | Level | Percentage (%) |
|----------|--------|----------------|
| Gender | Male | 27.4 |
| | Female | 72.6 |
| Grade | Nine | 40.5 |
| | Ten | 43.9 |
| | Eleven | 15.6 |

Table 2. Mean value and standard deviation of students' awareness of air pollution

| | Mean | SD | Degree of awareness |
|-------------|-------|------|---------------------|
| Entire tool | 35.25 | 2.96 | Moderate |

Participants

The research was conducted in four governorates in the Sultanate of Oman, namely Muscat, Al Dakhiliyah, North and South Al Batinah, investigating school students' knowledge of air pollution, the extent of behavioral responses to bad air quality, and attitudes towards prevention and mitigation practices. We surveyed samples of school students from each governorate from grades 9, 10, and 11. **Table 1** shows the distribution of the study sample according to variables (gender and grade). The survey questionnaire was implemented during the second semester of the 2022/2023 academic year.

Statistical Analysis

The responses were encoded into, and analyzed using, the statistical package for the social sciences. Initially, descriptive statistics were calculated. Following this, an independent samples t-test was used, and a one-way ANOVA test was performed. The reliability coefficient was calculated after administering the survey to a sample of students consisting of 144 participants. After a two-week interval, the same survey tool was re-administered to the same students under identical conditions. Subsequently, the Pearson correlation coefficient between the two administrations was calculated. The correlation coefficients for all survey items range between (0.455-0.876), indicating a correlation coefficient that varies within this range. This affirms the reliability of the survey. To determine the level of awareness among students in government schools regarding air pollution, the following scale was used: 19-30 score (weak), 31-42 (moderate), and 43-52 (high) (Unni et al., 2022).

Table 4. Results of one-way ANOVA test according to study variables

| | Source of contrast | Total of squares | df | Means of squares | F-value | Significance level |
|--------|--------------------|------------------|-------|------------------|---------|--------------------|
| Gender | Between groups | 1.004 | 1 | 1.004 | 9.501 | 0.001 |
| | Inside groups | 141.109 | 1,335 | 0.106 | | |
| Grade | Between groups | 121.486 | 2 | 60.743 | 6.982 | 0.001 |
| | Inside groups | 11,605.077 | 1,334 | 8.699 | | |

Note. Statistically significant at level 0.05

Table 3. Means values and standard deviations for the degree of students' awareness, of air pollution and its health effects according to the study variables

| | Gender | | Grade | | |
|--------|--------|--------|-------|-------|-------|
| | Male | Female | 11 | 10 | 9 |
| Number | 366 | 971 | 209 | 587 | 541 |
| Mean | 34.26 | 35.62 | 35.73 | 35.39 | 34.91 |
| SD | 2.57 | 2.81 | 3.59 | 2.68 | 2.96 |

RESULTS

To answer the first question, "What is the level of Omani public school students' awareness of air pollution and its health effects?", the statistical mean for whole the questionnaire was calculated (**Table 2**).

It is evident that the mean value was (35.25), thus; it can be stated that the level of awareness among students in government schools regarding air pollution and its health effects in the Sultanate of Oman is moderate.

To answer the second question, "Are there statistically significant differences at level of $\alpha \leq 0.05$ of Omani students' awareness of air pollution and its health effects due to gender and grade level?" A one-way ANOVA test was conducted to extract the values of the means, standard deviations, degrees of freedom, calculated F values, and values of the level of statistical significance for the responses of the sample members (**Table 3**).

Table 4 indicates that there are statistically significant differences at a significance level ($\alpha \leq 0.05$) in the student's opinions regarding awareness of air pollution and its health effects in the Sultanate of Oman attributed to gender which favors females, with a mean of 35.62 (**Table 3**). The results in **Table 4** indicate also that there are statistically significant differences at a significance level ($\alpha \leq 0.05$) in the student's awareness of air pollution and its health effects in the Sultanate of Oman due to the grade variable. To determine the tendency of these differences in the survey, the least significant difference (LSD) test for multiple post-comparisons was utilized, as illustrated in **Table 5**.

