Original Article

The Association of Air Pollution and Emergency Medical Service Seeking

Soheil Saadat, MD, MPH, PhD[1*], Saeed Sadeghian, MD[2], Reza Hamidian, MD[2], Mohammad Ali Najafi, PhD[3]

[1]Sina Trauma Research Center (STRC), Tehran University of Medical Sciences, Tehran, Iran.
[2]Tehran Heart Center, Tehran University of Medical Sciences, Tehran, Iran.
[3]Air Quality Control Company, Tehran Municipality, Tehran, Iran.

Abstract

Background: There are some reports on the association between air pollution and myocardial infarction, arrhythmia, and mortality due to cardiac problems in susceptible individuals. We aimed to evaluate the association of air pollution and the emergency visits due to cardiovascular diseases, in a specialized heart hospital in Tehran.

Methods: The study design was cross-sectional. Patients admitted to the emergency ward of Tehran Heart Center were consecutively included. Records of meteorological data for the study period were obtained from Air Quality Control Company that monitors the concentration of air pollutants through its several stations including one near to Tehran Heart Center. The principal component analysis was used to examine the association between daily air pollution level and the number of patients admitted as a result of unstable angina, myocardial infarction, and arrhythmia.

Results: The principal component score -reflecting the daily air pollution level- was higher on the admission date of the patients who died in hospital compared to that of the patients who discharged alive from the hospital and the difference was statistically significant. After adjustment for the effect of age, sex, smoking, hypertension, hyperlipidemia and diabetes, a statistically significant relationship between principal component score and the unstable angina and arrhythmia was detected in patients referred to the emergency department.

Conclusion: Air pollution was associated with the unstable angina and arrhythmia in patients referred to the emergency department of Tehran Heart Center, adjusted for the effect of other risk factors.

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Keywords: Air pollutants • Myocardial infarction • Angina, unstable • Arrhythmias, cardiac • Principal component analysis

Introduction

Progressive industrialization over the past decades has resulted in environmental pollution including air pollution.[1,2] Although air pollution is under control to some extent in developed countries, it is especially heightened in developing countries due to disorganized changing of traditional to industrialized life style and lack of serious surveillance on environmental pollution.[1,2] Furthermore, the growing occurrence of cardiovascular disease in developing countries imposes a heavy socioeconomic burden on them.[3-5]

In Tehran, the capital of Iran, with a population of approximately 7.9 million and total area of about 700 Km[2], only 30% of the days in a year profits healthy air quality.[6] Tehran's air pollution is monitored by the Air Quality Control Company (AQCC), a subsidiary of "Tehran Municipality".

Corresponding Author: Soheil Saadat, Assistant Professor of Epidemiology, Sina Trauma Research Center (STRC), Sina Hospital, Hassan Abad Sq, Emam Khomeini Ave, Tehran, Iran. 1411713138. Tel: +98 21 66705140. Fax: +98 21 88029256. Email: soheilsaadat@sina.tums.ac.ir.

Through its several stations across Tehran, AQCC hourly monitors the concentration of air pollutants according to the United States Environmental Protection Agency.[7]

Tehran Heart Center (THC) is a tertiary heart hospital in Tehran. Annually, approximately 14000 patients with coronary artery diseases are admitted to THC, and their clinical data are saved in a hospital data bank under strict quality control. If air pollution induces cardiovascular events, THC most likely faces its outcome(s).

The aim of this study was to evaluate the effect of air pollution on the emergency visits, mortality, and the prevalence of arrhythmia, myocardial infarction, and unstable angina among patients admitted to the THC emergency department.

Methods

The study design was cross-sectional. Patients admitted to the emergency ward of THC between 22 December 2006 and 22 October 2007 were included in the study. The patients' data were collected from the hospital data bank containing demographic, clinical, and para-clinical data of all patients admitted to the hospital under rigid quality control supervision.

Meteorological data during the same period of time were obtained from the AQCC Geophysics Station, which is located about 1000 meters away from THC. Meteorological data included the hourly concentration of nitrogen dioxide (NO_2), nitrous oxide (NO), other nitrogen compounds (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), 8-hour ground level ozone (O_3), and dust (including particulate pollutants with diameter 2.5 to 10 micrometers). The daily mean concentration of the air pollutants was considered as exposure level.

The relationship between the daily air pollution and the frequency of patients admitted with unstable angina, myocardial infarction, and arrhythmia -at the same day- was examined using the logistic regression analysis controlling for the effect of other risk factors.

Considering the high correlation of the air pollutants, a principal component analysis was utilized to extract a linear combination of the air pollutants. A linear combination representing eigenvalue more than 1 was formulated and was considered the exposure level for the logistic regression.

The study was ethically approved by the THC Board of Review. The ethical committee waived the need for patients' written consent given that all the data were gathered from the hospital data bank and the fact that the patients had already permitted the hospital by written consent to use their data anonymously for research purposes.

