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# Health Impacts of Exposure to $PM_{10}$ on Inhabitants of Shiraz, Iran

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**Background:** Particulate matters have harmful effects on human health and can intensify mortality and disease.
**Objectives:** The purpose of this study was to evaluate the health impacts of particulate matter < 10 µ in diameter ($PM_{10}$) on the inhabitants of Shiraz, one of the largest cities in southern Iran with a population of 1,500,000.
**Materials and Methods:** The AirQ2.2.3 model developed by the world health organization European centre for environment and health was used in this study. Excess cases of mortality, total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for cardiovascular disease (CVD) were calculated.
**Results:** The results of this study show that 25.3% cases of total mortality, 1.1% cases of cardiovascular mortality, 0.3% cases of respiratory mortality, and 3.3% cases of hospital admissions for CVD in 2012 occurred at particulate matter concentrations > 40 µg/m³. About 15.9% cases of total mortality, 0.7% cases of cardiovascular mortality, 0.2% cases of respiratory mortality, and 2% cases of hospital admissions for CVD in 2013 occurred at particulate matter concentrations >20 µg/m³. Moreover, in 2012, > 85% of the studied health effects were related to days with a $PM_{10}$ concentration of < 400 µg/m³, and in 2013, about 99% of the studied health effects were related to days with a $PM_{10}$ concentration of < 189 - 180 µg/m³.
**Conclusions:** According to the results obtained, the largest numbers of deaths and illnesses were due to the high average $PM_{10}$ concentration or an increase in the number of days of exposure to this pollutant.

*Keywords:* Relative Risk; Incidence; Mortality

## 1. Background

Since the 1970s and 1980s, the increased rates of mortality and illness have been attributed to air pollution incidents (1-3). Air pollution is a nonuniform mixture of particulate matter, nitrogen dioxide, sulfur dioxide, carbon monoxide, and ozone. It has been established in many epidemiological studies that air pollution, especially with particulate matter <10 µ in diameter ($PM_{10}$), has a serious effect on human health (4-6). The effects of air pollution include increased rates of hospital admissions, cardiovascular diseases (CVDs), asthma attacks, mortality, and reduced life expectancy (7-11). The major sources of particulate matter include road traffic, human intervention, fixed sources of combustion, transportation, power plants, thermal plants, and industrial processes (12). Short- and long-term contact with $PM_{10}$ can lead to lung irritation, immune system reactions, lung contraction, dyspnea, damaged cells, increased coughing, asthma, hospital admissions, chronic bronchitis, cancer, and death (7-11).

In recent years, several studies have shown a relationship between short- and long-term exposure to particulate matter in the air and various health effects (13-15). A study by the world health organization (WHO) showed that an increase of 10 µg/m³ in particulate matter can lead to an increase of 1 - 3% in the mortality rate (16). Jeong reported the relationship between $PM_{10}$ and total mortality, cardiovascular and respiratory mortality, and hospital admissions for CVD and respiratory diseases (17). Similarly, Naddafi et al. (18) studied the relationship between $PM_{10}$ and total mortality, cardiovascular and respiratory mortality, and hospital admissions for CVD and respiratory diseases. Fattore et al. (19) showed a relationship between $PM_{10}$ and total mortality, cardiovascular mortality, and respiratory mortality. Goudarzi et al. (20) described the relationship between daily mortality and $PM_{10}$ in Tehran. Zallaghi et al. (21) showed a relationship between daily mortality and $PM_{10}$ in Ahvaz, Kermanshah, and Bushehr. According to the results obtained by Zallaghi et al. in Ahvaz, 1.8% of the cases of respiratory mortality and 2.5% of the cases of deaths were attributable to $PM_{10}$ concentrations >20 µg/m³ (22).

In the recent decades, the metropolitan city of Shiraz, located in southwestern Iran, with an area of 1,268 km² and a population of 1,500,000, has experienced an increase in air pollution, especially with $PM_{10}$ owing to dust storms. This air pollution problem in Shiraz is exacerbated by topographic and climatic factors, sunlight, and intermittent temperature inversion (23).

The AirQ model or the Air Quality Health Impact Assessment software (AirQ 2.2.3) developed by the WHO is a reliable and useful tool for estimating the potential health effects of human exposure to certain pollutants in an urban area during a specific time period (24).

