Health endpoints caused by PM_{10} Exposure in Ahvaz, Iran

G. Goudarzi[1, 2], S. Geravandi[3], M.J. Mohammadi[1*], S. Saeidimehr[4], A. Ghomaishi[5], Sh. Salmanzadeh[6]

1) Department of environmental health engineering, school of public health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
2) Environmental technologies research center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
3) Islamic azad university, branch tehran university of medical sciences, Tehran, Iran
4) Oil grand hospital, The health affairs organization of oils and refineries industry, Ahvaz, Iran.
5) Department of anesthesiology, faculty of medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
6) Infectious and tropical diseases research center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

**Author for Correspondence*: javad_sam2000@yahoo.com - Mohamadi.m@ajums.ac.ir

Received: 25.Agu. 2014, Revised: 24 Sep. 2014, Accepted: 05 Oct.2014

ABSTRACT
PM_{10} emissions are defined as PM emissions that are less than ten microns in diameter. Long exposure of suspended particles as showed in his personal life. PM_{10} can cause harmful health effects such as the prevalence of bronchitis and reduced lung function in children and adults. Major sources of emissions are causing by human intervention particulate road traffic, stationary combustion and industrial processes. The aim of this study was to evaluate health- effects of carbon monoxide exposure in Ahvaz city (located in south-western Iran), during 2012. PM_{10} data were collected through Ahvaz Meteorological Organization and the Department of Environment. Raw data processing by Excel software includes (instruction set correction of averaging, coding and filtering) and after the impact of meteorological parameters was converted as input file to the Air Q model. Finally, respiratory mortality, cardiovascular death and hospital admissions respiratory disease of PM_{10} exposure was calculated. The results showed that the approximately 17% of total respiratory mortality, cardiovascular death and hospital admissions respiratory disease happened when the PM_{10} concentrations were more than 30μg/m^3. The results showed that the concentration of PM_{10} was related to Ahvaz with an annual average 321 μg/m^3. Sum of cardiovascular and respiratory death attributed to PM_{10} were 1055 and 189 cases in 2012. The higher percentage of these deaths perhaps could be the result of higher average PM_{10} or because of sustained high concentration days in Ahvaz. Therefore, the higher relative risk value can depict mismanagement in urban air quality.
Key Words: PM_{10}, Respiratory mortality, cardiovascular death, Hospital admissions, Ahvaz.

INTRODUCTION
Health effects of air pollution on human since the past have been considered by epidemiological researchers, government and people [1]. Epidemiological Researches of air pollution has been a consistent increased human health and the rate of death toll attributable to the air pollution [2-8]. The most important effects of air pollution include: increase rates hospital admissions, asthma attacks, cardiopulmonary disease, death and number of the years of life lost [9-13]. United States National Ambient Air Quality Standards (NAAQS) list air pollutants as carbon monoxide, ozone, particulate matter, sulfur dioxide, nitrogen dioxide, and Lead [14]. Particulate matter or PM is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets [1]. Short and long term exposure to PM_{10} can cases irritate the lungs, immune responses, lung constriction, producing shortness of breath, damage cells, aggravated coughing, aggravated asthma, increase hospital admissions, chronic bronchitis, cancer and deaths [9-13].
The major sources of Particulate matter are resulting from human intervention particulate road traffic, stationary combustion, transportation, power stations, heating plants and industrial processes. Particulate matter is classified by size, which is directly linked to the distance it will penetrate into the lung; the smaller the particle, the further it will penetrate. PM_{10} implies an air pollutant consisting of small particles with an aerodynamic diameter less than or equal to a nominal 10mm. The result of studies of short and long term effects of air pollution was estimated in the form of hospital admissions in excess cases, increasing in a number of consultations with a physician, asthma attacks, cardiopulmonary disease, death and number of the years lost [18-24]. Over the last two decades, a large number of epidemiological studies have been conducted around the world to highlight the health significance of ambient particulate matter [3-5]. WHO study showed that increased by 10 μg of

particle, can cases increase 1 to 3 percent of the mortality rate [1]. In recent years, several studies have shown a relation between the health effects and short and long term with particle matter in regional respiratory air among the population [6-8]. Dockery *et al* in a cohort study has shown adverse health impact of long-term air pollution exposure in the Six US cities. This study showed that chronic exposure to air pollutants is independently related to cardiovascular mortality [25]. In similar work Mohammadi *et, al* studied the association between daily mortality and PM_{10} levels in the Ahvaz in 2009 [26]. Also Goudarzi *et al* studied the association between daily mortality and PM_{10} levels in Tehran in 2009 [27]. Zallaghi *et al* studied the association between daily mortality and PM_{10} levels in the Ahvaz, Bushehr and Kermanshah in 2010 [28]. AirQ software was proved to be a valid and reliable tool to estimate the potential short-term effects of air pollution, predicts health endpoints attributed to criteria pollutants, and allows the examination of various scenarios in which emission rates of pollutants are varied [16-17]. The purpose of this study was to assess the potential effects of PM_{10} exposure on human health in Ahvaz city (located in south-western Iran) during the year 2012.