Results

During the study period, 3,525 patients were admitted to the emergency department of THC (Table 1). They consisted of 1,361 (38.6%) women and 2,164 (61.4%) men. The mean age of the male patients was 60.4 ($\pm$12.76) years and that of the females was 63.8 ($\pm$10.95); the difference was statistically significant (P<0.001).

Table 1. Frequency and gender distribution of cardiovascular patients' complaints between 22 December 2006 and 22 October 2007

Complaint	Male	Female	Total
Arrhythmia	32	33	65
Heart failure	17	29	46
MI	385	805	1190
SA	55	74	129
UA	688	1008	1696
NICP	56	50	106
OCP	85	107	192
Valvular	4	6	10
Others	32	44	76
Total	1354	2156	3510

MI, Myocardial infarction; SA, Stable angina; UA, Unstable angina; NICP, Non-ischemic chest pain; OCP, Other cardiac problems

During the study period, 42 patients died in the hospital. The general in-hospital mortality rate was similar in both genders: 1.1% for the men and 1.3% for the women (P=0.633). The mean age of the patients that expired in the hospital was 71.4 years ($\pm$13.23) and that of the patients discharged alive was 61.7 years ($\pm$12.00); the difference was statistically significant (P<0.001). Table 2 represents the air pollutants and their daily mean ranges during the study period.

The daily mean concentrations of the air pollutants were significantly correlated to one another (P<0.001). The correlation matrix is delineated in Table 3.

Table 2. Daily mean concentration of the air pollutants between 22 December 2006 and 22 October 2007

Pollutant	Minimum	Maximum	Mean	SD
CO (ppm)	1.1	16.2	4.6	2.67
NO_2 (ppm)	34.8	143.6	70.9	20.56
NO (ppm)	6.9	276.8	89.6	53.16
NO_x (ppm)	36.4	412.3	132.3	59.33
Ozone (ppm)	3	176.9	27.4	22.02
PM10 ($\mu g/m^3$)	13.9	131.8	54.4	17.48
SO_2 (ppm)	1.1	86.7	18.4	12.12

CO, Carbon monoxide; NO_2, Nitrogen dioxide; NO, Nitrogen monoxide; NO_x, Other nitrogen oxides; PM10, Particulate matter with diameter<10 micrometers; SO_2, Sulfur dioxide

The principal component analysis was utilized to develop a combined index of air pollution. The components of the air pollutants index were as follows: CO (0.749), No_x (0.863), SO_2 (0.757), and ozone (-0.630). This index explained 57% of all the variance of the air pollutants.

Figure 1 displays the mean amounts of SO_2, CO, and air pollution principal component according to the number of

patients admitted per day to the hospital. The difference was statistically significant (P<0.001).

The principal component score was higher on the admission date of the patients that expired during hospitalization (0.320) compared to that of the patients discharged alive from the hospital (0.004), and the difference was statistically significant (P<0.05). By adjusting this relationship for the

Table 3. The matrix of inter-correlation of air pollutants between 22 December 2006 and 22 October 2007

Pollutant	CO	NO_2	NO	NO_x	Ozone	PM10	SO_2
CO	1.000	0.486	0.685	0.694	-0.214	0.590	0.587
NO_2	0.486	1.000	0.695	0.837	-0.483	0.567	0.365
NO	0.685	0.695	1.000	0.955	-0.508	0.541	0.402
NO_x	0.694	0.837	0.955	1.000	-0.565	0.591	0.432
Ozone	-0.214	-0.483	-0.508	-0.565	1.000	-0.078	0.170
PM10	0.590	0.567	0.541	0.591	-0.078	1.000	0.676
SO_2	0.587	0.365	0.402	0.432	0.170	0.676	1.000

CO, Carbon monoxide; NO_2, Nitrogen dioxide; NO, Nitrogen monoxide; NO_x, Other nitrogen oxides; PM10, Particulate matter with diameter<10 micrometers; SO_2, Sulfur dioxide
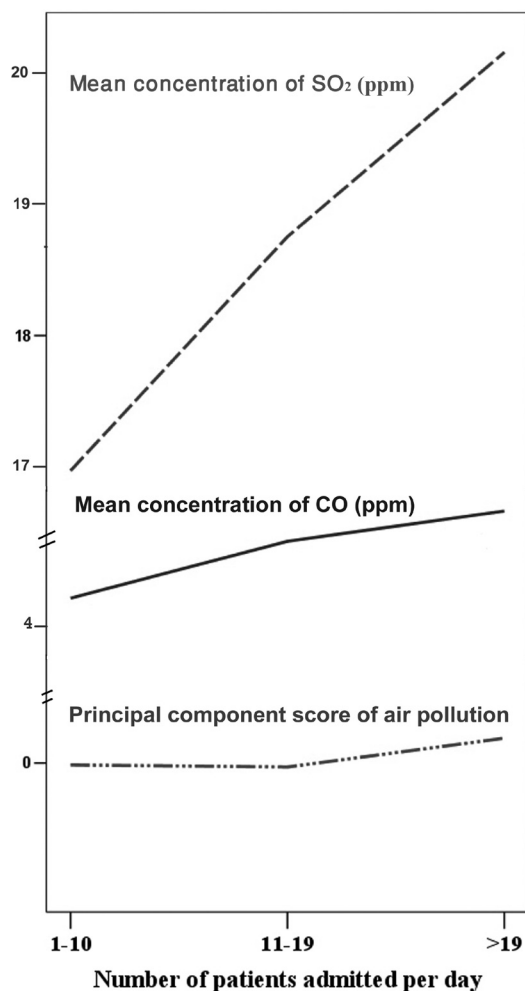

