کارگاه‌های آموزشی مرکز اطلاعات علمی

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آموزش مهارت های کاربردی در تدوین و چاپ مقاله
Survey on Air Pollution and Cardiopulmonary Mortality in Shiraz from 2011 to 2012: An Analytical-Descriptive Study

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ABSTRACT

Background: Expanding cities with rapid economic development has resulted in increased energy consumption leading to numerous environmental problems for their residents. The aim of this study was to investigate the correlation between air pollution and mortality rate due to cardiovascular and respiratory diseases in Shiraz.

Methods: This is an analytical cross-sectional study in which the correlation between major air pollutants (including carbon monoxide [CO], sulfur dioxide [SO₂], nitrogen dioxide [NO₂] and particle matter with a diameter of less than 10 µm [PM₁₀]) and climatic parameters (temperature and relative humidity) with the number of those whom expired from cardiopulmonary disease in Shiraz from March 2011 to January 2012 was investigated. Data regarding the concentration of air pollutants were determined by Shiraz Environmental Organization. Information about climatic parameters was collected from the database of Iran’s Meteorological Organization. The number of those expired from cardiopulmonary disease in Shiraz were provided by the Department of Health, Shiraz University of Medical Sciences. We used non-parametric correlation test to analyze the relationship between these parameters.

Results: The results demonstrated that in all the recorded data, the average monthly pollutants standard index (PSI) values of PM₁₀ were higher than standard limits, while the average monthly PSI value of NO₂ were lower than standard. There was no significant relationship between the number of those expired from cardiopulmonary disease and the air pollutant (\( P > 0.05 \)).

Conclusions: Air pollution can aggravate chronic cardiopulmonary disease. In the current study, one of the most important air pollutants in Shiraz was the PM₁₀ component. Mechanical processes, such as wind blowing from neighboring countries, is the most important parameter increasing PM₁₀ in Shiraz to alarming conditions. The average monthly variation in PSI values of air pollutants such as NO₂, CO, and SO₂ were lower than standard limits. Moreover, there was no significant correlation between the average monthly variation in PSI of NO₂, CO, PM₁₀, and SO₂ and the number of those expired from cardiopulmonary disease in Shiraz.

Keywords: Air pollution, cardiopulmonary disease, Shiraz
INTRODUCTION

Rapid expansions of cities along with fast economic growth and increasing energy consumption have caused numerous environmental problems for the residents. One of the most important risks caused by recent developments that have endangered human life is environmental pollution. Urban air pollution has always been a serious threat to public health and the environment. Moreover, increasing the episodes of air pollution has made many more researches in this array.[2] Nowadays air pollution in many developing countries has deteriorated significantly due to rapid industrialization, urbanization, and motorization.[3,4]

In recent years, epidemiological studies showed that there is an association between air pollution and mortality.[5,8] In addition, the clinical and epidemiological evidence showed adverse effects of air pollution on the respiratory system.[9] Many studies have linked air pollution to adverse health effects such as respiratory illness, heart disease, asthma and cancer.[10] For instance, nitrogen dioxide increases airway irritability, decreased lung function and immune system.[2] Short-term effects of outdoor air pollutants include changes in lung function, respiratory symptoms and mortality due to respiratory causes. Long-term and cumulative effects of these pollutants are impaired lung growth, chronic obstructive pulmonary disease, lung cancer, asthma, and allergies.[10]

Epidemiological studies show that in recent decades, the increasing mortality associated with air pollution was not only due to respiratory diseases but is fundamentally linked to heart diseases.[11] In the past decade, epidemiologic studies demonstrated an increase in daily cardiovascular mortality and morbidity related to acute exposures to particulate air pollution.[7,12] In general, air pollution has an adverse affects on heart rate, blood pressure, blood clotting, and atherosclerosis.[13] The epidemiological studies showed the association between air pollution, especially PM_{10} with disability and deaths from cardiovascular disease in North America and Europe.[3] The standard limit was established by the Environmental Protection Agency (EPA) for CO, PM_{10} and SO_{2} being 10 mg/m³, 50 and 80 mg/L, respectively.[14]