## 2. Objectives

The purpose of this study was to evaluate the short-term health effects of the $PM_{10}$ pollutant on the inhabitants of Shiraz in 2012 and 2013. The rates of relative risk (RR) and baseline incidence (BI) were calculated and localized using local statistics. This is rarely seen in similar studies.

## 3. Materials and Methods

### 3.1. Place of Study

This study was conducted in Shiraz, the center of Fars Province in southwestern Iran and one of the 7 metropolises in Iran with a population of > 1,500,000, an area of 1,268 $km^2$, and an altitude of 1,540 meters above sea level, which is located at latitude 29/37 and longitude 52/32. The rates of total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD were measured on a daily basis, and the $PM_{10}$ concentrations in 2012 and 2013 were used as the base values.

### 3.2. Environmental and Health Information

Information on $PM_{10}$ concentrations was collected on a daily basis from 2 air pollution monitoring stations in Setad square and Darwaze Kazeroon affiliated with Shiraz EPA. The daily average values for temperature and humidity were obtained from the Shiraz Meteorological Organization. Statistics on total mortality, cardiovascular mortality, and respiratory mortality were collected on a daily basis from the municipality of Shiraz. Data on the daily rates of hospital admissions for CVD were obtained from the Shiraz central emergency department in 2012 and 2013.

### 3.3. Statistical Methods

The potential health effects of human exposure to air pollutants were measured using the AirQ 2.2.3 developed by the WHO European centre for environment and health. Assessment using this software is based on attributable proportion (AP) that represents the health impacts of exposure of a particular population to air pollutants and shows the relationship between exposure and health outcomes without confounding effects on this relationship. AP is calculated using the following formula (19, 25):

$$AP = \frac{SUM([RR(C)-1].p(C))}{SUM[RR(C).p(C)]} \quad (1)$$

Where AP is the attributable proportion of health outcomes and RR (c) is the relative risk of health outcomes in the group c of exposure. The RR of selective health outcomes can be obtained using the exposure-response functions. P(c) is the proportion of the target population in group c of exposure. Considering the baseline incidence of the selected health outcomes, the amount attributable to the population exposure can be calculated as follows:

$$IE = I.AP \quad (2)$$

Where, IE is the incidence of health outcomes in the exposed subjects, and I is the baseline incidence of health outcomes in the population under study. Finally, considering the population size, the number of excess cases can be calculated as follows:

$$NE = IE \times N \quad (3)$$

Where NE is the number of cases attributable to exposure, and N is the size of the population under study.

The RR (per 10 $\mu g/m^3$ increase in the daily average $PM_{10}$ concentration) for total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD was calculated using a generalized additive model. The BI for total mortality, cardiovascular mortality, and respiratory mortality during the study period was obtained from the registration office of Shiraz. The BI of hospital admissions for CVD and respiratory diseases was obtained from the central emergency department of Shiraz.

### 3.4. Exposure Assessment

The required parameters for the software (annual and seasonal maximum and annual 98 percentile) were obtained for the $PM_{10}$ pollutant, and the pollutant concentrations were reported in terms of 10 $\mu g/m^3$ as a 24-h average. Then, the number of exposures was estimated in the 1,500,000 population of Shiraz.

## 4. Results

Table 1 shows the average concentrations of $PM_{10}$ in a year, in summer and winter as well as the maximum values in summer and winter. As shown in this table, the average $PM_{10}$ concentrations in 2012 and 2013 were 111.95 and 70.6 $\mu g/m^3$, respectively. A decrease in the average concentration of the pollutant was observed in 2013 as compared to that in 2012. The results indicate that the average $PM_{10}$ concentrations in 2012 and 2013 were 2.24 and 1.41 times the basic standard concentrations of $PM_{10}$ published by the National Ambient Air Quality Standards (NAAQSs) and were 5.60 and 3.53 times the standard concentrations of $PM_{10}$ specified by the WHO. As shown in Table 1, the maximum $PM_{10}$ concentration in Shiraz in 2012 and 2013 was observed in summer. The maximum $PM_{10}$ concentration in 2012 was 960.88 µg/m³ and was observed in summer, while in 2013, it was 192.49 µg/m³.

