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Community perception about air pollution, willingness to pay and awareness about health risks in Chandigarh, India

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ABSTRACT

Air pollution is one of the major risk factors for mortality, as per the Global Burden of Diseases. Various natural and anthropogenic sources contribute to air pollution, which makes air quality worse. Community perceptions of air pollution are crucial in deciding how people will react and whether they will accept relevant policies. Therefore, people's awareness, behavior and perception must be known to engage communities in air pollution reduction. This study aimed to determine the levels and correlations between people's perceptions of pollution and health risk before COVID-19 and during the COVID-19 period in Chandigarh. The study was conducted following the interview schedule methodology using a standard questionnaire. Univariate and air pollution hotspot analysis was conducted to assess the correlation of variables and to evaluate the spatial variation in the perceived levels. The results revealed that 79.9% of respondents were worried about the city's air quality. It was observed that 39.2% of study participants perceived that automobile emissions were the primary source of air pollution. Association of sociodemographic factors with the awareness of air pollution, health effects, and people's attitudes was also assessed. The study observed a strong correlation between people's education status and their knowledge of air pollution during the COVID-19 period (p-value = 0.064) and the pre-COVID period (p-value = 0.035). On assessing the air quality perception and respondent's happiness as a place to live, participants' happiness was found to be strongly correlated with their neighborhood as a place to live with their opinion of the air quality (p-value = 0.000). However, this correlation was insignificant during the COVID-19 period (p-value = 0.192). Respondents perceived that exposure to air pollution is related to respiratory and chest problems. A linear relationship was observed between people's willingness to improve air quality and awareness, which shows a statistically significant association (0.076 and 0.001) during the COVID-19 and pre-COVID period. People's attitudes and actions towards air pollution suggested that people are willing to pay to mitigate air pollution to enhance environmental sustainability and quality of life.

1. Introduction

Air pollution is the mixture of harmful or toxic substances, such as solid particles and gases in the air, which are hazardous to health. Air pollution is one of the major risk factors for health problems (Egondi et al., 2013) and ranked at 5th position for the associated premature mortality globally, as per the Global Burden of Diseases (Cohen et al., 2017). World Health Organization (WHO) reported that 7 million people lose their lives every year due to air pollution and 9 out of 10 people breathe air that contains a high level of pollutants or guidelines set by WHO World Health Organization (2022a). Various natural and anthropogenic activities contribute to an increased load of air pollutants that worsens the air quality. Both outdoor and indoor air pollution are caused by various natural and anthropogenic activities.

Outdoor air pollutants increase due to transportation, industries, power generation, biomass burning, stubble burning, etc. The burning of solid fuels such as firewood and dried cow dung for cooking is the major cause of indoor / household air pollution and is being used by over 3 billion people, mainly by poor households or people living in rural areas (Jindal et al. 2020). Smoking tobacco inside homes is also a major factor for indoor air pollution, resulting in adverse health outcomes (Suryadhi et al., 2019). Other pollutants released from freshly painted walls, pesticides, gases such as radon, carbon monoxide, poorly ventilated buildings, etc. Vehicular emissions are the most critical factor leading to air pollution in urban areas. Rapid population growth

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leads to large consumption of resources contributing to air pollution (Gurjar et al., 2016).

High level of air pollution in the cities is a risk factor for various health problems such as cardiovascular disease, respiratory diseases, etc. Outdoor air pollution (mainly industrial and vehicular emissions) is associated with an increased incidence of lung cancer in humans (Ravindra et al., 2001). Vulnerable populations such as children, women and senior citizens and those with prior heart diseases are more susceptible to adverse effects of air pollution (Tibuakuu et al., 2018). Every year, around 93% of children below 15 years of age get exposed to polluted air and suffer from serious health issues (World Health Organization, 2022b). According to WHO, if the concentration of fine particulate matter is reduced from 35 $\mu g/m^3$ to 10 $\mu g/m^3$, 15% of deaths related to air pollution could be reduced (Giannadaki et al., 2016).

Air pollution is a major health concern in India and many cities in the country are struggling with poor air quality (Mor et al., 2022; Ravindra et al., 2022c). Chandigarh is also one of the cities that are notified as non-attainment cities in India (Singh et al., 2020). Vehicular emissions, construction works around the city, industries, soil dust, and agricultural emission (burning in the open) are the major sources of air pollution in the city (Cisneros et al., 2017; Ravindra et al., 2022b). To mitigate air pollution, many policies have been implemented in the country; but without involving people. However, it is not possible to combat the problem of air pollution without citizen engagement. Hence, understanding the population's knowledge, attitude, and perception (KAP) is the key to formulating and implementing new program such as the National Clean Air Programme (NCAP) in India, which aim to reduce 40–60% of particulate pollution in non-attainment cities by 2024-26.

Considering this, the study's primary goal was to understand the Chandigarh residents' knowledge, attitude, and perception (KAP) about the city's air quality and related health risks. A better understanding of public perception about air pollution and associated risk will help policymakers to better plan and implement appropriate policies under NCAP, as the region remains a hotspot of high air pollution, especially during the winter season. Further, while we were in the middle of the study, the Indian Government introduced a complete lockdown to restrict the spread of COVID-19 disease. The first lockdown was enforced in India from 25th March to 17th May 2020. During the lockdown, traffic plummeted and the major anthropogenic activities were limited till 31st August 2020 (partial relaxation) . Hence, the proposed study also provided us an opportunity to assess the KAP of the people before and during the COVID-19 pandemic in Chandigarh. Many examples showed how COVID-19 changes people's perception of environmental conservation (Rousseau and Deschacht, 2020; Zebardast and Radaei, 2022). Hence, this study will be helpful in exploiting people's awareness of air pollution reduction, including green recovery, to promote environmental sustainability. Further, this is the first study deliberating on people's perception of air quality before and during COVID-19 to strengthen community participation in air pollution reduction.