The association between high levels of air pollutants and human diseases has been confirmed for over half a century. Air pollution is a heterogeneous mixture of compounds such as ozone, carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate.[15] Masjedi et al. studied the correlation between major air pollutants and acute heart attacks in Tehran. According to their results, there was a relationship between the number of patients suffering from asthma and SO_{2} and NO_{2} concentration, but no significant relationship was found in other cases.[2] Another survey by Mohammadi demonstrated a main correlation between air pollutants in Tehran and the number of people who died because of cardiovascular disorders during 1999-2003.[16] Künzli et al. showed that air pollution causes more than 6% or approximately 40,000 deaths/year in Europe.[17] A study in Taiwan showed that levels of PM_{10}, NO_{2}, CO, and O_{3} in ambient air were significantly associated with hospital admissions due to cardiovascular diseases on warm days, but on cool days all pollutants except O_{3} and SO_{2} were significantly associated with the admissions. The results of this study also showed that higher levels of ambient pollutants increase the risk of hospital admissions for cardiovascular diseases.[18]

Shiraz is the third largest city of Iran (in terms of the area) with particular geographical conditions (surrounded by mountains). It is affected by numerous air pollution sources such as industrialization and massive traffic congestion, therefore evaluating the correlation between its air pollution and human health is absolutely essential. The objectives of our study were to (i) determine the association between climate parameters with mortality rates due to cardiovascular-respiratory diseases in Shiraz, (ii) assess the effects of air pollution on the mortality rate and (iii) compare Shiraz pollutants standard index (PSI) with the value set by EPA and propose strategies for improving the air quality and preventing emergency condition.

METHODS

This was an analytical-descriptive study conducted in Shiraz from March 2011 to January 2012. In our study, the correlation between major air pollutants including carbon monoxide (CO), sulfur dioxide (SO_{2}), ozone (O_{3}), and particle matter with diameters less than 10 µ (PM_{10}) and
mortality rates due to the cardiopulmonary disease were evaluated. The survey was performed in three phases.

In the first phase, data regarding the concentration of pollutants CO, SO$_2$, NO$_2$, O$_3$, and PM$_{10}$ [Table 1] were measured daily at two stations, i.e. Imam Hossein Square station and Sibvieh Blvd. station by the Environmental Organization. The locations of these stations are shown in Figure 1. In order to measure the air pollutants, the Horiba Model (USA) was used. Hourly air sampling was done 24 h/day and a 24-h mean concentration was used. Since data regarding Sibvieh Blvd. station was not recorded regularly, information regarding this station was not used.

In the second phase, data regarding climatic parameters (temperature and relative humidity) was collected from the database of Iran’s Meteorological Organization [19] [Table 1]. In the third phase, data of deaths from cardiovascular and respiratory diseases were provided by the Department of Health, Shiraz University of Medical Sciences [Table 2].

Air Quality Index (AQI) is used for reporting daily air quality. AQI measured the concentration of air pollution and determined the associated health effect. AQI was used for five major pollutants recommended by clean air act. These pollutants include ozone, particulate matter of air, carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these air pollutants, the standards were set to protect the health of people and decrease the adverse effects of air pollution. An AQI range from 0 to 500 and higher than 100 is recorded as unhealthy. Data collected by Shiraz Environmental Agency is reported by PSI index. Since the difference between PSI index and AQI was not significant, PSI was used in the current study. The following formula was used to calculate PSI:

$$I_P = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} (C_P - BP_{Lo}) + I_{Lo}$$

$I_P$ = The index for pollutant P
$C_P$ = The rounded concentration of pollutant P
$BP_{Hi}$ = The breakpoint that is greater than or equal to $C_P$
$BP_{Lo}$ = The breakpoint that is less than or equal to $C_P$
$I_{Hi}$ = The PSI value corresponding to $BP_{Hi}$
$I_{Lo}$ = The PSI value corresponding to $BP_{Lo}$

Table 1: The monthly variation of the concentration of air pollutants (CO, SO$_2$, NO$_2$, PM$_{10}$) and climatic parameters (temperature, relative humidity) in Shiraz from March 2011 to January 2012

| Month     | CO (ppm) | PM$_{10}$ (ug/m$^3$) | NO$_2$ (ppm) | SO$_2$ (ppm) | Temperature (°C) | Relative humidity (%) |
|-----------|----------|----------------------|--------------|--------------|------------------|----------------------|
| March     | 2.08     | 68.5                 | 0.017       | 0.004        | 15.5             | 44                   |
| April     | 1.66     | 76.43                | 0.016       | 0.002        | 22.1             | 34                   |
| May       | 1.48     | 103.32               | 0.015       | 0.003        | 27.35            | 21.5                 |
| June      | 1.58     | 106.51               | 0.015       | 0.004        | 29.3             | 24.5                 |
| July      | 1.42     | 141.45               | 0.015       | 0.004        | 29.45            | 24                   |
| August    | 1.4      | 131.54               | 0.017       | 0.005        | 25.85            | 28.5                 |
| September | 1.35     | 132.54               | 0.018       | 0.006        | 21.1             | 30.5                 |
| October   | 1.55     | 129.28               | 0.016       | 0.005        | 7.45             | 57                   |
| November  | 1.53     | 116.03               | 0.013       | 0.005        | 7.25             | 56.5                 |
| December  | 1.79     | 79.55                | 0.015       | 0.003        | 6.65             | 54.5                 |
| January   | 2.38     | 95.04                | 0.017       | 0.006        | 9.2              | 40.5                 |