The results in **Table 5** revealed statistically significant differences between the ninth and tenth grades in favor of the tenth grade (the standard deviation [SD] for the tenth grade is 2.68) and between the ninth and eleventh grades in favor of the eleventh grade (the SD for the eleventh grade is 3.59). Meanwhile, no statistically significant differences existed between the tenth and eleventh grades.

Table 5. LSD test results for multiple post-comparisons in the "grade" variable

| Dual comparisons | Mean differences | Sig. level |
|-----------------------|------------------|------------|
| Grade 10 vs. grade 9 | -.48055* | 0.006 |
| Grade 11 vs. grade 9 | -.81600* | 0.001 |
| Grade 9 vs. grade 10 | .48055* | 0.006 |
| Grade 11 vs. grade 10 | -.33545 | 0.158 |
| Grade 9 vs. grade 11 | .81600* | 0.001 |
| Grade 10 vs. grade 11 | .33545 | 0.158 |

First: Gender Variable

Table 6 shows the students' perceptions regarding air pollution by gender with response categories of yes & no. Overall, 86% of males and 95.7% of females are aware of what air pollution is. Around 77% of males and 81% of females are interested in the issue of air quality in the area in which they live. About 72% of males and 90% of females are concerned about air pollution from vehicles or any other sources. The results show

significant variation between male and female students in the awareness of air pollution. Over 75% of male students 'care' about air quality when doing outdoor sports activities. This percentage varied significantly with 81.4% of female respondents. Approximately 79% of male and 80% of female participants perceived that there are actions they can take to protect themselves and reduce their exposure to air pollution. The difference between males and females in this response was insignificant (**Table 6**).

Around 59% of male and 50.5% of female students observed that schools are keen on raising awareness about air pollution. Moreover, 61.7% of male and 53.8% of female participants perceived that the school is keen to reduce air pollution. The results show significant variation between males and females in the awareness of air pollution (**Table 6**).

Table 7 presents the students' perceptions regarding air pollution by gender. Around 58.7% of males and 56%

Table 6. Students' perceptions regarding air pollution by gender (response category yes & no)

| Items | Response category | | | | Sig. level |
|--|-------------------|--------|--------|--------|------------|
| | Yes (%) | | No (%) | | |
| | Male | Female | Male | Female | |
| Do you understand the meaning of air pollution? | 86.0 | 95.7 | 13.9 | 4.3 | 0.01* |
| Do you care about the issue of air quality in the state in which you live (your governorate)? | 77.3 | 81.1 | 22.7 | 18.9 | 0.13 |
| Are you bothered by air pollution from vehicles or other sources? | 72.1 | 90.3 | 27.9 | 9.7 | 0.01* |
| Do you care about air quality when you do outdoor sports activities? | 75.1 | 81.4 | 24.9 | 18.6 | 0.01* |
| Do you think there are actions you can take to protect yourself and reduce your exposure to air pollution? | 79.0 | 80.8 | 21.0 | 19.2 | 0.44 |
| Do you think there are actions you can take to reduce air pollution in your school? | 75.4 | 73.1 | 24.6 | 26.9 | 0.40 |
| Is your school keen on raising awareness about air pollution? | 59.0 | 50.5 | 41.0 | 49.5 | 0.05* |
| Do you think your school is keen to reduce air pollution? | 61.7 | 53.8 | 38.3 | 46.2 | 0.01* |

Note. * $p \leq 0.05$

Table 7. Students' perceptions regarding air pollution by gender (other categories)

