

*Original Article****Relation between Mortality Rate and air pollutant concentrations in Mashhad, 2007-2009***

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Abstract

Background and purpose: Air pollution has been known as one of the most effective factors on cardiovascular, pulmonary and infectious diseases. This study aims to determine the relation between mortality rate and air pollution in Mashhad during 2007-2009.

Materials and Methods: Data of air pollution, mortality rate and geographic factors were collected during 2007-2009 and analyzed. Mortality rate, the average PSI of individual pollutants, temperature and moisture were weekly measured and the diagrams were then drawn according to the methods of statistical correlation and regression analysis of air pollution and mortality rate.

Results: According to the findings, there was no significant relation between CO and mortality rate, but the other pollutants played a significant role in this regard. The maximum correlation was obtained for SO₂ and O₃ in the concentrations of 0.936 and 0.154 ppm, respectively, but in the final model for all pollutants and weather variables, only PSI for O₃, season and humidity showed significant change.

Conclusion: O₃ has increased during three years of research and has been the leading cause of death among the pollutants. Most deaths occurred in cold seasons. Among all pollutants, the maximum concentration of SO₂ was in winter and the maximum concentration of O₃ was in spring and summer 2009. [*Alidadi H. Shakeri M.T. Hossein zadeh H. Noorani A. **The Relation between Mortality Rate and Air Pollutant concentrations in Mashhad, 2007-2009. IJHS 2013; 1(2):68-74** <http://jhs.mazums.ac.ir>

Key words: Air pollution, Mortality Rate, Pollutants.

1. Introduction

Air pollution is a major environmental risk for human health, and its impacts on economic activities continue to be a worldwide concern. Air pollution is the presence of one or more pollutants or the combination of them in atmosphere for a certain period of time, which can be harmful to humans, plants or animal life (1,2). The major sources of air pollution are vehicles, industrial factories, smokes, fire, pollens, sand storms, storms, dust, volcanic activities and forest fires. Five air pollutants criteria including particulate matter (PM), sulfur dioxide (SO₂), nitrogen dioxide (NO₂), ozone (O₃) and carbon monoxide (CO) are regularly measured around the world. PM₁₀ or particles which are less than 10 micron in diameter, or toxic gases such as SO₂ are considered to be the most hazardous because when inhaled, these particulate matters or gas can reach deep into the lungs and interfere with internal gas exchange(2,3,4,5).

In recent years, more attention has been given to the effects of air pollution on human health. In the late 20th century, episodes of extremely high air pollution have been strongly correlated with mortality (6,7). Epidemiological research over the last two decades has determined that there is a direct relationship between poor air quality and a decline in overall human health. The EPA estimates that mobile sources (car, truck and bus) of air toxics account for as much as half of all cancers attributed to outdoor sources of air toxics (8,9,10,11). In a study on the relationship between air pollution and mortality rate, it was revealed that a significant relationship exists between these two variables. As WHO mentioned,

the estimated annual air pollution is responsible for 3 million premature deaths across the world. These contaminants can cause various diseases and can be influential in mortality rate. Nowadays, the role of air pollution in urban communities as an effective factor in various diseases and the mortality rate has been confirmed (4,8,10,11). Reducing pollution and thereby mortality rate seems to be important and necessary. Although several studies on the relationship between air pollution-related health complications and mortality rate have been done, there is not an accurate and appropriate methodology for this problem in our country. Most studies have been performed in the United States and Europe and such studies have been done less frequently in Asia (9, 13, 14, 18). In this study, the relationship between the frequencies of deaths associated with air pollution has been studied in Mashhad.

2. Materials and Methods

This longitudinal study was conducted on the relationship between mortality rate due to cardiovascular, pulmonary and infectious diseases and pollutant concentrations in the air in Mashhad during 2007 - 2009. In order to determine the levels of air pollution parameters such as carbon monoxide, sulfur dioxide, oxides of nitrogen, hydrocarbons and particles in different times of the year and deaths due to cardiovascular, pulmonary and infectious diseases in Mashhad during the year, all data were taken collected from Environmental Protection Agency, in Mashhad, Khorasan, also data of deaths due to air pollution such as cardiovascular,

pulmonary and infectious diseases in Mashhad during 2007-2009, were taken collected Emam Reza cemeteries of municipality. Information about daily concentrations of pollutants was taken from the site of the Environmental Protection Agency. The average concentration of about 24 micro pollutants smaller than 10 micrometers (PM_{10}) in microgram per cubic meter ($\mu g / m^3$), 24-hour average concentration of Nitrogen dioxide (NO_2), maximum-hour concentration of ozone (O_3), maximum 8-hour concentrations of carbon monoxide (CO) and 24-hour mean concentration of sulfur dioxide (SO₂) (all in PPM) have been reported.