2. Material and methods

2.1. Site specifications

Chandigarh is a planned city and the Union Territory of India (constituted on 1st November 1966) and the capital of two neighboring states of Haryana and Punjab. It is 265 km north of New Delhi. The city was designed by the Swiss-French modernist architect Le Corbusier (Shaw, 2009). The buildings designed by Le Corbusier were Capitol Complex with its High Court, Secretariat and Legislative Assembly, etc. The total area of the Union Territory is 114 sq km. The population of Chandigarh in 2011 was 1,063,000 and the population in 2020 increased to 1,148,000. The sex ratio of Chandigarh stood at 818 females for every 1000 males. The city is divided into rectangular sectors. UNESCO in 2016 declared the Chandigarh capitol complex, located in sector-1 of the town, as a World Heritage Site. In the city, five sampling sites were selected. These sites include Sector 17 (Commercial area), IMTECH (Institutional area), Village Kaimbwala (Rural area), Industrial area (Industrial area) and PEC Sector 12 (Institutional area), shown in Fig. 1.

2.2. Sampling procedure

The study area covered the population living in Chandigarh for more than five years. The sampling units were households and markets places and the sample size was calculated based on the following formula:

$$\mathbf{N} = \frac{\mathbf{t^2xpq}}{\mathbf{d^2}}$$

where t= critical value for the desired confidence level, confidence interval set at 95% for which t = 1.96.

Since the proportion of interest is unknown; we considered it to be 50% (p = 0.5), where q = 1-p and d= desired precision. 95% chance that the real value is within +6.93% to – 6.93% of the surveyed value. From the above formula, the final sample size was set at 200. We included 200 study participants before COVID-19 and 200 during the COVID-19 period, totaling 400 study participants for this comparative study.

2.3. Study design and study tools

Sampling was carried out using a cross-sectional study. Information gathered from the study participants was taken using a quantitative questionnaire. Both open-ended and close-ended questions were used in the research questionnaire. The questionnaire consisted of 85 questions, which were divided into five different sections. The first section covered the respondents' basic sociodemographic characteristics, such as age, gender, marital status, education, monthly family income, etc. The second section covered the current health status of the people. The third section consisted of the perception of air pollution, such as awareness of air pollution, sources of air pollution, impacts of air pollutants, etc.

The fourth section covered the perceptions about the health effects of air pollution, such as difficulty in breathing, eye irritation, asthma, heart disease, etc.. The fifth section covered the people's attitude towards air pollution, such as what one can do to prevent air pollution, their willingness to pay to improve the air quality. A pilot test on the 12 people was done to check the ambiguous wording and unclear instructions in the questionnaire. Both English and Hindi languages were used for a better understanding of the people's perceptions.

People were surveyed from households and marketplaces from each sampling site. Interviews were taken from people who were 18 years of age and above of both gender and those who have resided in Chandigarh for more than five years. Only one adult was selected from each home. When multiple adult residents live together, the adult with the closest birthday was selected to participate in the survey. Therefore, the selection criteria were based on age, gender, location (as Chandigarh city was divided into five zones), education and occupation. In the study, information was collected in two different periods: during February- March 2020 (in the pre-COVID period) and during the COVID-19 period (in August- September 2020) using the same questionnaire.

The data in two different periods were taken to analyze the respondents' knowledge, attitude, and perception of air pollution and its health hazards before and during the COVID-19 pandemic. The air pollution data was taken from the Chandigarh Pollution Control Committee (CPCC) and Continuous Air Quality Monitoring Station (CAQMS), situated in Sector 25, Panjab University, Chandigarh, to explore the association of spatial variation and community perception.