| Items | Response category | | | | | | Sig. level |
|--|--------------------|--------|---------------|--------|----------------|--------|------------|
| | Always (%) | | Sometimes (%) | | Never (%) | | |
| | Male | Female | Male | Female | Male | Female | |
| When you leave your home or school, do you care about the quality of the air you breathe? | 26.2 | 35.8 | 58.7 | 56.0 | 15.0 | 8.1 | 0.01* |
| Have you ever experienced difficulty or shortness of breath due to air pollution? | 7.1 | 9.4 | 54.1 | 60.2 | 38.8 | 30.4 | 0.01* |
| If you were walking in your neighborhood and the air felt polluted, to what extent would you look for a less polluted route? | 23.2 | 29.9 | 57.9 | 56.5 | 18.9 | 13.6 | 0.01* |
| To what extent do you think air pollution poses a risk to your health? | 27.9 | 36.9 | 55.7 | 54.3 | 16.4 | 8.9 | 0.01* |
| | Excellent | | Good | | Bad | | |
| How well would you rate the air quality in your neighborhood/place? | 65.0 | 70.2 | 6.8 | 7.8 | 28.1 | 21.9 | 0.06 |
| How high would you rate the air quality in the school you teach at? | 29.2 | 25.1 | 56.0 | 64.5 | 14.8 | 10.4 | 0.01* |
| | Dermal contact (%) | | Ingestion (%) | | Inhalation (%) | | |
| Do you know how people are exposed to toxic air pollutants that can pose health risks? | 9 | 2.8 | 19.7 | 8.5 | 71.3 | 88.7 | 0.01* |

Note. * $p \leq 0.05$

Table 8. Students' perceptions on other issues of air pollution by gender

| Items | Response category | | | | | | Sig. level |
|---|-------------------|--------|---------------------|--------|-------------------------|--------|------------|
| | Radio (%) | | TV (%) | | Social media (%) | | |
| | Male | Female | Male | Female | Male | Female | |
| How do you usually obtain information about air quality in your province? | 7.7 | 1.2 | 25.7 | 12.0 | 56.8 | 82.6 | 0.01* |
| What is the main means of transportation you use to get to and from school? | On foot (%) | | Private car (%) | | Bus (%) | | 0.01* |
| | 13.7 | 1.8 | 18.6 | 23.9 | 59.6 | 73.6 | |
| To what extent do you think the school curriculum pays attention to the issue of air pollution? | Never care (%) | | Care a little (%) | | Always care (%) | | 0.01* |
| | 30.3 | 15.1 | 53.6 | 65.9 | 16.1 | 18.9 | |
| In general, how do you rate yourself in paying attention to information about air quality? | I care a lot (%) | | I care somewhat (%) | | I don't care at all (%) | | 0.01* |
| | 32.8 | 30.9 | 55.7 | 62.2 | 11.5 | 6.9 | |

Note. * $p \leq 0.05$

of females 'sometimes' pay attention to the quality of the air when they go outdoors while few of them (8%-15%) never pay attention to the same issue. Only a few respondents (7%-9%) of male and female students felt they 'always' had difficulty or shortness of breath due to air pollution. While 54.1% of males and 60.2% of females had 'sometimes' felt shortness of breath due to air pollution. Around 23% of males and 30% of females always expressed their willingness to look for a less polluted route. While most of the participants sometimes expressed their willingness to take the same action. The results also show that nearly 28% of male and 37% of female students believe that air pollution poses a risk to their health. Differences between male and female participants regarding these responses were statistically significant (Table 7). Interestingly, most participants (over 65% male and 70% female) rated the air quality in their neighborhood/ place as excellent. While 28% of male students and 22% of females rated the air quality in their neighborhood/place as bad. No statistically significant difference between the genders' awareness of air pollution in this response. 56% of males and 64.5% of females rated the air quality in the school they teach general speaking as good. Almost 71.3% of males and 88.7% of females reported that 'breathing' contaminated air is the main pathway of exposure to toxic air pollutants that can pose health risks. While few respondents perceived other exposure routes including 'ingesting' or 'touching' contaminated soil and/or dust leading to exposure (Table 7). The results show significant differences between male and female respondents.

Table 8 illustrates students' perceptions of other issues of air pollution by gender. According to the responses of the students, social media was the main source of access to information about air pollution. The results reveal a significant variation between males and females in this response (Table 8). Over 59.6% of male and 73% of female students use the bus as the main means of transportation to get to and from the school

compared to 18.6% of males and 23.9% of females using private cars. While 13.7% of male students used to walk to school compared to only 1.8% of female students. Most of the students (over 53.6% of males and 65.9% of females) thought the school curriculum paid little attention to the issue of air pollution. Nearly 32% of males and only 30.9% of females 'care a lot' regarding air quality information compared to 55.7% of males and around 62.2% of females care 'somewhat' about the same issue. Differences between males and females in the abovementioned responses were significant (Table 8).