Figure 1 shows the percentage of exposure of Shiraz inhabitants to different concentrations of $PM_{10}$ in 2012 and 2013. As shown in the chart, the highest number of days of exposure to $PM_{10}$ in 2012 and 2013 were in the 80 - 89 and 60 - 69 µg/m³ concentration ranges, which was higher than the NAAQSs for the annual average $PM_{10}$ concentration.

Figure 2 shows the cumulative rates of total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD on the basis of a lower, central, and upper RR in the specified concentration intervals (10 µg/m³) in 2012 and 2013. Table 2 shows the RR and BI values estimated with 95% confidence interval (CI) per 10 µg/m³ increase in the daily average $PM_{10}$ concentration associated with total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD.

Table 3 shows the short-term health effects of exposure to $PM_{10}$ on total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD according to the RR and BI shown in Table 2 for the 10 µg/m³ reference level. As shown in this table, the number of cases of total mortality and respiratory mortality attributed to $PM_{10}$ at a low and middle RR index (RR = 1) equals zero. Therefore, the attributable proportion and number of excess cases for this pollutant is zero. In Table 3, the number of total excess deaths associated with $PM_{10}$ based on the upper RR was about 379 in 2012 and about 293 in 2013, indicating a decrease in the total mortality in 2013 as compared to that in 2012. Moreover, as shown in this table, the rates of cardiovascular mortality, respiratory mortality, and hospital admissions for CVD decreased in 2013.

**Table 1.** Summary of Data on the $PM_{10}$ Concentrations in Shiraz in 2012 and 2013

| Parameter | 2012 | 2013 |
|---|---|---|
| **Annual mean, µg/m³** | 111.95 | 70.60 |
| **Summer mean, µg/m³** | 133.76 | 82.24 |
| **Winter mean, µg/m³** | 78.73 | 58.38 |
| **Summer max, µg/m³** | 960.88 | 192.49 |
| **Winter max, µg/m³** | 273.10 | 136.46 |
| **98 percentile, µg/m³** | 489.47 | 151.97 |