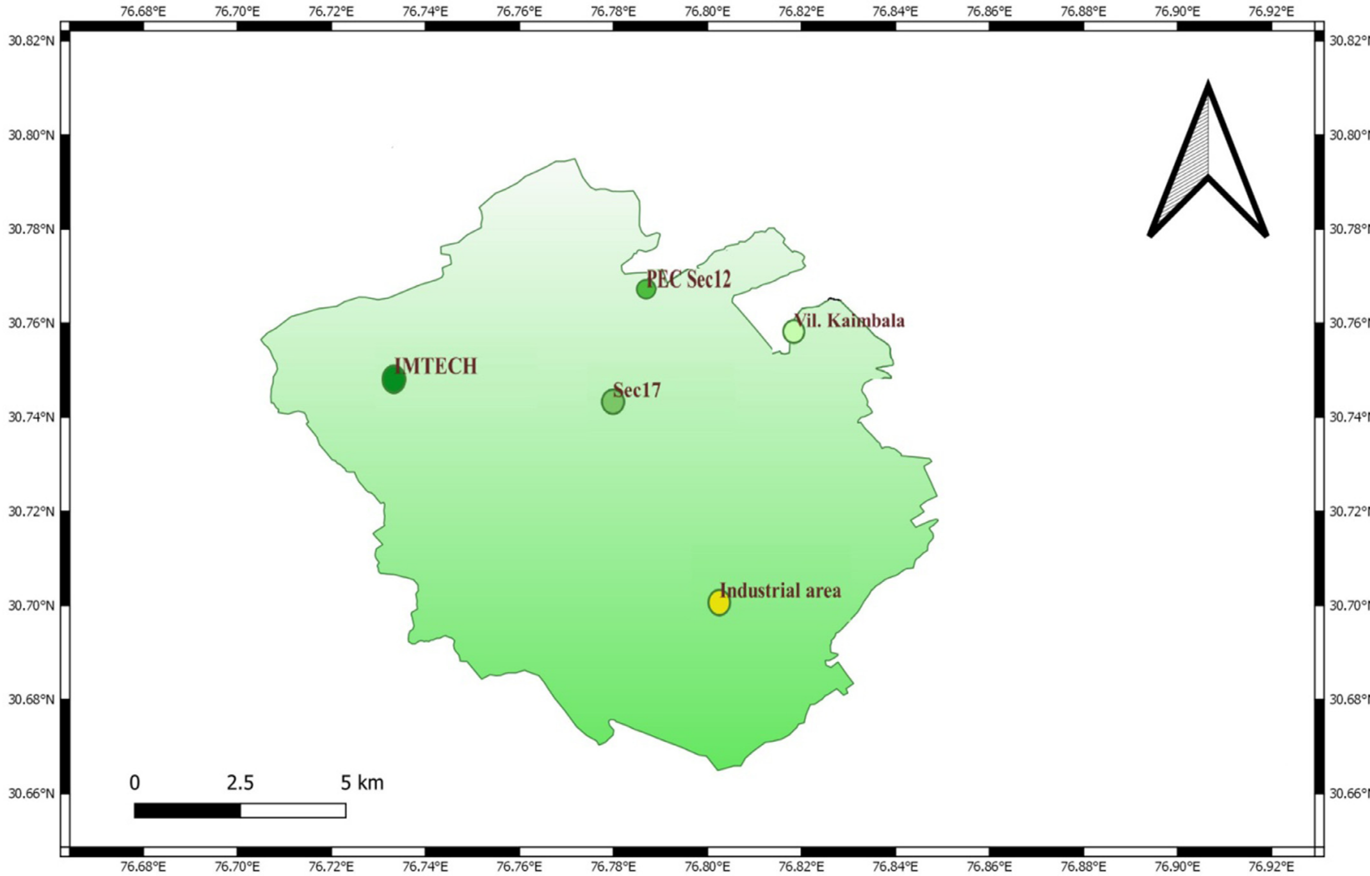

Fig. 1. Locations of the sampling sites on the map of Chandigarh.

2.4. Ethical clearance

The study protocol was approved by the Institute Ethics Committee of the Post Graduate Institute of Medical Education and Research, Chandigarh, India (NK/6031/MPH/908). The details are provided in the supplementary file.

2.5. Statistical analysis

Statistical tests were used to scrutinize the relationship between the independent variable and the dependent variable. Here, the chi-square test was used to assess the correlation of variables as well as the associated linear trend. Univariate analysis of the data was done using Microsoft excel in the form of tables and frequencies and bivariate analysis was done using the software SPSS 16. To assess the spatial pattern in perception and air pollution, maps were generated using the QGIS program.

3. Results and discussion

3.1. Sociodemographic characteristics of the respondents

Sociodemographic factors are important predictors of community perception of air pollution. We have compared the information gathered from respondents in the pre- and during the COVID-19 period to assess the behavioral aspect of people. During the COVID-19 pandemic, a significant reduction in the pollution level was observed, as also reported by Mor et al. (2020). We find that despite the decline in pollution levels, respondents' awareness of the environment was not affected. Respondent's awareness was stratified based on age group (Table 1). During the COVID-19 period, 100% of people above 60 years, 82.6% in 18–24 years and 75.7% in the 35–40 years age group were aware of air pollution. Similar results in pre-COVID time were also observed, i.e., 100% of people in the 35–40 years age group had shown awareness. Similar results (75%) were seen in the 41–50 years age group in both periods. Respondents in the younger age group were found to be more aware of air pollution in both periods. This might be because younger people living in cities or working in factories are exposed to poor air quality (Pantavou et al., 2017). However, senior (60+ age group) respondents during the COVID-19 period were more aware (100%) of air pollution. Results showed that different age groups' knowledge of air pollution during the COVID-19 and pre-COVID periods did not significantly correlate (p-values of 0.204 and 0.200, respectively).

To differentiate awareness based on gender, we stratified the data based on the sex variable. In pre-COVID time, a significant association (p-value = 0.000) was seen between sex variables and awareness of air pollution. Approximately 72% of males and 75% of females were aware of air pollution. A study by Pantavou et al. (2017) found that females were more aware of air pollution than males. During the COVID-19 period (p-value = 0.064) and pre-COVID time (p-value = 0.035), a significant association was seen between people's education status and air pollution awareness. Awareness of air pollution was more among educated people than among illiterate respondents. Public education was associated with health risks due to exposure to harmful air pollutants (Liu et al., 2016). Only 50% of the illiterate respondents had shown awareness of air pollution. We have assessed the results of occupation with air pollution awareness.

However, the results were not statistically significant during the COVID- 19 period (p-value = 0.807) and pre- COVID period (p-value = 0.182). Mixed results were observed for professional, non-

Table 1
Association between air pollution awareness and various sociodemographic factors.

Variables	Respondents aware of air pollution				*p*-value	
	(During COVID period)		(pre-COVID time)		During the COVID period	Pre-COVID time
	N	n (%)	N	n (%)		
Age group						
18-24	23	19 (82.6%)	136	101 (74.3%)	0.204	0.200
25-34	97	63 (64.9%)	38	29 (76.3%)		
35-40	33	25 (75.7%)	4	4 (100%)		
41-50	32	24 (75%)	4	3 (75%)		
51-59	19	13 (68.4%)	1	0		
60+	8	8 (100%)	1	0		
Sex						
Male	154	115 (74.6%)	88	64 (72.7%)	0.117	0.000
Female	58	37 (63.7%)	99	75 (75.8%)		
Education						
Graduate or postgraduate	173	122 (70.5%)	155	115 (74.2%)	0.064	0.035
post high school/school	37	29 (78.3%)	23	18 (78.3%)		
Illiterate	2	1 (50%)	2	1 (50%)		
Occupation						
Profession	142	103 (72.5%)	52	39 (75%)	0.807	0.182
Non-Professional	45	30 (66.6%)	15	11 (73.3%)		
Unemployed	24	18 (75%)	104	81 (77.9%)		

Table 2
Perception of air pollution and participants' happiness with their neighborhood.