CO=Carbon monoxide, PM=Particulate matter, NO$_2$=Nitrogen dioxide, SO$_2$=Sulfur dioxide
Statistical analysis

We used Excel 2007 and SPSS 11.5 Version 20.0. Armonk, NY: IBM Corp. The Kendall test was used to analyze the relationship between the impacts of air pollutants on the mortality rates due to cardiopulmonary diseases. Repeated measures analysis of variance (test) was also used to compare the various air pollution indices for the time period. The post-hoc tests, least significant difference was used when the differences was significant.

RESULTS

Figure 2 shows the monthly variation of PSI values of CO in Shiraz from March 2011 to January 2012. The maximum and minimum PSI values of CO in March and October were 23.64 and 15.40, respectively. The amount of monthly PSI values of carbon monoxide in March was significantly different compared with other months. Figure 3 shows the monthly variation of PSI values of SO$_2$ and the maximum and minimum PSI values for sulfur dioxide were 9.06 and 2.94 in March and May, respectively. The average PSI value of SO$_2$ in May had a significant difference compared with other months ($P < 0.05$). Figure 4 shows the monthly variation of PSI value of NO$_X$ and the maximum and minimum PSI values for nitrogen dioxide were 16.68 and 12.69 in October and January, respectively. The average PSI value of NO$_X$ in January was significantly different from the other months as well ($P < 0.05$). Figure 5 shows the monthly variation of PSI values of PM$_{10}$ and the maximum and minimum PSI value PM$_{10}$ were 99.04 and 56.31 in August and April, respectively. The average monthly of PSI value of PM$_{10}$ was higher than standard limits (0-50). The average monthly of PSI values of CO, SO$_2$, and NO$_2$ was lower than standard limits (0-50).

Minimum temperature and humidity in Shiraz from March 2011 to January 2012 were in January and June, respectively, and the maximum temperature and humidity were in July and December, respectively. Based on the data obtained in the present study, the relationships between the average temperature and relative humidity and the mortality rate of cardiovascular and respiratory diseases were not statistically significant ($P > 0.05$).

Cardiovascular disease is the leading cause of death in Iran. Latest available data from March 2011 to January 2012 shows that 2640 people in Shiraz died from cardiovascular disease and among them 48.1% were female and 51.9% male, respectively. From March 2011 to January 2012, 5.8% of deaths due to cardiovascular disease occurred before the age of 50 and 94.2% were older than 50 years. The highest and lowest rates of mortality due to cardiovascular disease was in December (10.9%) and November (4.3%), respectively. The correlation between the average monthly PSI value of air pollutants SO$_2$, CO, PM$_{10}$, and NO$_2$ with mortality from cardiovascular disease was not statistically significant as well ($P > 0.05$).

Among the 387 people who died from respiratory disease, males (59.9%) were more than females (40.1%). The average age of death due to respiratory disease was 68. The highest and lowest mortality rates due to respiratory diseases were in January (11.9%) and September (4.1%), respectively. The results demonstrated that there was no correlation between the average monthly rate of PSI value of SO$_2$, CO, PM$_{10}$, and NO$_2$ and mortality from respiratory disease ($P > 0.05$).

The average monthly PSI of PM$_{10}$ showed that the highest concentration of the pollutant occurred in August and the highest mortality rate due to respiratory diseases was in January. Statistical analysis showed that there was no significant correlation between deaths due to cardiovascular diseases and SO$_2$, CO, PM$_{10}$, and NO$_2$ emissions ($P > 0.05$). In addition, there was no significant correlation between deaths from respiratory disease and SO$_2$, CO, PM$_{10}$, and NO$_2$ emissions ($P > 0.05$).