Second: Grade Variable

Table 9 shows students' perceptions regarding air pollution by grade (response category yes & no). Overall, 92.8%, 93.7%, and 91.9% of students from classes 9th, 10th, and 11th, respectively, are aware of what air pollution is. Over 77% of students in the three different grades are interested in the issue of air quality in the area in which they live. The results show insignificant variation between the three different grades in these responses. Over 85.8%, 86.9%, and 79.9% of students from classes 9th, 10th, and 11th, respectively, are bothered about air pollution from vehicles or any other sources. The results show significant variation between the three different categories in this response. Above 79% of students from classes 9th, 10th, and 11th 'care' about air quality when doing outdoor sports activities. Over 78% of students in the three different categories believed there are actions they can take to protect themselves and reduce their exposure to air pollution. Moreover, most of the students (over 69%) in three different grades believed there were actions they could take to reduce air pollution in their schools. However, 61.7% of students in grade 9th perceived that schools were keen on raising awareness about air pollution compared to almost 53% of the other two grades (10th and 11th) who did not perceive that. Almost 62.5% of students in grade 9th, 53.2% in grade 10th and only 46.9% in grade 11th perceived that the school is keen to reduce air pollution. The results show

Table 9. Students' perceptions regarding air pollution by grade (response category yes & no)

| Items | Response category | | | | | | Sig. level |
|--|-------------------|------------------|------------------|-----------------|------------------|------------------|------------|
| | Yes (%) | | | No (%) | | | |
| | 9 th | 10 th | 11 th | 9 th | 10 th | 11 th | |
| Do you understand the meaning of air pollution? | 92.8 | 93.7 | 91.9 | 7.2 | 6.3 | 8.1 | 0.64 |
| Do you care about the issue of air quality in the state in which you live (your governorate)? | 81.0 | 80.2 | 77.0 | 19.0 | 6.3 | 23.0 | 0.48 |
| Are you bothered by air pollution from vehicles or other sources? | 85.8 | 86.9 | 79.9 | 14.2 | 19.8 | 20.1 | 0.05* |
| Do you care about air quality when you do outdoor sports activities? | 79.5 | 79.6 | 80.4 | 20.5 | 20.4 | 19.6 | 0.96 |
| Do you think there are actions you can take to protect yourself and reduce your exposure to air pollution? | 81.3 | 80.1 | 78.5 | 18.7 | 20.4 | 21.5 | 0.66 |
| Do you think there are actions you can take to reduce air pollution in your school? | 76.7 | 72.6 | 69.4 | 23.3 | 27.4 | 30.6 | 0.09 |
| Is your school keen on raising awareness about air pollution? | 61.7 | 46.7 | 46.9 | 38.3 | 53.3 | 53.1 | 0.01* |
| Do you think your school is keen to reduce air pollution? | 62.5 | 53.2 | 46.9 | 37.5 | 46.8 | 53.1 | 0.01* |

Note. * $p \leq 0.05$

Table 10. Students' perceptions regarding air pollution by grade (other categories)

| Items | Response category | | | | | | | | | Sig. level |
|--|--------------------|------------------|------------------|-----------------|------------------|------------------|-----------------|------------------|------------------|------------|
| | Always (%) | | | Sometimes (%) | | | Never (%) | | | |
| | 9 th | 10 th | 11 th | 9 th | 10 th | 11 th | 9 th | 10 th | 11 th | |
| When you leave your home or school, do you care about the quality of the air you breathe? | 31.4 | 33.4 | 37.3 | 58.8 | 56.6 | 52.2 | 9.8 | 10.1 | 10.5 | 0.58 |
| Have you ever experienced difficulty or shortness of breath due to air pollution? | 7.4 | 7.5 | 15.8 | 57.9 | 62.2 | 50.2 | 34.8 | 30.3 | 34.0 | 0.01* |
| If you were walking in your neighborhood and the air felt polluted, to what extent would you look for a less polluted route? | 30.1 | 25.2 | 30.6 | 57.1 | 58.1 | 53.1 | 12.8 | 16.7 | 16.3 | 0.14 |
| To what extent do you think air pollution poses a risk to your health? | 33.6 | 33.9 | 37.8 | 55.6 | 55.2 | 50.7 | 10.7 | 10.9 | 11.5 | 0.80 |
| | Excellent (%) | | | Good (%) | | | Bad (%) | | | |
| How well would you rate the air quality in your neighborhood/place? | 68.2 | 71.7 | 62.2 | 5.7 | 5.8 | 17.2 | 26.1 | 22.5 | 20.6 | 0.001* |
| How high would you rate the air quality in the school you teach at? | 29.9 | 24.0 | 23.0 | 60.4 | 63.7 | 62.2 | 9.6 | 12.3 | 14.8 | 0.06 |
| | Dermal contact (%) | | | Ingestion (%) | | | Inhalation (%) | | | |
| Do you know how people are exposed to toxic air pollutants that can pose health risks? | 4.1 | 3.6 | 8.1 | 9.8 | 10.6 | 19.1 | 86.1 | 85.9 | 72.7 | 0.01* |