MATERIALS AND METHODS

The present study is an epidemiological and used model study. In this retrospective study, was used to assess the potential effects of PM_{10} exposure on human health in Ahvaz city (located in south-western Iran) during the year 2012. PM_{10} data was derived from Ahvaz Department of Environment (ADoE). These data were on volumetric base. These data were in volumetric base. Health effects are being related to the mass of pollutants inhaled and this is why the AirQ model was on a gravimetric basis. So, there was a conflict between AirQ model and ADoE data. Conversion between volumetric and gravimetric units (correction of temperature and pressure), coding, processing (averaging) and filtering is implemented for solving such problem. Raw air quality monitoring data were in a Microsoft Office Excel spread sheet. Therefore, all processing mechanisms such as correction, coding, averaging and filtering took place in this software. The temperature and pressure are unlikely to be standard, so we also need to be able to convert gravimetric units at STP to other temperatures and pressures. According to model database, it is suggested to specify the highest and the lowest stations before using secondary filtering. The station was considered as the highest when the mean value of this station is greater than the mean parameter at other stations and vice versa for the lowest. We calculated cardiovascular death, respiratory mortality and hospital admissions for respiratory disease related to PM_{10} by Air Q2.2.3 based on the relative utilizing risk, attributed proportion and baseline incidence from WHO data [16-17]. This model includes four screen inputs (Supplier, AQ data, location, and parameter) and two output screens (Table and Graph) [2-3]. For estimated of health impact attributable to the exposure to air pollution on the target population using AirQ model, that estimate this impacts to specific air pollutants on a resident population in a certain area and period.

Geographical features of Ahvaz: Ahvaz city, with a population of 1 million approximately, with an area of 8152 square kilometers, the capital city of Khuzestan Province is located between 48 degree to 49°29′ east of Greenwich meridian and between 31 degrees and 45 minutes to the north of the equator [2-3]. Data was taken from Ahvaz Department of Environment (ADoE). Stations were downtown “Naderi”, old building of School of Public Health Bureau of Meteorology and Head Office of ADoE.

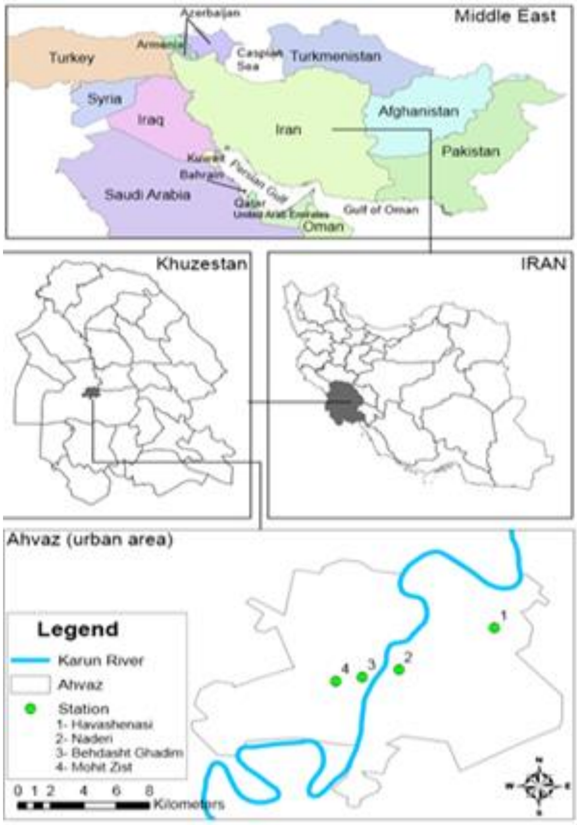

Fig 1: Location of the study area and sampling station in the Khuzestan Province (Ahvaz city), in the south west of Iran (29).

Data analysis

For estimated of health impact attributable to the exposure to air pollution on the target population using AirQ model, that estimate this impacts to specific air pollutants on a resident population in a certain area and period. AirQ model is based on statistical equations. Sample community was Ahvaz city which was considered one million persons approximately. Data capture was gathered for criteria air pollutants. Attributable proportion is the fraction of health consequences in a specific population that can be attributed to a specific air pollutant exposure with this notion that there is proven causative correlation between health consequences and air pollutant exposure. Attributable proportion was calculated as following formula: [30].