Association between air quality perception and participants' happiness with their neighborhood

Variable	Air quality perception								p-value	
	During COVID period				Pre-COVID period					
	N	Bad, n (%)	Neither bad nor good, n (%)	Good, n (%)	N	Bad, n (%)	Neither bad nor good, n (%)	Good, n (%)	During COVID	Pre-COVID
Happy	127	9 (7.0)	35 (27.6)	83 (65.3)	127	33 (26.0)	42 (33.1)	46 (36.2)	0.192	0.000
Neither happy nor unhappy	31	2 (6.4)	16 (51.6)	13 (41.9)	27	6 (22.2)	16 (59.3)	4 (14.8)		
Unhappy	53	6 (11.3)	16 (30.1)	31 (58.4)	14	11 (78.6)	3 (21.4)	0		

Variable	Perception of Air Pollution n (%)		
	During COVID time	Pre-COVID time	Total
Aware of air pollution	152(72%)	142(91%)	294(79.9%)
Not aware of air pollution	60(28%)	14 (9%)	74(20.1%)
Air quality perception compared to the previous year			
Much better	45(21%)	25 (15.4%)	70(18.7%)
Slightly better	65(31%)	42 (25.9%)	107(28.6%)
Same	84(40%)	53 (32.7%)	137(36.6%)
Slightly worse	18(8%)	35 (21.6%)	53(14.2%)
Much worse	0(0%)	7 (4.3%)	7(1.9%)
People's perception about the time of maximum pollution in a day			
Morning	37(14.2%)	30 (17.5%)	67(15.5%)
Noon	41(15.8%)	34 (19.9%)	75(17.4%)
Afternoon	151(58.1%)	86 (50.3%)	237(55%)
Night	31(11.9%)	21 (12.3%)	52(12.1%)
How informed are you about air quality issues?			
Very well informed	20 (10%)	34 (20.2%)	54 (14.3%)
Well informed	104 (50%)	77 (45.8%)	181 (48%)
Not well informed	68 (32%)	44 (26.2%)	112 (29.7%)
Not informed at all	8 (4%)	2 (1.2%)	10 (2.7%)
'Don't know	9 (4%)	11 (6.5%)	20 (5.3%)
Do you know of any place in Chandigarh that shows Air Quality Information?			
Yes	99 (47%)	61 (40.7%)	160 (44.2%)
No	113 (53%)	89 (59.3%)	202 (55.8%)

professional and unemployed respondents who had shown awareness of air pollution. This is because workers (laborers) in factories are exposed to harmful pollutants such as particulate matter (PM), black smoke, nitrogen dioxide (NO_2) and ozone (O_3), etc., people with low socioeconomic status are more likely to expose to air pollutants (Egondi et al., 2013). Detailed results are shown in Table 1.

3.2. Perception of air pollution

Association between air quality perception and respondent's happiness as a place to live has been summarized in Table 2. In both the COVID-19 and pre-COVID periods, the maximum number of respondents (51.6% and 59.3%) perceived air quality as neither good nor bad, so

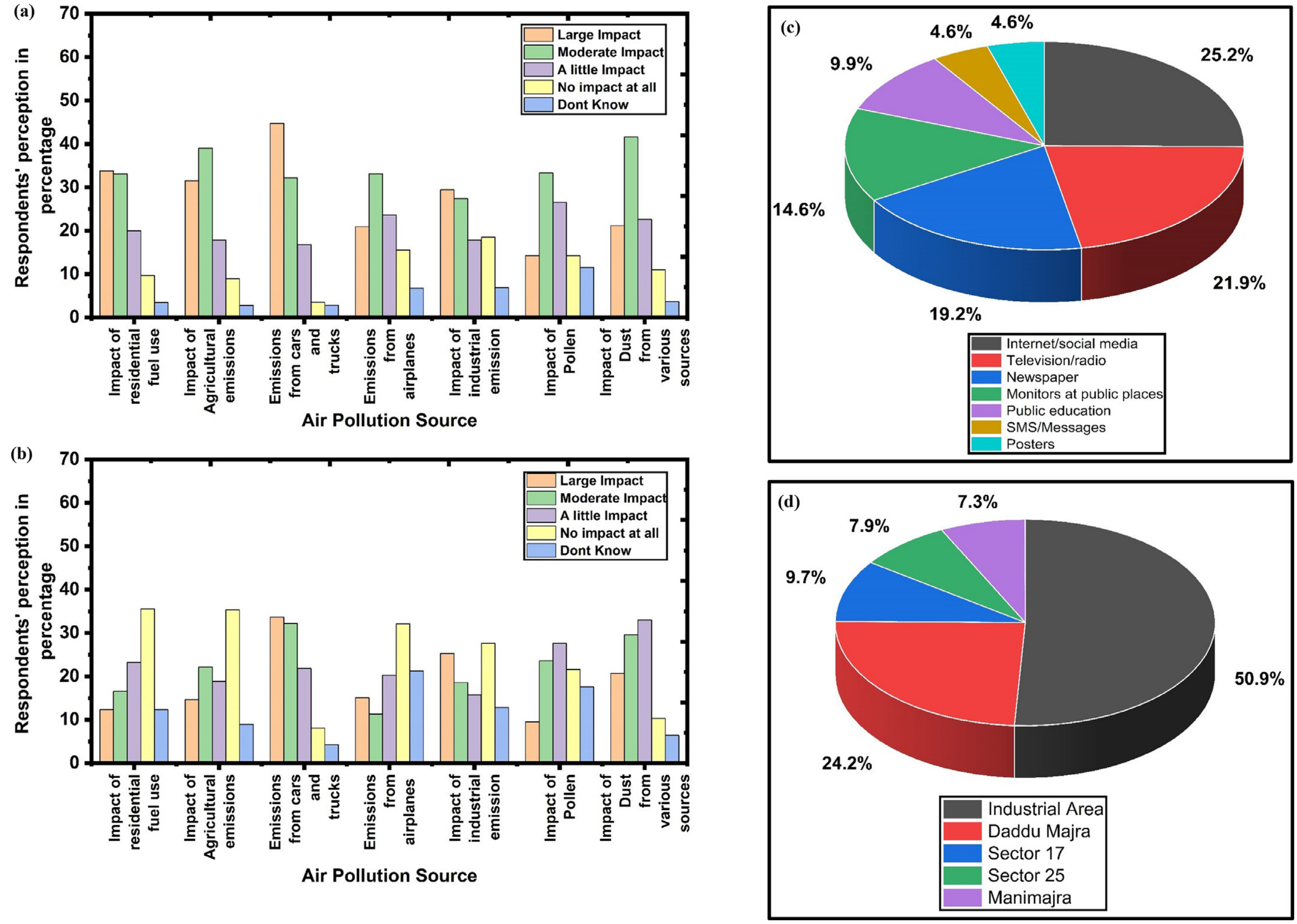

Fig. 2. Respondents' perception of air pollution sources (a) during the COVID period and (b) in the pre-COVID period (c) Ways to disseminate information on air pollution and (d) Top 5 most polluted areas in Chandigarh.

they responded that they were neither happy nor unhappy as a place to live. Before COVID, participants' happiness with their neighborhood as a place to live was strongly correlated with their opinion of the air quality (p-value = 0.000). However, this poor correlation was observed during COVID (p-value = 0.192). People's happiness was associated with air quality perception, such that people who perceived bad air quality were unhappy and depressed (Ban et al., 2017). When respondents were asked about their awareness of air pollution, 79.9% responded that they were concerned about the air quality in their area.