All data was gathered from Vahdat Station which measures the concentrations of pollutants in Mashhad, located at the nearest station to Imam Reza Holy Shrine in the city center which is the most polluted part of city. The pollutants standard index, PSI, which is an index for reporting daily air quality and usually five of the pollutants including CO, O₃, NO₂, SO₂ and PM were used in this report to specify which of the pollutants have more adverse effects. To calculate the PSI value, the concentrations of the pollutants were transformed to a numerical scale between 0 and 500. As it measures the concentration of the pollutants based on a single standard scale, comparison between indicators becomes possible.

The equation below is used for converting the pollutants concentration to PSI. Equation:

$$I_{\max} - I_{\min} / C_{\max} - C_{\min} (C_{\max} - C_{\min}) + I_{\min}$$

In this relation I_{\max} and I_{\min} are the maximum standard range and minimum standards of the desired interval, and C_{\max} and C_{\min} are maximum concentration ranges and the minimum concentration intervals of the desired interval.

2.1. Statistical Analysis

At first, Matlab software was used for converting the daily concentrations of pollutants to standard index, then, the average standard of each pollutant was calculated for five weeks. The frequencies of mortality due to three factors were calculated in each week. The relationships between the variables were described in the graphics. The correlation coefficient of individual pollutants with the number of deaths was calculated and its significance was set. ANOVA test was used to compare the emissions in different seasons. The linear regression method was used in order to fit statistical models to determine the frequency of death and pollution.

3. Results

Table1. Prevalence of seasonal mortality (person) due to air pollution in Mashhad

Season/Year	2007	2008	2009
Spring	512	592	784
Summer	464	746	656
Autumn	505	944	779
Winter	614	975	942
Total	2095	3227	3161

Results shows that the most deaths occur in 2008 and the mortality rate in winter was more than other seasons. The table 2 shows

mean and standard deviation Psi of carbon monoxide in different seasons 2007 to 2009.

Table2. Mean and standard deviation Psi of carbon monoxide at different seasons in Mashhad

Season/Year	2007	2008	2009
Spring	26.02±11.19	25.76±9.60	19.11±6.69
Summer	25.03±7.647	22.21±10.81	21.12±8.98
Autumn	33.038±15.99	29.80±19.03	25.94±6.54
Winter	28.79±12.02	31.30±8.86	37.29±14.56
P _{value}	P=0.231	P=0.267	P<0.001

Results showed that high pollution and low pollution result of Psi carbon monoxide occurs in winter and spring 2008. There was significant relationship between Psi CO and

seasons (P value<0.001). The table 3 shows mean and standard deviation Psi of Nitrogen dioxide in different seasons 2007 to 2009.

Table3. Mean and standard deviation Psi of Nitrogen dioxide at different seasons in Mashhad

Season/Year	2007	2008	2009
Spring	17.30±1.60	11.90±1.58	6.41±2.61
Summer	20.62±6.30	10.68±1.26	6.27±2.63
Autumn	14.10±17.87	13.66±3.69	8.59±2.52
Winter	17.02±28.66	19.92±4.31	3.63±3.00
P _{value}	P=0.793	P<0.001	P<0.001

Results showed that between 2007 to 2009 Psi Nitrogen dioxide decreased and There was significant relationship between Psi CO and seasons in 2008 and 2009(P_{value}<0.001).

The table 4 shows mean and standard deviation Psi of ozone in different seasons 2007 to 2009.

Table4. Mean and standard deviation Psi of ozone at different seasons in Mashhad

Season/Year	2007	2008	2009
Spring	15.16±3.12	52.71±3.72	51.10±8.44
Summer	7.02±3.86	38.60±3.67	62.51±12.61
Autumn	29.64±7.38	40.86±6.39	32.23±15.19
Winter	42.98±8.45	42.71±20.18	32.11±29.17
P _{value}	P<0.001	P>0.001	P<0.001

Results showed that between 2007 to 2009 Psi Nitrogen dioxide increased and high pollution and low pollution result of Psi O₃ occurs in spring, summer and autumn. There was significant relationship between Psi O₃

and seasons in 2007 to 2009 ($P_{\text{value}} < 0.001$). The table 5 shows mean and standard deviation Psi of ozone in different seasons 2007 to 2009.