Note. * $p \leq 0.05$

significant variation between the three different grades in the above responses (**Table 9**).

Table 10 presents students' perceptions regarding air pollution by grade level. About 58.8%, 56.6%, and 52.2% of students from grades 9th, 10th, and 11th, respectively, 'sometimes' pay attention to the quality of the air when they go outdoors while few of them (9.8%-10.5%) never pay attention to the same issue. Only a few respondents (15.8-7.4%) of three different categories of students felt they 'always' had difficulty or shortness of breath due to air pollution.

In contrast, 57.9%, 62.2%, and 50.2% of students from classes 9th, 10th, and 11th, respectively, had 'sometimes' felt shortness of breath due to air pollution. Differences between the three different categories in this response were significant. Over 53% of the participants expressed their willingness to look for a less polluted route. Likewise, most participants of the three different grades

(50.7-55.6%) believe that air pollution poses a risk to their health. Differences between participants regarding these responses were statistically insignificant (**Table 10**). Remarkably, most students over 68.2%, 71.7%, and 62.2% in grades 9th, 10th, and 11th, respectively rated the air quality in their neighborhood/ place as excellent. While few of the students (around 5.7%-17%) rated the air quality in their neighborhood/ place as good. The difference between the three groups in this response was significant. Most of the participants (over 60%) rated the air quality in the school they teach at is overall good. Nearly 72% to 86% of students in the different three grades reported that 'breathing' contaminated air is the main pathway of exposure to toxic air pollutants that can pose health risks. While only a few respondents (4%-8%) perceived that 'touching' contaminated soil and/ or dust leads to exposure (**Table 10**). The results show significant differences between different respondent groups.

Table 11. Students' perceptions on other issues of air pollution by grade

| Items | Response category | | | | | | | | | Sig. level |
|---|-------------------|------------------|------------------|---------------------|------------------|------------------|-------------------------|------------------|------------------|------------|
| | Radio % | | | TV% | | | Social media % | | | |
| | 9 th | 10 th | 11 th | 9 th | 10 th | 11 th | 9 th | 10 th | 11 th | |
| How do you usually obtain information about air quality in your province? | 3.70 | 1.5 | 5.3 | 20.7 | 5.5 | 10 | 70.6 | 79.7 | 76.6 | 0.01* |
| What is the main means of transportation you use to get to and from school? | On foot (%) | | | Private car (%) | | | Bus (%) | | | 0.01* |
| | 4.1 | 3.6 | 11.5 | 19.4 | 27.3 | 16.7 | 72.8 | 66.8 | 70.3 | |
| To what extent do you think the school curriculum pays attention to the issue of air pollution? | Never care (%) | | | Care a little (%) | | | Always care (%) | | | 0.01* |
| | 15.0 | 19.6 | 29.7 | 65.1 | 63.9 | 52.2 | 20.0 | 16.5 | 18.2 | |
| In general, how do you rate yourself in paying attention to information about air quality? | I care a lot (%) | | | I care somewhat (%) | | | I don't care at all (%) | | | 0.09 |
| | 31.2 | 30.8 | 33.5 | 60.8 | 62.4 | 54.1 | 7.9 | 6.8 | 12.4 | |