Table 2: The monthly variation of the number of those expired from cardiovascular and respiratory diseases in Shiraz in March 2011 till January 2012

| Month  | The number of those expired from cardiovascular diseases | The number of those expired from respiratory diseases |
|--------|--------------------------------------------------------|------------------------------------------------------|
| March  | 223                                                    | 38                                                   |
| April  | 254                                                    | 28                                                   |
| May    | 215                                                    | 20                                                   |
| June   | 239                                                    | 36                                                   |
| July   | 222                                                    | 39                                                   |
| August | 215                                                    | 16                                                   |
| September | 225                                              | 29                                                   |
| October| 289                                                    | 37                                                   |
| November | 254                                      | 46                                                   |
| December | 172                                         | 32                                                   |
| January | 218                                                    | 37                                                   |
DISCUSSION

According to the results, it can be concluded that the most important air pollutant in Shiraz is PM$_{10}$. PM$_{10}$ is produced by fossil fuels by stationary and mobile sources near urban areas. High concentrations of PM$_{10}$ are observed near industrial areas, roadways, and coal-fired power plants. These particulates are also produced by natural and man-made processes, being mainly produced by industrial and mechanical processes.

The monthly average of PSI value of pollutants NO$_2$, CO and SO$_2$ in Shiraz was lower than the standard limit. Many studies in Tehran demonstrated that the air pollutants such as SO$_2$, NO$_2$ and CO were the main cause of death from cardiovascular disease. Masjedi et al. indicated that there was a significant relationship between levels of SO$_2$ and NO$_2$ in the air and the rate of asthma attacks recorded in Tehran.

Zalghi et al. showed that the number of deaths occurring due to PM$_{10}$ in Ahwaz was 17.5%, which was actually 5.5% higher than 2009. Another survey carried out by Chen et al. in Australia revealed that the most important causes of hospital admission due to respiratory disease were particle matter and Ozone. Zhong et al. also showed that the major causes of hospital admission of children with asthma attack was Ozone and PM$_{2.5}$.

The results of the study carried out by Dehghani et al. in Shiraz in 2008 showed that there was a significant correlation between the average monthly variation of PSI value of sulfur dioxide and cardiovascular diseases. However, a significant correlation was not observed between the average monthly variation of PSI value of CO and cardiovascular diseases, and SO$_2$ was the main air pollutant in Shiraz. However, based on data obtained in this study a significant correlation was not observed between the average monthly value of PSI of sulfur dioxide pollutant and...
cardiovascular disease in Shiraz. This study also did not show a significant correlation between the average monthly variation of PSI value of CO and cardiovascular disease as well and PM$_{10}$ was the main air pollutant in the current study. Basically, it was expected to find a correlation between monthly variation of PSI value of CO and the mortality rate due to cardiopulmonary disease, but such a relationship was not found. This might have been caused by a lack of information due to the fact that air pollutants were only monitored in two stations and data were not recorded on some days.

**Study limitations and strengths**

The main limitation of the current study is its cross-sectional nature, thus the associations documented in this study should be considered with caution.

**CONCLUSIONS**

Cardiovascular diseases are caused by several factors such as age, family history, physical inactivity, overweight, smoking, high cholesterol level, high blood pressure, and unhealthy diets. Air pollution is the other important cause that can aggravate chronic heart and lung diseases. According to the results obtained in this study, PM$_{10}$ is the most important component of local air pollution in Shiraz. Mechanical processes such as wind blowing from neighboring countries is the most important parameter increasing PM$_{10}$ in Shiraz to alarming conditions. Average monthly variation of the PSI values of air pollutants such as NO$_2$, CO and SO$_2$ are lower than standard limits. Moreover, there was no significant correlation between the average monthly variation of PSI of NO$_2$, CO, PM$_{10}$ and SO$_2$ and cardiovascular and respiratory diseases in Shiraz.