Table 5. Mean and standard deviation Psi of sulfur dioxide at different seasons in Mashhad

Season/Year	2007	2008	2009
Spring	5.81±1.07	10.75±2.62	8.51±1.92
Summer	5.80±0.82	8.62±2.08	11.95±2.64
Autumn	15.30±3.78	17.09±8.49	17.97±3.20
Winter	20.75±5.78	14.19±3.84	15.69±5.28
P _{value}	P<0.001	P<0.001	P<0.001

Results showed that high pollution and low pollution result of Psi SO₂ occurs in autumn, winter and spring, summer. There was significant relationship between Psi SO₂ and seasons in 2007 to 2009 ($P_{\text{value}} < 0.001$). Results showed that there was no significant relationship between CO and mortality, however, other pollutants showed a significant role in the mortality. The highest correlation was for the gases SO₂ and O₃ in the concentrations of 0.936 and 0.154 ppm, respectively. Linear regression model was used for the role of pollutants in

mortality changes. In this model, the dependent variable was the weekly number of mortality, and the independent variables were average amount of pollutants over 3 years. This model was fitted with data every 3 years, the PSI for CO was not significant ($P_{\text{value}} = 0.619$). However, other pollutants showed a significant role in this model. Determining factors in this model such as regression coefficients $R^2 = 0.187$ and significance of individual variables in this model is shown in the table below.

Table 6. Regression coefficients (β) of pollutants in Mashhad

Variable	β Coefficient	P _{value}
Constant	50.158	P<0.001
PSI(SO ₂)	0.936	P<0.001
PSI(O ₃)	0.154	P=0.014
PSI(PM ₁₀)	0.129	P = 0.014
PSI(NO ₂)	0.222	P = 0.045

There was a close relationship between mortality, and air pollution and cardiovascular, infectious and pulmonary diseases. This means that increasing

concentration of pollutants in the three years is associated with increasing the frequency of morbidity and mortality through the three mentioned categories of disease.

4. Discussion

Based on correlation coefficient during 2007-2009, the weekly average PM₁₀, NO₂, O₃, and SO₂ showed a significant relationship between death and cardiovascular, pulmonary and infectious diseases, but CO showed no significant association with mortality. In the first statistical model, SO₂ and O₃ had the highest correlation with mortality. Other variables such as the level of socio-economic or smoking can be confounding variables and play an important role in this regard; it seems that it is one of the reasons responsible for the different results in different years of research by creating a fake relationship or by covering the real relationship. It can be due to the other causes such as environmental or statistical problems of data or different interpretations in different years. According to the study by Yang in Taiwan, NO₂ and CO had the greatest impact on mortality due to respiratory disease (5). General results indicated that ozone has increased during research process; it was the main cause of death among gases because of 15-20 kilometers destruction of ozone layer above the atmosphere.

Ozone depleting gases are mainly from refrigeration and cooling industries, the sponge and foam-building industries, systems of agricultural pests, air conditioning, fire capsules, solvent cleaners spray and electronics. Shelf-life of ozone depleting gases is from 50 to 150 years; to remove these gases from atmosphere, at least half a century is necessary. Kim et al., found that ozone has a strong seasonal component; it is very difficult to separate the main effect of ozone on mortality from the confounding effect of season and temperature (12).

Lee et al., reported that SO₂ was significantly associated with daily mortality, but total suspended particulate was not (4). Xu et al., discovered that SO₂ was significantly associated with increased mortality, but TSP was not significant (3,16). Correlation and regression relationships between climatic elements and the average weekly mortality due to cardiovascular, pulmonary and infectious diseases demonstrated that climatic elements such as temperature and humidity and the mortality are associated with a significant strong correlation. Facing decreasing temperature, the number of mortality has been increased as mortality rate increases. As long as cooling air, pressure, solar radiation and short day length reduce; the inversion layer height increases the concentration of pollutants and the density of dust in the limited space and surface. The minimum mortality rate was in spring and summer, with the relative rise of temperature and decreased pressure, number of thermal inversion, height and atmospheric concentration of pollutants. Weekly average correlation between the elements of climate suggests a strong relationship with mortality. Farajzadeh reported more mortality rate in cold season (December, January and February) (17, 19). SO₂ and CO peak were in winter and maximum O₃ in spring and summer during 2009. Due to the increased mortality in winter in cardiopulmonary patients, it could be advised to them not to get out of their houses or to use mask.