Regarding awareness of air pollution, a large proportion of the study participants (24.8%) indicated that the internet/social media is the best way to disseminate air pollution information. The other major outlets are television/radio (21.7%), newspapers (19.3%), public surveillance (13.7%), public education (9.9%), SMS/messages (5.6%), as shown in Fig. 2c. Without the people's awareness and active participation, any policy or program could not be implemented successfully. Only people who are well aware of air quality problems were found to be interested in protecting the environment (Chin et al., 2019). Around 36.6% of the respondents perceived air quality was the same as the last year.

During the COVID-19 period, due to reduced air pollution, the maximum number of respondents (40%) perceived the same air quality as compared to last year and 31% perceived that the air quality was slightly better than the previous year. This is because the restricted human activities due to imposed lockdown in the entire country had improved air quality (Ravindra et al., 2020, 2021, Ravindra et al., 2022a). A significant proportion of the respondents (55%) perceived that the worst air quality was in the afternoon and the best air quality was perceived later in the night. Similar kind of results were also obtained in pre-COVID and during the COVID-19 period. Maximum respondents (48%) were well informed about air quality problems. However, a mixed response was seen when respondents were asked about the places of air quality information. Similar results were observed in a study (Singh et al., 2020) in that maximum air pollutant reduction was observed at midnight. Around 44% of the respondents knew about the places where air quality information is being displayed, but 55.8% did not have any idea of air quality information.

Sources of air pollution have been summarized in Fig. 2 (a and b). In pre-COVID time, people (44.8%) perceived that vehicular emissions greatly impacted air pollution. Chandigarh, along with adjoining cities Panchkula and Mohali, is called a tri-city. These cities contribute a massive amount of daily influx and outflux of vehicles. Not only this, ' 'Chandigarh's population has doubled from the five lakhs that were originally projected to live there, and around two vehicles per person are reported to be the average number of vehicles on city roadways (Sood et al., 2014). However, during COVID-19, the respondents' perceptions changed due to imposed lockdown. During the lockdown period, vehicular activity, coal and waste burning reduced or fell sharply (Singh et al., 2020).

In pre-COVID time, an enormous impact of agricultural emissions (31.5%) and residential fuel use (33.8%) was perceived. Still, during

Table 3
Health risk perception of air pollution.

Association between participants' health risk perception and various sociodemographic factors						
Variable	Health problems caused by air pollution				p-valuep-value	
	During COVID period		Pre-COVID period		During COVID period	Pre-COVID period
	N	Yes, n (%)	N	Yes, n (%)		
Age						
18-24	23	4 (17.4%)	136	42(30.9%)	0.955	0.981
25-34	96	18 (18.8%)	38	12 (31.6%)		
35-40	33	6 (18.2%)	4	1 (25%)		
41-50	32	7 (21.9%)	4	0		
51-59	19	3 (15.8%)	1	1 (100%)		
60+	8	2 (25%)	1	0		
Gender						
F	58	12 (20.7%)	99	40 (40.4%)	0.387	0.39
M	153	28 (18.3%)	88	17 (19.3%)		
Marital Status						
Married	152	28 (18.4%)	16	4 (25%)	0.401	0.647
Single	59	12 (20.3%)	171	53 (31%)		
Educational Status						
Graduate or postgraduate	173	34 (19.6%)	155	47 (30.3%)		
School/ Diploma	36	6 (16.7%)	23	8 (34.8%)	0.992	0.084
Illiterate	2	0	2	1 (50%)		
Occupation						
Professional	142	31 (21.8%)	52	17(32.7%)		
Non- professional	44	6 (13.6%)	15	4 (26.7%)	0.385	0.291
Unemployed	24	3 (12.5%)	104	34(32.7%)		
Monthly family income						
≥ Rs 32050	140	28 (20%)	71	19(26.8%)	0.047	0.000
≤ Rs 32050	69	12(17.4%)	114	38(33.3%)		

Perception of health effects due to air pollution			
Variable	n (%)		
	During COVID period	Pre-COVID period	Total
Difficulty in breathing	112 (52.8%)	94 (50.3%)	206(51.6%)
Irritation to eyes	101 (47.6%)	98 (52.4%)	199(49.9%)
Irritation to throat	72 (34%)	67 (35.8%)	139(34.8%)
Nasal irritation	68 (32.1%)	62 (33.2%)	130(32.6%)
Skin problems	66 (31.1%)	61 (32.6%)	127(31.8%)
Asthma	31 (14.6%)	32 (17.1%)	63(15.8%)

the COVID-19 period, the impact of agricultural emissions and residential fuel use was reduced to 14.6% and 12.3%, respectively. It was found in a study that due to the lockdown during the COVID-19 period, there was an unprecedented reduction in the global economy and transport activity which led to a decrease in air pollution levels (Venter et al., 2020). Similar results were observed in another study that during the lockdown, traffic plummeted and all human activities stopped for almost 2-3 months; this improved the air quality (Mor et al., 2020). Air pollution levels sharply fell due to restrictions on all human activities. After that, many activities were permitted under the set guidelines in each subsequent stage of the lockdown period. The industrial area was perceived as the most polluted in Chandigarh, as shown in Fig. 2d. The other polluted areas in the city were Daddumajra, sector 17, sector 25 and Manimajra.

3.3. Health risk perception of air pollution

We assessed the association between the health impacts of air pollution and various sociodemographic characteristics of the respondents. The detailed results are shown in Table 3. The perception of the health impacts of air pollution was stratified according to age group. During the COVID-19 period and pre-COVID time, the association was not significant (0.955 and 0.981). In the pre-COVID period, respondents perceived that air pollution caused health problems. Still, during the COVID-19 period, ' 'people's perception was not the same, i.e., in pre-COVID time, 31.6% of the people in the 25–34 years age group perceived that air pollution impacted health. Still, during the COVID-19 period, the perception was reduced to 18.8%.