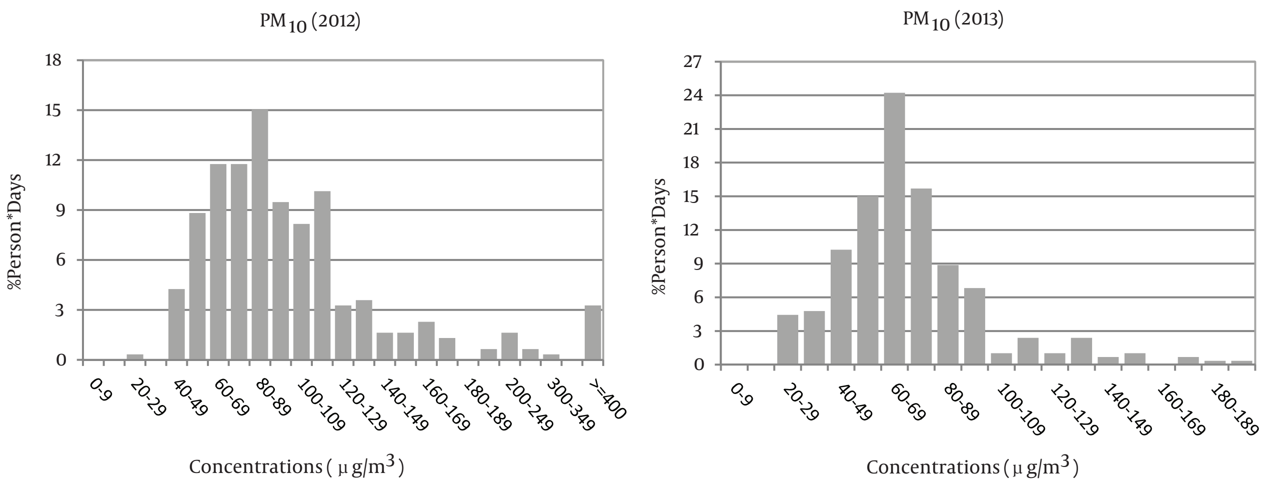


**Figure 1.** Percentage of Exposure of Shiraz Inhabitants to Different Concentrations of $PM_{10}$

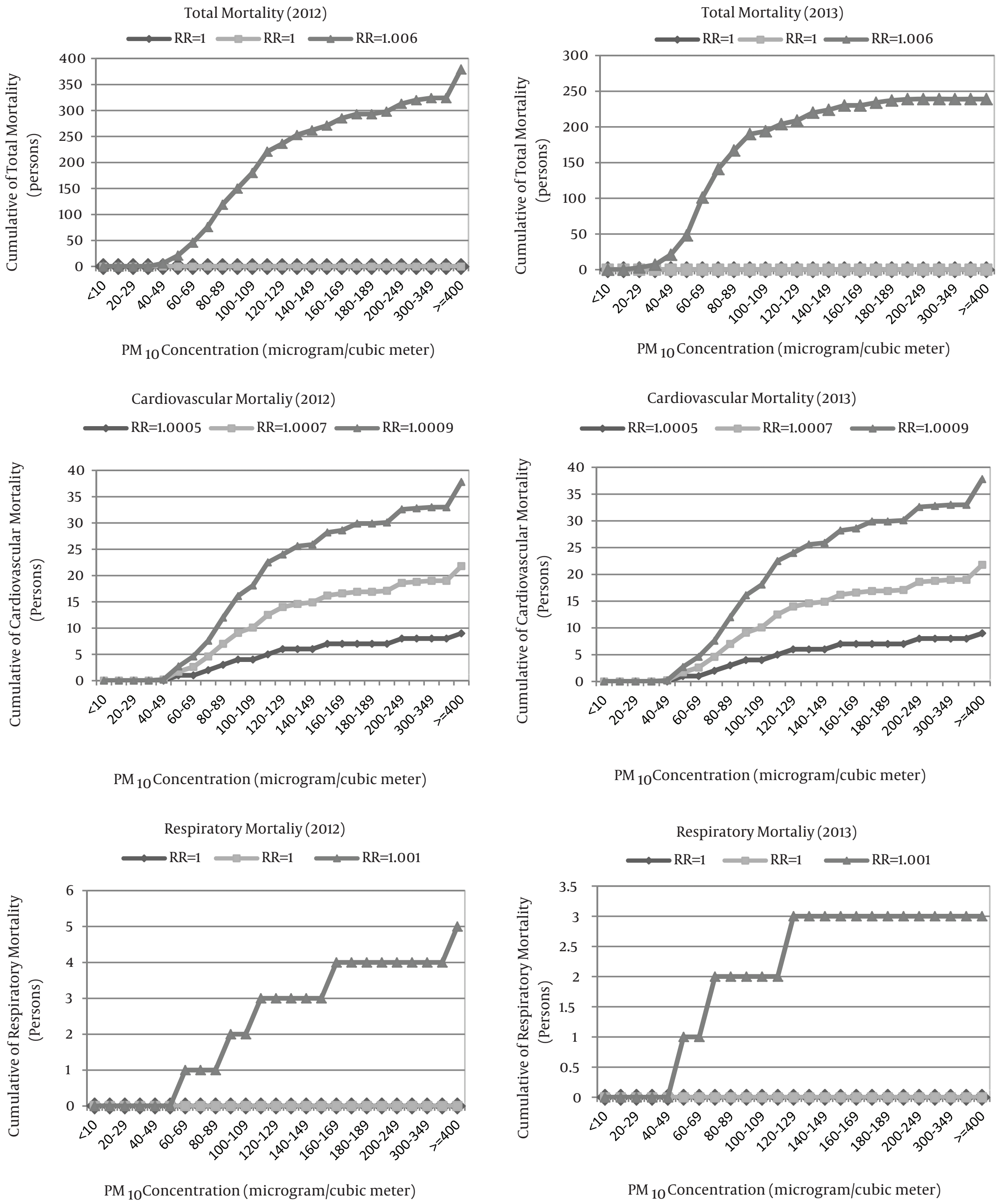


**Figure 2.** Cumulative Rates of Total Mortality, Cardiovascular Mortality, Respiratory Mortality, and Hospital Admissions for CVD According to Exposure to $PM_{10}$ at Concentration Intervals

**Table 2.** BI and RR With a 95% CI Per 10 μg/m³ Increase in the Average Daily $PM_{10}$ Concentration

| Health Endpoint | Baseline Incidence [a] | Relative Risk |
|---|---|---|
| **Total mortality** | 454.3 | 1 (1 - 1.006) |
| **Cardiovascular mortality** | 125.3 | 1.0007 (1.0005 - 1.0009) |
| **Respiratory mortality** | 32.3 | 1 (1 - 1.001) |
| **Hospital admission for cardiovascular disease** | 373.6 | 1.0006 (1.0003 - 1.0009) |

[a] Crude rate per 100,000 inhabitants.