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References

1. Toren K, Bergdahl IA, Nilsson T. Occupational exposure to particulate air pollution and Mortality due to ischaemic heart disease and cerebrovascular disease. *Occup Environ Med* 2007; 64: 515–519.
2. Perez L, Medina-Ramón M, Künzli N. Size fractionate particulate matter, vehicle traffic, and case-specific daily mortality in Barcelona, Spain. *Environ Sci Technol* 2009; 43:4707–4714.
3. Xu X, Gao J, Dockery D. Air Pollution and Daily Mortality in Residential Areas of Beijing, China. *Archives of environmental health* 1994; 49:216-216.
4. Lee J, Son J, Cho Y. A comparison of mortality related to urban air particles between periods with Asian dust days and without Asian dust days in Seoul, Korea, 2000-2004. *Environmental Research* 2007;105:409-413.
5. Yang Ch, Chang Ch, Chuang HY, Tsai ShSh, Wu TN, Ho Chk. Relationship between air pollution and daily mortality in a subtropical city: Taipei, Taiwan. *Environ int* 2004;30(4): 519-23.
6. Zhang P, Dong G, Sun B. Long-Term Exposure to Ambient Air Pollution and Mortality Due to Cardiovascular Disease and Cerebrovascular Disease in Shenyang, China. *Journal pone.* 2011;20:827.
7. Helen S. The relationship between ambient air pollution and heart rate variability differs for individuals with heart and pulmonary disease. *Environmental Health Perspectives* 2006.
8. Filleul L, Rondeau V, Vandentorren S. Twenty five year mortality and air pollution: results from the French PAARC survey. *Occup Environ Med* 2005;62:453–460.
9. Franklin M, Koutrakis P, Schwartz J. The role of particle composition on the association between PM_{2.5} and mortality. *Epidemiology* 2008;19: 680–689.
10. Dominici F, Daniels M, Zeger S. Air Pollution and Mortality: Estimating Regional and National Dose–Response Relationships. *Journal of the American Statistical Association.* 2002;97:457
11. Murray Ch, Nelson J, Charles R. State space modeling of the relationship between air quality and mortality. *J. of the Air and Waste Management Association* 2000.
12. Kim S, Lee J, Hong Y. Determining the threshold effect of ozone on daily mortality: an analysis of ozone and mortality in Seoul, Korea, 1995-1999. *Environmental Research* 2004; 94:113-119.
12. Lee J, Shin D, Chung Y. Air pollution and daily mortality in Seoul and Ulsan, Korea. *Environmental Health Perspectives* 1999;107:149-154.
13. Min J, Min K, Cho S. Lag effect of particulate air pollution on lung function in children. *Pediatric pulmonology*, 2008.
14. Welty L, Peng R, Zeger S, Dominici F. Bayesian Distributed Lag Models: Estimating Effects of Particulate Matter Air Pollution on Daily Mortality. *Biometrics* 2008.
15. Peng R, Dominici F, Louis T. Model choice in time series studies of air pollution and mortality. *Journal of the Royal Statistical Society Series A* 2006;169:179-203.
16. Kan H, London SJ, Chen G. Season, sex, age, and education as modifiers of the effects of outdoor air pollution on daily mortality in Shanghai, China: The Public Health and Air Pollution in Asia Study. *Environ Health Perspect* 2008;116: 1183–1188
17. Pope CA, Burnett RT, Thurston GD. Cardiovascular mortality and long term exposure to particulate air pollution: epidemiological evidence of general pathophysiological pathways of disease. *Circulation* 2004;109:71–7.
18. Zhang F, Krafft Th. Study on the Association between Ambient Air Pollution and Daily Cardiovascular and Respiratory Mortality in an Urban District of Beijing. *Int J Environ Res Public Health* 2011;8(6):2109–2123.
19. Faraj-Zadeh M. The effect of temperature on mortality in Tehran. *Hakim Research Journal* 2008;11(1):34-27.