Note. * $p \leq 0.05$

According to the responses of the students in the three grades, social media was the primary source of access to information about air pollution. However, students in grade 9th use TV as a source of access to information about air pollution significantly more than others in grades ten and eleven (**Table 11**). Most of the students (over 66%) from the three different grades use the bus as the main transportation mode to get to and from the school compared to some of them using private cars and very few on foot. The majority (over 52%) thought that the school curriculum pays little attention to the issue of air pollution. The results show a significant variation between the three groups in the above responses (**Table 11**). Just about 30.8% to 33.5% of the participants 'care a lot' regarding air quality information compared to 54.1% to 62.4% of the participants are 'somewhat' about the same issue. The difference between the three groups in this response was insignificant (**Table 11**).

DISCUSSION

In this study, we aimed to investigate the level of Omani school students' awareness of air pollution and its health effects due to gender and grade variables. The participants in the study were mainly composed of 27.4% male and 72.6% female and comprised of 40.5% grade 9 students, while the grade 10 students were 43.9%, and the grade 11 students were 15.6% (**Table 1**). The percentage of female student participants was more than their male student counterparts. This could be explained as either the number of female schools who participated was higher than the male schools or the female students were more interested in the study. In the study conducted by Rajper et al. (2018), the number of female student participants was more than their male counterparts. The percentage of participants from grade nine and ten students was almost double that for grade eleven students. According to NCSI (2023), the number of grade 11th students in government schools is lower than their grade counterparts in 9th and 10th. The

correlation coefficients for all survey items range between (0.455-0.876), revealing a correlation coefficient that varies within this range which affirms the reliability of the survey.

For the first question of the study, "What is the level of Omani public school students' awareness of air pollution and its health effects?" A statistical calculation shows a moderate level of awareness among students in government schools regarding air pollution and its health effects in the Sultanate of Oman. Unni et al. (2022) found that the levels of knowledge and behavior towards indoor air quality were low while the attitude levels within the study population were moderate.

For the second question, "Are there statistically significant differences at level of $\alpha \leq 0.05$ of Omani students' awareness of air pollution and its health effects due to gender and grade level?" The results show statistically significant differences in student's opinions regarding awareness of air pollution and its health effects in the Sultanate of Oman attributed to gender and grade variables. **Table 6** revealed statistically significant differences between the ninth and tenth grades in favor of the tenth grade and between the ninth and eleventh grades in favor of the eleventh grade. Meanwhile, no statistically significant differences existed between the tenth and eleventh grades. Shabani et al. (2024) found that the perceptions of air pollution were affected by the grade level and gender of the student participants. There was a statistically significant difference between the responses of the students regarding air pollutants in different year groups (Myers et al., 2004). It can be stated that the students' perceptions regarding air pollution are affected by gender and grade level.

Our data show that around 86% of males and 95.7% of females are aware of what air pollution is (**Table 6**). On the other hand, 77% of males and 81% of females are interested in the issue of air quality in the area in which they live. Also, 72% of males and 90% of females are concerned about air pollution from vehicles or any other sources. The awareness of females about air pollution

was significantly higher than that of males. Rajper et al. (2018) noticed that female students had significantly higher levels of air pollution awareness as compared to their male counterparts. Almost 75% of male respondents' 'care' about air quality when doing outdoor sports activities varied significantly with 81.4% of female respondents. The female respondents were more careful regarding air pollution as they took more preventative measures (Rajper et al., 2018). It can be stated that females are more vulnerable than males to the effects of air pollution. Remarkably, 59% of male and 50.5% of female students observed that schools were keen on raising awareness about air pollution. Furthermore, 61.7% of male and 53.8% of female participants perceived that the school is keen to reduce air pollution. The results show that the awareness of male students towards the school's role regarding air pollution awareness and reduction actions is significantly higher than female students (Table 6). There was a significant difference between males and females in the awareness and adoption of preventive measures (Ullah et al., 2021).