**Table 3.** Attributable Proportion and Number of Excess Cases for $PM_{10}$ by Health Effects in 2012 and 2013

| Health Endpoint | 2012 | | 2013 | |
|---|---|---|---|---|
| | Attributable Proportion | No. of Excess Cases | Attributable Proportion | No. of Excess Cases |
| **Total mortality** | 0.0 (0.0 - 5.5591) | 0.0 (0.0 - 378.8) | 0.0 (0.0 - 3.5083) | 0.0 (0.0 - 293.1) |
| **Cardiovascular mortality** | 0.6820 (0.4881 - 0.8752) | 12.8 (9.2 - 16.4) | 0.4224 (0.3021 - 0.5424) | 7.9 (5.7 - 10.2) |
| **Respiratory mortality** | 0.0 (0.0 - 0.9715) | 0.0 (0.0 - 4.7) | 0.0 (0.0 - 0.6023) | 0.0 (0.0 - 2.9) |
| **HA for cardiovascular disease** [a] | 0.5852 (0.2935 - 0.8752) | 32.8 (16.4 - 49.1) | 0.3623 (0.1815 - 0.5424) | 20.3 (10.2 - 30.4) |

[a] Hospital Admission.

## 5. Discussion

This study investigated the effects of short-term exposure to $PM_{10}$ pollutants on total mortality, cardiovascular mortality, respiratory mortality, and hospital admissions for CVD in 2012 and 2013 by using the AirQ model.

As shown in Table 3, the number of total mortality cases attributed to $PM_{10}$ in 2012, based on the upper RR and BI of 454.3, was about 379 per 100,000 people. The results show that the number of excess cases of total mortality attributable to $PM_{10}$ decreased by 22.6% in 2013 compared to that in 2012. Moreover, in 2012, the number of cases of cardiovascular mortality, respiratory mortality, and hospital admissions for CVD attributable to $PM_{10}$, based on the upper RR and BI values in Table 2, was 16, 4, and 49, respectively. As shown in Table 3, the rates of cardiovascular mortality, respiratory mortality, and hospital admissions for CVD decreased by 37.8%, 38.3%, and 38%, respectively, in 2013, compared to those in 2012. According to the cumulative values presented in Figure 2, in 2012, 25.3% cases of total mortality, 1.1% cases of cardiovascular mortality, 0.3% cases of respiratory mortality, and 3.3% cases of hospital admissions for CVD were attributable to $PM_{10}$ concentrations of > 40 µg/m³. In 2013, 15.9% cases of total mortality, 0.7% cases of cardiovascular mortality, 0.2% cases of respiratory mortality, and 2% cases of hospital admissions for CVD were attributable to $PM_{10}$ concentrations of >20 µg/m³. Moreover, the cumulative values show that the largest number of deaths due to exposure to $PM^{10}$ was 55 at a concentration of >400 µg/m³ in 2012 in Shiraz and was 53 at a concentration of 60–69 µg/m³ in 2013. More than 85% of the health effects studied in 2012 occurred on the days when the $PM_{10}$ concentration was <400 µg/m³. In 2013, about 99% of the health effects occurred on the days when the $PM_{10}$ concentration was < 180 - 189 µg/m³.