Perceived health impacts of air pollution were observed higher in the 51–59 age group. This might be due to the chronic illness that is sometimes associated with the higher age group. Similar results were obtained in a study that older people have a higher likelihood of air pollution-related mortality. The health of the elderly (defined in this study as persons over 50 years old, middle-aged, and old) has been worse recently, associated with worsening air pollution (Pi et al., 2019). Then we stratify the health impacts of air pollution based on sex and marital status. Association between health impacts and sex variables was not found to be statistically significant (during the COVID-19, *p*-value = 0.387 and in the pre-COVID period, *p*-value = 0.39). The result has shown that 40.4% of the females in pre-COVID time perceived the health impacts of air pollution, while the perception of health impacts was only 19.3% in males. Females with a lower level of education are more likely to be affected by air pollution as they are still burning wood and animal dung for cooking (Banik, 2010).

Perception of health impacts of air pollution was more in the pre-COVID period than during the COVID-19 period. This is because people perceived that during the COVID-19 period, the level of air pollution was reduced and due to the imposed lockdown, their exposure to outdoor air was reduced. According to the respondents' education, occupation, and marital status, they feel that the health impacts of air pollution were more in the pre-COVID period than in the COVID-19 period. When respondents were asked about the health effects of air pollution, a significant proportion (51.6%) perceived that difficulty in breathing

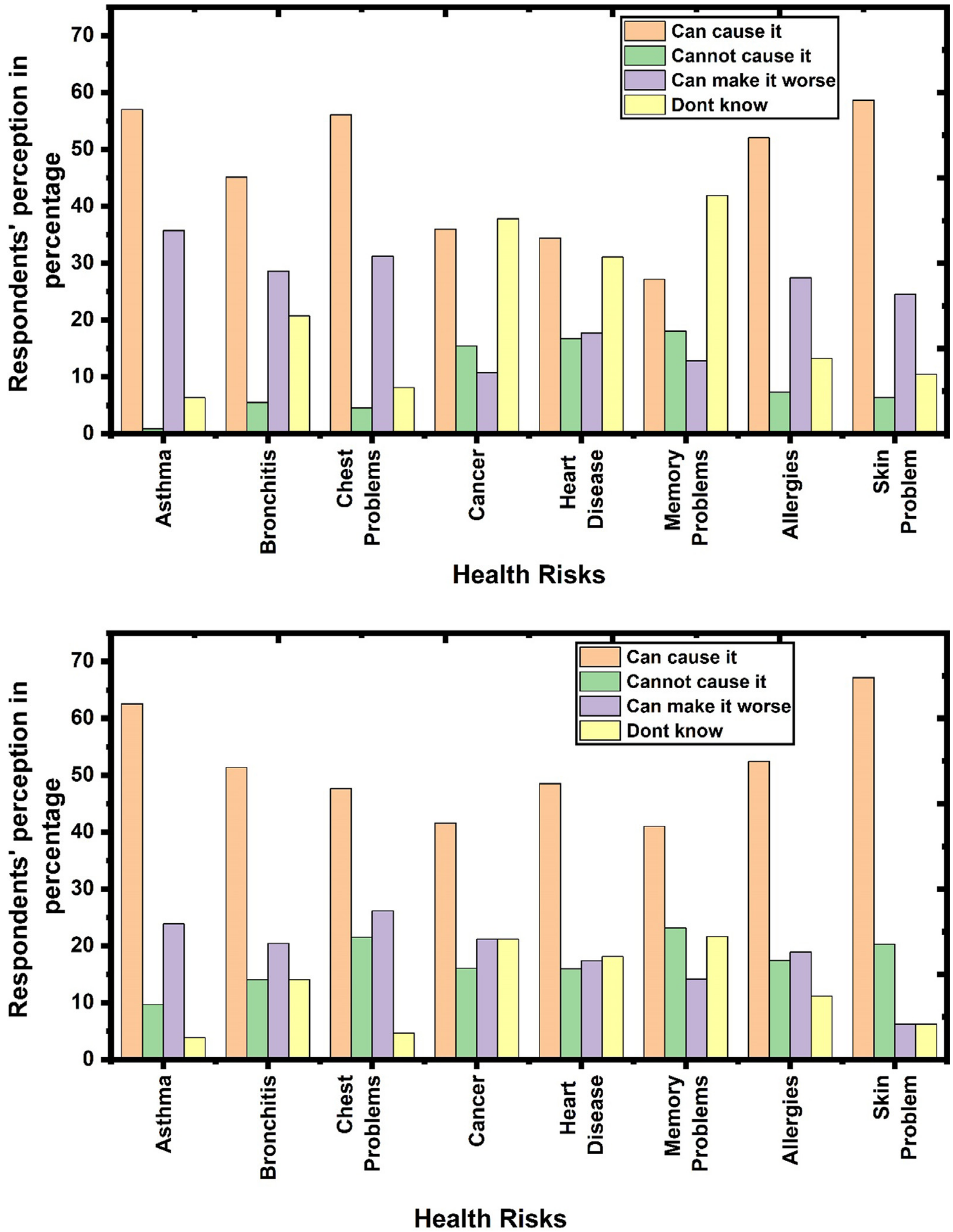

Fig. 3. Health risk perception of air pollution (a) during the COVID-19 period and (b) pre-COVID period.

was the major effect of air pollution and the other health effects reported by them include irritation of the eyes (49.9%), irritation to throat (34.8%), nasal irritation (32.6%), skin problems (31.8%) and asthma (15.8%).

Air pollution contains harmful substances which can be toxic to respiratory problems, chest problems, reproductive system and central nervous system, etc., such that in the pre-COVID and COVID-19 period, a major proportion of the people (67.2% and 59%) perceived that skin problem was caused by air pollution and according to (62.6% and 57%) of the respondent's asthma was caused by air pollution, other problems that were caused by air pollution were bronchitis (51.4% and 45%), allergies (52.4% and 52%), and chest problems (47.7% and 56%) as shown in Fig. 3(a and b).