About 58.7% of males and 56% of females 'sometimes' pay attention to the quality of the air when they go outdoors while a few of them (8-15%) never pay attention to the same issue (Table 7). Another finding was that 54.1% of males and 60.2% of females had 'sometimes' felt shortness of breath due to air pollution. Results from Table 7 show that female students pay a significant attention to the quality of the air when they go outdoors than their male counterparts. Another finding was that around 23% of males and 30% of females always expressed their willingness to look for a less polluted route. Similarly, nearly 28% of male and 37% of female students believe that air pollution poses a risk to their health. Table 7 demonstrates that female students expressed their willingness to take action to reduce their exposure to air pollution risk significantly compared to male students. This is consistent with the previous research where Myers et al. (2004) found that females are more inclined towards taking individual action regarding air pollution. Moreover, we found that most participants reported that the air quality in their neighborhood/place was excellent. However, few of them rated that the air quality in their neighborhood/place is bad. There was no significant difference between the genders' awareness of air pollution in this response. Further, most respondents recognized that the air quality in the school they study at is good. This can be explained as that the general air quality condition in the four governorates in Oman from the students' view seems good. Al-Shidi et al. (2020a) reported that the average concentration of particulate air pollution in the major three cities in Oman did not exceed WHO (2013) standards which may be considered better as compared to polluted cities. Our results also show that most of the participants have indicated that

breathing contaminated air is the main pathway to exposure to toxic air pollutants. This result was consistent with the previous studies conducted by Liu et al. (2017).

Results from the study show that social media was the main source of access to information about air pollution (Table 8). Female students usually use social media to access information about air pollution significantly compared to male students. Our result is consistent with the previous studies (Al-Shidi et al., 2021; Liu et al., 2017). Public authorities may utilize social media platforms to inform the public about air quality outdoors principally in areas with more exposed people such as schools, children's play yards, and elderly care centers (Al-Shidi et al., 2021). Female students use the bus as their major daily transportation mode to get to and from school significantly more than male students. On the other hand, male students used to walk to school significantly compared to female students. McDonald (2012) reported that males walked to and from school significantly more than females whereas female students use the school bus or private vehicle to go and return from school. There are many reasons for this, one of them related to female physiology and another one due to Omani culture where the parent would not allow their daughters to go walking alone (too much care about their safety). Results also show that most of the students thought the school curriculum pays little attention to the issue of air pollution. This may be because the school curricula did not address the issue of air pollution widely, especially the science curricula, or because there is no curriculum specialized in the environment or environmental issues. Another finding was that male students 'care a lot' regarding air quality information significantly compared to female (Table 8). Al-Shidi et al. (2021) reported that males' greater exposure to pollutants in the outdoor environment than females may have in turn led to increased interest in air quality information.

The results show that most of the students in the three different grades reported that they are aware of what air pollution is and they are interested in the issue of air quality in the area in which they live (Table 9). This could be indicated by a high level of students' air pollution awareness. The results also show significant variation between the three different categories in the awareness of air pollution where the students from grade 10th are significantly concerned about air pollution from vehicles or any other sources. Cho et al. (2014) stated that polluted air aggravates tension, and depression and changes behavior. Another finding was that most of the students from the three grades 'care' about air quality when they are doing outdoor sports activities and believe there are actions, they can take to protect themselves and reduce their exposure to air pollution. Air pollution negatively affects the outdoor sports activities that an individual practices to maintain

his fitness and physical health (Li et al., 2014). Similarly, results show that most of the students believed there are actions they can take to reduce air pollution in their school. Our data also show that most of the students in grade 9th have significantly perceived that the schools are keen on raising awareness about air pollution and keen to reduce air pollution (**Table 9**). Our outcomes are consistent with most of the literature. Rajper et al. (2018) found that most of the students reported that they had experienced the ill effects of air pollution and suffered from different effects such as breathing and respiratory problems.