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**REFERENCES**

1. Jamshidi A, Karimzadeh K, Rayeganshirazi A. Study on suspended particles pollution in air of Ghachsaran in 2005. Armaghan Danesh 2007;12:89.
2. Masjedi MR, Jamati HR, Dokohaki P, Ahmadzadeh Z, Alinejadtaheri S, Bigdeli M, et al. Study the correlation of air pollution with acute heart and respiratory attack. J Med Res 2001;25:25-33.
3. Su TC, Chen SY, Chan CC. Progress of ambient air pollution and cardiovascular disease research in Asia. Prog Cardiovasc Dis 2011;53:369-78.
4. Makra L, Matyasovszky I, Bálint B. Association of allergic asthma emergency room visits with the main biological and chemical air pollutants. Sci Total Environ 2012;432:288-96.
5. Gill EA, Curl CL, Adar SD, Allen RW, Auchincloss AH, O’Neill MS, et al. Air pollution and cardiovascular disease in the Multi-Ethnic Study of Atherosclerosis. Prog Cardiovasc Dis 2011;53:353-60.
6. Beelen R, Raaschou-Nielsen O, Stafoggia M, Andersen ZJ, Weinmayr G, Hoffmann B, et al. Effects of long-term exposure to air pollution on natural-cause mortality: An analysis of 22 European cohorts within the multicentre ESCAPE project. Lancet 2013;48:35.
7. Gharehchahi E, Mahvi AH, Amini H, Nabizadeh R, Akhlaghi AA, Shamsipour M, et al. Health impact assessment of air pollution in Shiraz, Iran: A two-part study. J Environ Health Sci Eng 2013;11:11.
8. Dehghani M, Taghizadeh MM, Hashemi H, Rastgoo E. A preliminary assessment of dispersion level of SO 2 in Fars industrial region, south of Iran, by GIS. J Environ Public Health 2013;2013:670590.
9. Dehghani M, Aboueshaghi AS, Zamanian Z. A study of the relationship between indoor and outdoor particle concentrations in Hafez hospital in Shiraz. J Health Syst Res 2013;9:1349-56.
10. Moeini L, Fani A, Bakhteyar M, Rafiee M. The relationship between the concentration of inhaled pollutants nitrogen dioxide, sulfur dioxide, carbon monoxide, and pulmonary function. J Shahrekord Univ Med Sci 2010;12:25-37.
11. Emmerechts J, Jacobs L, Hoylaerts M. Air Pollution and Cardiovascular Disease 2011. The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources. Available from: http://www.intechopen.com. [Last accessed on 2012 June 10].
12. Dockery DW. Epidemiologic evidence of cardiovascular effects of particulate air pollution. Environ Health Perspect 2001;109 Suppl 4:483-6.
13. Simkhovich BZ, Kleinman MT, Kloner RA. Air pollution and cardiovascular injury epidemiology, toxicology, and mechanisms. J Am Coll Cardiol 2008;52:719-26.
14. Dehghani M, Azadbakht P, Pakizehkho R, Shamsedini N. The correlation of Shiraz air pollutants on the hospital admission due to the cardiopulmonary disease in Shiraz selective educational hospitals. J Health Syst Res 2013;9:7.
15. Sun Q, Hong X, Wold LE. Cardiovascular effects of ambient particulate air pollution exposure. Circulation 2010;121:2755-65.
16. Mohammadi H. The correlation of Tehran atmospheric parameters and air pollution with the heart attack mortality rate (1999-2003 study periods). J Geogr Res 2006;58:47-66.
17. Künzli N, Kaiser R, Medina S, Studnicka M, Chanel O, Filliger P, et al. Public-health impact of outdoor and traffic-related air pollution: A European assessment. Lancet 2000;356:795-801.
18. Chang CC, Tsai SS, Ho SC, Yang CY. Air pollution and hospital admissions for cardiovascular disease in Taipei, Taiwan. Environ Res 2005;98:114-9.
19. Fars Meteorological Bureau. Available from: http://www.farsmet.ir/Amars.aspx.2012. [Last accessed on 2012 Jun 3].
20. Guideline for Reporting of Daily Air Quality – Pollutant Standards Index-(PSI). North Carolina: U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, 27711; 1998.
21. Khodarahmi F, Godarzi Gh, Hashemi A, Alavi NA, Ahmadi K, Dehghani M. The survey on effect of environmental parameters on the concentration of suspended particles and bacteria in the air Ahwaz. New Cellular and Molecular Biotechnology Journal (NCMBJ) 2013;3:83-90.
22. Ostro B. Outdoor air pollution: Assessing the environmental burden of disease at national and local level. Environ Burden Dis 2004;5:30-54..
23. Environmental Protection Agency. Heart disease, stroke, and outdoor air pollution. Available from: http://www.epa.gov/airnow/heart-flyer-1-28-10. [Last accessed on 2012 June 10].
24. Zalghi A, Gogarzi GH, Saki A. Quantification respiratory and cardiovascular deaths attributable to PM10 emissions in the air of Ahvaz during 2009-2010 using Air Q. Conference on Management of Air Pollution and Noise.
25. Chen L, Mengersen K, Tong S. Spatiotemporal relationship between particle air pollution and respiratory emergency hospital admissions in Brisbane, Australia. Sci Total Environ 2007;373:57-67.
26. Zhong W, Levin L, Reponen T, Hershey GK, Adhikari A, Shukla R, et al. Analysis of short-term influences of ambient aeroallergens on pediatric asthma hospital visits. Sci Total Environ 2006;370:330-6.
27. Dehghani M, Goudarzi GH, Khairabadi TD, Karamimanesh M, Zamanian Z. A study of the correlation of Shiraz air pollutions with the mortality rate due to the cardiopulmonary disease. 13th National Conference on Environmental Health 2010, Iran.

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