Figure 1. The mean amounts of sulfur dioxide (SO_2), carbon monoxide (CO), and air pollution principal component according to the number of patients admitted per day to the hospital

effect of cardiovascular risk factors (age, sex, hypertension, hyperlipidemia, smoking, and diabetes), the P value for the relationship between in-hospital mortality and the principal component score on the date of admission increased to 0.07.

To examine the relationship between the frequencies of myocardial infarction, unstable angina, and arrhythmia amongst the patients admitted to the hospital and the principal component score on the date of admission, a logistic regression analysis was utilized separately for each of the above-mentioned conditions. After adjustment for the effect of age, sex, smoking, hypertension, hyperlipidemia, and diabetes; a statistically significant relationship between the principal component score at the admission date of the patients and the frequency of unstable angina (P<0.05) and arrhythmia (P<0.05) was detected. Although a statistically significant association was detected between the frequency of myocardial infarction and the mean concentration of NO (P<0.05) and No_x (P<0.05) on the date of admission in the univariate analysis, the association between the principal component score on the admission date of the patients and the frequency of myocardial infarction failed to reach significance level after adjustment for the effect of other risk factors (P>0.10).

Discussion

The present study sought to evaluate the association between air pollution and emergency visit numbers, in-hospital mortality and the proportion of patients admitted to THC with a diagnosis of myocardial infarction, arrhythmia, and unstable angina. In this study, we did not determine the underlying mechanisms of the relationship between air pollution and emergency visit and patients' condition. There was an association between the emergency visits and the air pollution principal component, CO, and SO_2. This is in accordance with Barnett et al., who showed that CO, NO_2, and particulate pollutants significantly influenced the cardiovascular admissions in the elderly.[8]

The association between the air pollution principal component score on the admission date of the patients and the in-hospital mortality failed to remain significant after controlling the effect of age, smoking, sex, hypertension, and diabetes. This may indicate that the association detected in the univariate analysis is not a straightforward association. Instead, air pollution may cause risky patients (smokers for example) to refer to the hospital. This may in turn result in increased in-hospital mortality amongst patients admitted during air polluted days. The increased risk of myocardial infarction after the exposure of susceptible persons to air pollutants is documented in several studies;[9-12] we, however, did not detect an association between air pollution and myocardial infarction.

A study by Peters et al. concluded that age older than 60

years was a risk factor for cardiovascular mortality after exposure to air pollution.[13] The mean age of the patients admitted to THC was more than 60 years.

Heart rate variability in patients exposed to air pollution may be another explanation for increased in-hospital mortality.[14] There was a significant association between the principal component score and arrhythmia in the patients admitted to the THC. The association remained significant after adjustment for the effect of other risk factors. A recent case crossover survey on cardiovascular patients with intra-cardiac defibrillator concluded that a moderate increase in air pollution appeared to be associated with ventricular arrhythmias.[15] Berger and colleagues found out that patients with underlying coronary artery disease were susceptible to ventricular and supraventricular arrhythmias.[16] A new survey in Sao Paulo indicated that air pollutants, especially CO and a mixture of nitrous oxide, acutely affected cardiac rhythm and resulted in arrhythmias even under standard air quality.[17]

There was a direct association between unstable angina diagnosis and the principal component score of air pollution on the admission date of our patients, which remained significant after controlling for the effect of other risk factors. This may indicate a real association of developing unstable angina following exposure to air pollution in susceptible patients. A recent study verified such association. This study concluded that short-term exposure to air pollutants (especially PM) contributed to acute coronary events, including unstable angina and myocardial infarction, at least amongst patients with underlying coronary disease.[18] Several studies emphasize on this relationship.[19-21] Such an association was not seen between the air pollution principal component and myocardial infarction. Air pollution may aggravate the cardiovascular status of susceptible patients to develop unstable angina, but it might not be potent enough to give rise to myocardial infarction.

Our study was subject to limitations. We did not measure the air pollution level of the patients' residences. Patients' exposure to air pollution at home or work place may change their in-hospital outcome.

Conclusion

There was an association between the air pollution principal component score and cardiovascular admissions, unstable angina, and arrhythmia amongst the patients admitted to a tertiary heart hospital over a one-year period.

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