Our finding shows that most of the students from the three categories 'sometimes' pay attention to the quality of the air when they go outdoors compared to the few of them who never pay attention to the same issue (**Table 10**). This can be explained as most of the participants are interested in air quality when they go outdoors and have a good awareness, behavior, and attitude towards air pollution. Another finding was that a few respondents felt they 'always' had difficulty or shortness of breath due to air pollution while most of them had 'sometimes' felt shortness of breath due to air pollution. The variation in these responses can be attributed to the student's health status, variation in air pollution levels in the governorates studied, and multiple genetic polymorphisms (London, 2007; Sandstrom & Kelly, 2009). We also found that most of the students expressed their willingness to look for a less polluted route and they also believe that air pollution poses a risk to their health. The results show that there was no significant difference between the awareness of students in each grade towards the associated health risks of air pollution. Our result was consistent with the study conducted by Rajper et al. (2018), where no significant difference was observed between the students in the awareness of the associated health risks of air pollution. Another relevant finding of the study is that most students rated the air quality in their neighborhood/place as excellent while they rated the air quality in the school, they teach at is good. This is because the general air quality conditions in the governorates studied were accepted (Al-Shidi et al., 2020a). Another finding is that most of the participants reported that 'breathing' contaminated air is the main pathway of exposure to toxic air pollutants that can pose health risks which is consistent with the previous studies (Al-Shidi et al., 2021; Liu et al., 2017).

We found that social media was the primary source of access to information about air pollution in the three different categories (**Table 11**). Yet grade 9th students use TV as a source of access to information about air pollution significantly more than others in different grades. Grade 9th students may spend more time watching television and its various programs than students in the other two grades, but this requires more studies to confirm this behavior. Skamp et al. (2004)

found that schools and other media such as television are the primary sources for students to obtain information about environmental issues. Various sources, such as the Internet, multimedia, and social networking sites, are useful means of conveying information about air pollution (Rajper et al., 2018). The main means of transportation to and from the school is the bus for most participating students, followed by the private car, and then very few of them use walking. This result is accepted because the Ministry of Education (2019, 2022) in the Sultanate of Oman provides school transportation by buses free of charge to all students, while some of them might use private cars or other means of transportation. We also found that most of the participants in different categories thought that the school curriculum pays little attention to the issue of air pollution. The result shows only 30.8% to 33.5% of the participants 'care a lot' regarding air quality information compared to most of the participants who care 'somewhat' about the same issue. This can be explained as that the students are interested in getting the air quality information where the majority 'somewhat' and some of them 'care a lot'. While in the study conducted by Kasirye et al. (2020) found that students normally look for information on air pollution on the Internet and they want to share it on social media platforms.

CONCLUSION

The current study indicated that the level of awareness among students in government schools regarding air pollution and its health effects in the Sultanate of Oman is moderate. Results also demonstrate significant differences in the students' perceptions regarding awareness of air pollution and its health effects attributed to gender which is mainly in favor of females. Additionally, there are statistically significant differences in the students' perceptions regarding awareness of air pollution and its health effects in the Sultanate of Oman due to the grade variable. The data reveal that female students are significantly careful about air quality when doing outdoor sports activities more than male students. The results also show that the awareness of male students towards the school's role regarding air pollution awareness and reduction actions is significantly higher than female students. Conversely, female students pay significant attention to the quality of the air when they go outdoors.

Furthermore, female students expressed their willingness to take action to reduce their exposure to air pollution risk significantly compared to male students. Moreover, most of the participants have indicated that breathing contaminated air is the main pathway of exposure to toxic air pollutants. We also found that female students usually use social media to access information about air pollution and they use the bus as their major school transportation mode significantly compared to their male counterparts. In contrast, male

students used to walk to school significantly compared to female students. The data reveal that male students 'care a lot' regarding air quality information significantly compared to females. The results exhibit that there was no significant difference between the awareness of students in each grade towards the associated health risks of air pollution. In addition, the results show that grade nine students use TV as a source of access to information about air pollution more than students in grades ten and eleven. Also, the data show that most of the participants in different categories thought that the school curriculum pays little attention to the issue of air pollution.

Environmental education is considered a basic pillar of formal education within the general framework of the national curriculum. Therefore, including environmental concepts and initial innovative approaches regarding air pollution in the current curriculums has significant implications for improving school students' awareness of environmental issues (Ambusaidi et al., 2012). Thus, the environmental education curriculum should be conducted in a way that enables students to take responsibility for raising awareness of various environmental issues. Meantime a comprehensive study needs to be conducted in all governorates in Oman to assess students' awareness, of air pollution in the different cities.

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Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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