3.4. People's attitudes towards air pollution

The results of attitudes towards air pollution have been summarized in Table 4. When asked about the people's actions in response to air pollution, a maximum of respondents (64.8%) revealed that they should be actively involved in decisions making to curb air pollution. Approximately 43% of the respondents restricted their outdoor activities due to high levels of air pollution. However, some respondents (20.5%) also believed in doing more exercise. Similar results were observed in another study that physical exercise adversely correlated with bad air quality. Participants reported a decrease in outdoor activities to lessen the adverse effects of air pollution (An et al., 2018). But people, especially athletes, should try to avoid exercise during high pollution

Table 4
Actions can be taken toward air pollution control measures.

	n (%)		
	During COVID period	Pre-COVID period	Total
Public actively engaged in addressing air pollution			
• Actively engaged	139 (66.2%)	95(62.9%)	234(64.8%)
• Passively engaged	50 (23.8%)	39(25.8%)	89(24.7%)
• Not engaged	6 (2.9%)	9 (6%)	15(4.2%)
• 'Don't know	15 (7.1%)	8 (5.3%)	23(6.4%)
Air pollution has effects on daily activities			
• Less outdoor activities	127(43.8%)	88 (42.5%)	215(43.3%)
• Doing more exercise	65 (22.4%)	37 (17.9%)	102(20.5%)
• Eating healthier food	64 (22.1%)	41 (19.8%)	105(21.1%)
• Wanting to shift to some other place	15 (5.2%)	21 (10.1%)	36(7.2%)
• Feeling depressed and worried	19 (6.6%)	20 (9.7%)	39(7.8%)
Avoid using vehicles for environmental reasons			
• Always	15 (7%)	46 (27.4%)	61(16.2%)
• Often	46 (22%)	37 (22%)	83(22.1%)
• Sometimes	113 (54%)	61 (36.3%)	174(46.3%)
• Never	24(12%)	13 (7.7%)	37(9.8%)
• I do not own one	10 (5%)	11 (6.5%)	21(5.6%)
People's preferences for environmentally friendly alternatives like cycling on vehicular regulation			
• Have preference	168 (80%)	96(71.6%)	264(76.7%)
• No preference	15 (7%)	27(20.1%)	42(12.2%)
• 'Don't know/'Can't say	27 (13%)	11(8.2%)	38(11.0%)
People's responses to a car-free day/ vehicular regulations			
• Supported	134 (63%)	102 (68.5%)	236(65.6%)
• Not supported	27 (13%)	23 (15.4%)	50(13.9%)
• 'Don't know/Can't say	50 (24%)	24 (16.1%)	74(20.6%)
People turn off their vehicles at a traffic signal with red light			
• Yes, always	88 (42.9%)	78 (53.8%)	166(47.4%)
• Mostly	64 (31.2%)	37 (25.5%)	101(28.9%)
• Sometimes	45 (22%)	25 (17.2%)	70(20%)
• Never	8 (3.9%)	5 (3.4%)	13(3.7%)

Association between willingness to pay and air pollution awareness

Variable	Air pollution awareness				p-value	
	During COVID time		Pre-COVID timePre-COVID time		During COVID time	Pre-COVID time
Willingness to pay	N	Yes, %	N	Yes, %		
• Yes	113	88 (77.9)	116	91 (78.4)	0.076	0.001
• No	53	36 (67.9)	63	40 (63.5)		
• Don't know	46	28 (60.9)	7	7 (100)		

levels, i.e., in the afternoon or evening, because while doing exercise and physical activity, people tend to breathe more vigorously, leading to inhalation of harmful pollutants (Atkinson 1997; Sharman et al., 2004).

Around 21.1% of the respondents perceived that eating healthier food protects them against the detrimental effects of air pollution. People adopted some of the actions against air pollution, such as 46% of them sometimes avoiding using cars/bikes, etc., to reduce vehicular pollution. People should be more concerned about adopting motor vehicle regulations. A close association seems to exist between vehicle regulations and the degree of air pollution (Chin, 1996). Another study revealed that the policies restricting private vehicles, to some extent, lessened the level of air pollution (Chen et al., 2021). When people were asked about their actions in response to air pollution, 41% said they avoided going out sometimes during the COVID-19 period. In pre-COVID time 35.6% of the respondents occasionally avoided going out. This may be due to imposed lockdown in the COVID-19 period that restricted almost all human activities.

In pre-COVID time 46.6% of the respondents often kept their windows closed. During the COVID-19 period, 29.3% of people used to wear masks. Detailed results of people's actions in response to air pollution have been summarized in Fig. 4 (a and b). When respondents were questioned about alternatives for air pollution control initiatives, 96.8% perceived that planting more trees was the best choice for air pollution control; the other better options were public education fines (91.5%), polluting vehicles fines (90.4%), penalties on polluting industries (87.4%), better car technology (87%), restriction on vehicular traffic (74.1%), cleaner fuel (72.2%) as shown in Fig. 4c. When asked about cleaner preferences, 80% of respondents in the COVID-19 period and 71.6% in the pre-COVID period indicated their interest in using cleaner vehicles such as cycling. However, eleven percent of respondents did not know about cleaner choices for vehicle regulations. Approximately 47% of the respondents always turn off their vehicle at a traffic signal, 28.9% of them mostly turn off their vehicle, but 3.7% never turn off their vehicle.

It seems that about half of the people were aware of air pollution. In the aggregate, strong public support for improving air quality is critical to mitigating air pollution (Liao et al. 2015). Detailed results have been described in Table 4. The results were statistically significant (0.076 and 0.001) during COVID-19 and pre-COVID periods. About 77.9% and 78.4% (during COVID-19 and pre-COVID period) of those respondents who had awareness about air pollution were willing to pay to improve air quality. Similar findings were obtained in a study by Chin et al. (2019), where they reported that more than half of the respondents are ready to contribute part of their income, willing to pay for cleaner petrol, and willing to consider cuts in their living standards to protect the environment, promote green recovery and ensure sustainability.