In a similar study, Zallaghi et al. (21) studied the health effects of $PM_{10}$ in Kermanshah and Bushehr using the AirQ model. The results showed that in Kermanshah, 12% of the CVD cases and 17% of the respiratory disease cases were attributable to $PM_{10}$ concentrations of > 30 µg/m³, and in Bushehr, 14% of the CVD cases and 19% of the respiratory disease cases were attributable to $PM_{10}$ concentrations of > 20 µg/m³. In a related study by Goudarzi et al. in Tehran, 4% of the respiratory mortality cases were associated with $PM_{10}$ concentrations of > 20 µg/m³ (20). In the present study, the number of health effects was relatively lower because of the lower $PM_{10}$ concentration in Shiraz city. A 1-year study on 1-month-old children in North America showed that a 20 µg/m³ increase in the daily mean $PM_{10}$ concentration led to an 82% increase in the risk of death (26). Tominz et al. (27) studied the health effects of $PM_{10}$ by using the AirQ model and showed that 1.8% of the cases of total mortality and 2.5% of the cases of respiratory mortality were attributable to $PM_{10}$ concentrations > 20 µg/m³. In this study, the $PM_{10}$ concentration was higher in Shiraz than in Trieste City. In a study by Guo et al. (28), there was an approximate 0.23% increase in hospital admissions per 10 µg/m³ increase in the $PM_{10}$ concentration, and in a study by Chen et al. in North China in 2010, there was a 0.036% increase in hospital admissions per 10 µg/m³ increase in the $PM_{10}$ concentration (29). In a study by Shakour et al. in Egypt, there was a 4% increase in hospital admissions for respiratory diseases per 10 µg/m³ increase in the $PM_{10}$ concentrations (30). The results of the present study differ from those of the previous studies because of the differing geographic, demographic, and climatic characteristics. The health effects of $PM_{10}$ in Shiraz were consistent with those reported by other similar studies, and a comparison of the results of this study and other studies conducted in Iran and worldwide shows that the largest number of deaths and illnesses occurred owing to the high average $PM_{10}$ concentration or an increase in the number of days of exposure to this pollutant.

In this study, the health effects of $PM_{10}$ on the inhabitants of Shiraz were quantified using RR and BI values obtained from local statistics. Previously, such an assessment was performed by the WHO by using default BI and RR values. Considering the varying geographic and climatic features in different countries, further studies with RR and BI values calculated according to local statistics and characteristics are needed.

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## Authors' Contributions

Abooalfazl Azhdarpoor was involved in the development of the study design and protocol, data analysis and interpretation, and manuscript drafting and is a guarantor. Aezam Mohammadi, Abbas Shahsavani, and Hamidreza Tabatabaee contributed to the development of the study protocol, data analysis and interpretation, and manuscript drafting.

## References


1. Nemery B, Hoet PH, Nemmar A. The Meuse Valley fog of 1930: an air pollution disaster. *Lancet.* 2001;**357**(9257):704–8.
2. Bell ML, Davis DL. Reassessment of the Lethal London Fog of 1952: Novel Indicators of Acute and Chronic Consequences of Acute Exposure to Air Pollution. *Environ Health Perspect.* 2001;**109**(s3):389–94.
3. Bell ML, Davis DL, Fletcher T. A retrospective assessment of mortality from the London smog episode of 1952: the role of influenza and pollution. *Environ Health Perspect.* 2004;**112**(1):6–8.
4. Brook RD, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, et al. Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. *Circulation.* 2004;**109**(21):2655–71.
5. Simkhovich BZ, Kleinman MT, Kloner RA. Air pollution and cardiovascular injury epidemiology, toxicology, and mechanisms. *J Am Coll Cardiol.* 2008;**52**(9):719–26.
6. Mills NL, Donaldson K, Hadoke PW, Boon NA, MacNee W, Cassee FR, et al. Adverse cardiovascular effects of air pollution. *Nat Clin Pract Cardiovasc Med.* 2009;**6**(1):36–44.
7. Ritz B, Yu F, Fruin S, Chapa G, Shaw GM, Harris JA. Ambient air pollution and risk of birth defects in Southern California. *Am J Epidemiol.* 2002;**155**(1):17–25.
8. Clancy L, Goodman P, Sinclair H, Dockery DW. Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. *Lancet.* 2002;**360**(9341):1210–4.
9. Kelly FJ. Oxidative stress: its role in air pollution and adverse health effects. *Occup Environ Med.* 2003;**60**(8):612–6.
10. Goudarzi G, Zallaghi E, Saki A, Neisi AK, Ahmadi Angali K, Mohammadi MJ. Cardiopulmonary mortalities and chronic obstructive pulmonary disease attributed to Ozone air pollution. *Arch Hyg Sci.* 2013;**2**(2):62–7.
11. Schwartz J. The distributed lag between air pollution and daily deaths. *Epidemiology.* 2000;**11**(3):320–6.
12. Goudarzi G, Geravandi S, Mohammadi MJ, Saeidimehr S, Ghomaishi A, Salmanzadeh S. Salmanzadeh Sh. Health endpoints caused by PM10 exposure in Ahvaz, Iran. *J Health Saf Environ.* 2014;**1**(4):159–165.
13. Baccarelli A, Barretta F, Dou C, Zhang X, McCracken JP, Diaz A, et al. Effects of particulate air pollution on blood pressure in a highly exposed population in Beijing, China: a repeated-measure study. *Environ Health.* 2011;**10**:108.
14. Soleimani Z, Goudarzi G, Naddafi K, Sadeghinejad B, Latifi SM, Parhizgari N, et al. Determination of culturable indoor airborne fungi during normal and dust event days in Ahvaz, Iran. *Aerobiologia.* 2012;**29**(2):279–90.
15. Scapellato ML, Lotti M. Short-term effects of particulate matter: an inflammatory mechanism? *Crit Rev Toxicol.* 2007;**37**(6):461–87.
16. Mirhosseini SH, Birjandi M, Zare MR, Fatehizadeh A. Analysis of Particulate matter (PM10 and PM2.5) concentration in Khorramabad city. *Int J Env Health Eng.* 2012;**1**(7):1–4.
17. Jeong SJ. The Impact of Air Pollution on Human Health in Suwon City. *Asian J Atmos Environ.* 2013;**7**(4):227–33.
18. Naddafi K, Hassanvand MS, Yunesian M, Momeniha F, Nabizadeh R, Faridi S, et al. Health impact assessment of air pollution in megacity of Tehran, Iran. *Iranian J Environ Health Sci Eng.* 2012;**9**(1):28.
19. Fattore E, Paiano V, Borgini A, Tittarelli A, Bertoldi M, Crosignani P, et al. Human health risk in relation to air quality in two municipalities in an industrialized area of Northern Italy. *Environ Res.* 2011;**111**(8):1321–7.
20. Goudarzi G. *Quantification of health effects of air pollution in Tehran and determining the impact of a comprehensive program to reduce air pollution in Tehran on the third axis[In Persian].* Tehran University of Medical Sciences; 2007.
21. Zallaghi E. *Survey of health effects of air Pollution Ahvaz, Bushehr and Kermanshah with use of AirQ model[In Persian].* Islamic Azad University, Science and Research Branch, Ahvaz; 2010.
22. Zallaghi E, Goudarzi G, Geravandi S, Mohammadi MJ. Epidemiological Indexes Attributed to Particulates With Less Than 10 Micrometers in the Air of Ahvaz City During 2010 to 2013. *Health Scope.* 2014;**3**(4):e22276.
23. Statistical Centre of Iran. *Estimated population of country cities for 2011.* 2011. Available from: http://www.amar.org.ir/.
24. WHO. *Air Quality Health Impact Assessment Software AirQ 2.2.* 2004.
25. Krzyzanowski M. Methods for assessing the extent of exposure and effects of air pollution. *Occup Environ Med.* 1997;**54**(3):145–51.
26. Commission for Environmental Cooperation of North America . *Health impacts of air pollution on morbidity and mortality among children of Ciudad Juarez, Chihuahua, Mexico.* 203.
27. Tominz R, Mazzoleni B, Daris F. [Estimate of potential health benefits of the reduction of air pollution with PM10 in Trieste, Italy]. *Epidemiol Prev.* 2005;**29**(3-4):149–55.
28. Guo Y, Tong S, Zhang Y, Barnett AG, Jia Y, Pan X. The relationship between particulate air pollution and emergency hospital visits for hypertension in Beijing, China. *Sci Total Environ.* 2010;**408**(20):4446–50.
29. Chen R, Pan G, Kan H, Tan J, Song W, Wu Z, et al. Ambient air pollution and daily mortality in Anshan, China: a time-stratified case-crossover analysis. *Sci Total Environ.* 2010;**408**(24):6086–91.
30. Shakour AA, El-Shahat MF, El-Taieb NM, Hassanein MA, Mohamed AMF. Health impacts of particulate matter in greater Cairo. *Am J Sci.* 2011;**7**(9):840–848.