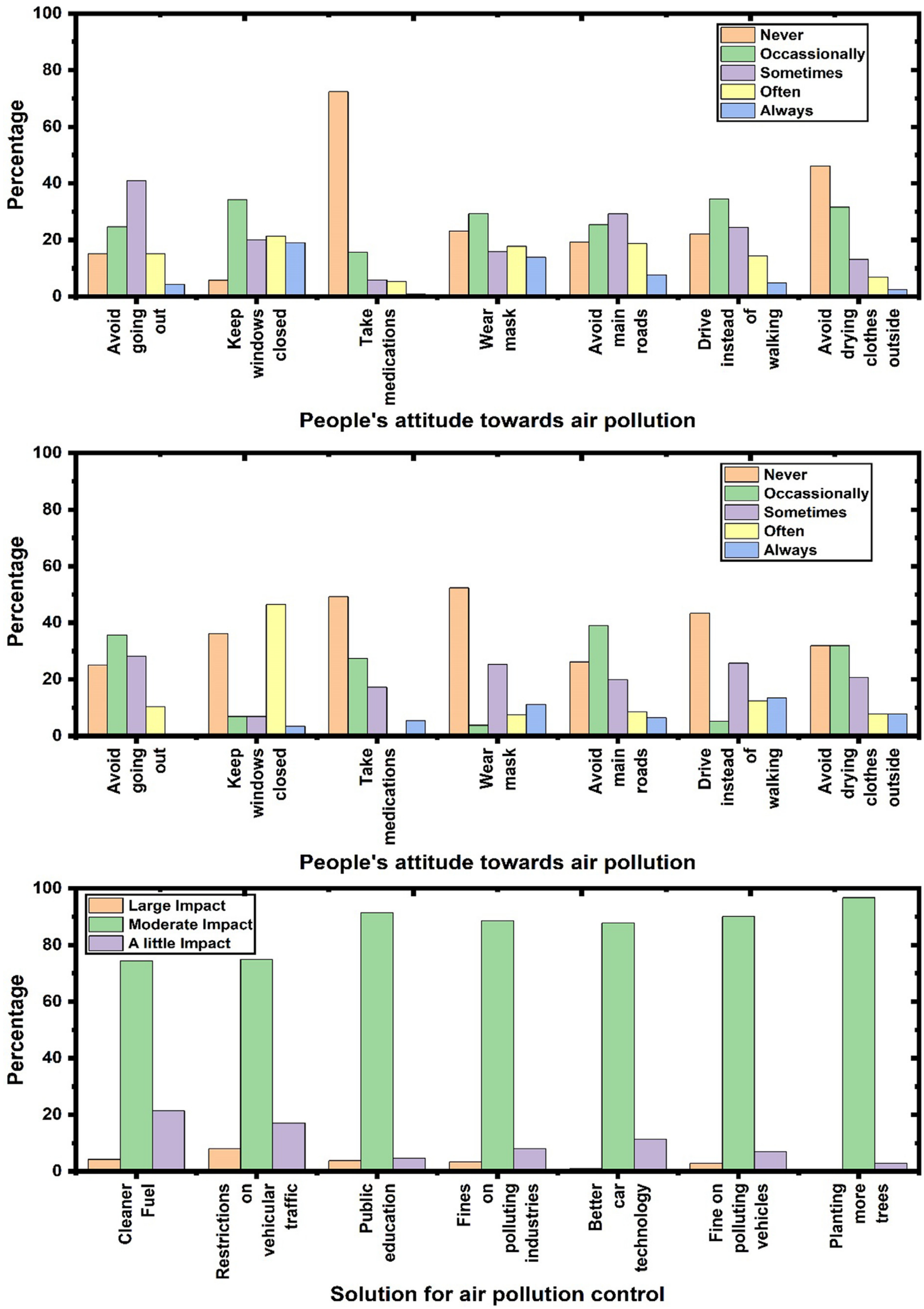

Fig. 4. People's attitude towards air pollution (a) during COVID-19 and (b) pre-COVID period and people's opinion on air pollution control measures.

4. Conclusions

The findings of this study suggest that air quality expectations are influenced mainly by respondents' level of concern regarding air quality. This paper attempts to find people's knowledge, attitude and perception toward air pollution and its health hazards. Sociodemographic factors were associated with the awareness of air pollution, health effects, and people's attitudes. Both during the COVID-19 period (p-value = 0.064) and pre-COVID time (p-value = 0.035), a significant association was seen between people's education status and air pollution awareness. As more people become aware about the risk associated with air pollution, more they will be keen to take action toward its mitigation. This will consequently enhance community participation for the successful implementation of public policies such as NCAP. Vehicular emissions (44.8%) were perceived as the main source of air pollution in the city. As Chandigarh is the urban site and though it is a Tricity (Chandigarh, Panchkula and Mohali), people from Panchkula and Mohali travel to Chandigarh for daily activities.

The other sources were agricultural emissions (31.5%) and residential fuel use (33.8%) also aggravated air pollution. Again the association of sociodemographic factors was tested with the health effects of air pollution. Respondents perceived that exposure to air pollution was toxic to respiratory problems and chest problems. Difficulty in breathing and irritation to the eyes and throat were some of the self-reported health effects of air pollution. Most respondents avoided going outside during high pollution levels or preferred restricted outdoor activities. Most respondents had chosen to plant more trees, penalty on polluting vehicles and industries, and better car technology as the better option for controlling air pollution. During the COVID-19 time and pre-COVID time, there was a statistically significant association between awareness of air pollution and willingness to pay to improve air quality (0.076 and 0.001). The majority of respondents (77.9% and 78.4%) who were aware of air pollution were willing to pay to improve air quality both during the COVID-19 period and pre-COVID time.

Various dimensions of the perception of people were assessed in the study and it covered almost all city areas. The public's perception of risk is significant because it directly impacts policy. In the post-COVID era, policymakers will be better able to plan and implement appropriate policies and programs to promote green recovery if they understand how the public perceives air pollution. Furthermore, comparing perception levels to actual ambient air quality data can assist in determining whether or not it is a reasonable measure of pollution. Hence, people's knowledge, attitude and perception (KAP) toward air pollution make it easy to successfully implement public policies.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.envc.2022.100656.

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