AP= SUM {[RR(c)-1] p(c)} /SUM [RR(c) p(c)]

Where: p(c) is population of city.

RR denotes the relative risk for a given health endpoint.

The rate attributable to the exposure can be calculated as the following equation if the baseline frequency of the health endpoint is known in the population:

IE = I AP

Where: (AP) is the fraction of health impacts which can be attributed to the exposure to a given population at a certain time period [30]. Of statistics and mathematical epidemiology, relative risk (RR) is the risk of an event (or of developing a disease) relative to exposure. Relative risk is a ratio of the probability of the event occurring in the exposed group versus a non-exposed group. (I) is the baseline incidence attributed to select health effects [31].

$$RR = \frac{\text{Probability of event when exposed}}{\text{probability of event when non-exposed}}$$

The number of cases attributable to the exposure can be estimated as the following equation knowing the size of the population:

$$NE = IE \times N$$

Where: NE denotes the number of cases attributed to the exposure. N denotes the size of the population investigated.

Attributable proportion was multiplied at baseline incidence and divided to 105. Obtained value should be multiplied by population (106). The results will be the excess cases of mortality or morbidity attributed to give pollutant (PM_{10}). In order to verify and compare the results with the actual results were referred to the registration center for disease But unfortunately because of lack and was not database quantities we used values of parameters required calculated by the from WHO (in Middle East).

The primary and secondary standard of particulate matter according to national ambient air quality standard (NAAQS) for 24-hour is 150μg/m^3(14). World health Organization (AQG WHO) has recommended 20 and 50 μg/m^3 as annual and 24-hour means of PM_{10} guidelines, respectively [32].

Ethical considerations

Sampling and collection data's don by Ahvaz Department of the Environment and we analysis of PM_{10} data by use of Excel software and AirQ model. Estimated of health impact attributable to the exposure to air pollution on the target population using AirQ model, that estimate these impacts to specific air pollutants on a resident population in a certain area and period.

RESULT AND DISCUSSION

In view of PM_{10} concentrations, Havashenasi and Naderi had the highest and the lowest PM_{10} concentrations during 2012, respectively. The annual average, summer average, winter average, 98 percentile, Annual Max, Summer Max and Winter Max of PM_{10} concentrations in these stations has presented in Table 1. Table 1 shows that the annual mean of PM_{10} in Ahvaz was 321 μg/m^3 in 2012 which is higher than EU AQS and also much higher than NAAQS standards.

Table 1: Highest and lowest concentrations of PM_{10} (μg/m^3) corresponding to stations

Stations / Parameter	Average Ahvaz	lowest stations (Naderi)	highest stations (Havashenasi)
Annual mean	321	284.22	368.23
Summer mean	438	389.46	501.65
Winter mean	276	211.12	324.14
98 percentile	2132	1426.47	2314.89
Annual Max	6743	5986.32	6743
Summer Max	6743	5986.32	6743
Winter Max	4361	3861	4635

Relative risk and estimated Attributable proportion percentage were estimated in table 2 for cardiovascular deaths. As mentioned earlier BI was taken from model's default which is 497 per 105 for this health endpoint. Therefore, estimated number of excess cases were calculated 1055 at centerline of relative risk (RR=1.008 and AP=12. 6962%).

Cumulative cases of cardiovascular mortality attributed to PM_{10} concentrations have illustrated in Figure 2 with three ranges of relative risk (down, mean, up). 1987 persons were estimated by model as total cumulative number of cardiovascular death within one year of exposure. 48% of these cases have occurred in days with PM_{10} levels not exceeding 200μg/m^3. Also, Show that despite the relative risk of health effects of PM_{10} concentrations below to 20μg/m^3 due to lack of contact with the population concentration is zero In other words, no one day in 2012 has been reaches the PM_{10} concentration below 20µg/m^3. It should be noted that 82 percent of above number are corresponding to the days with concentrations below 400µg/m^3.

Table 2: Estimated relative risk indicators and the component exposure to PM_{10} cases attributable to cardiovascular deaths (BI= 497)

Indicator / Estimate	RR (Medium)	Estimated AP (%)	Estimated number of excess cases (persons)
Down	**1.0050**	**8. 3318**	**621.3**
Mean	**1.0080**	**12. 6962**	**1055.1**
Up	**1.0180**	**24. 6538**	**1987.2**

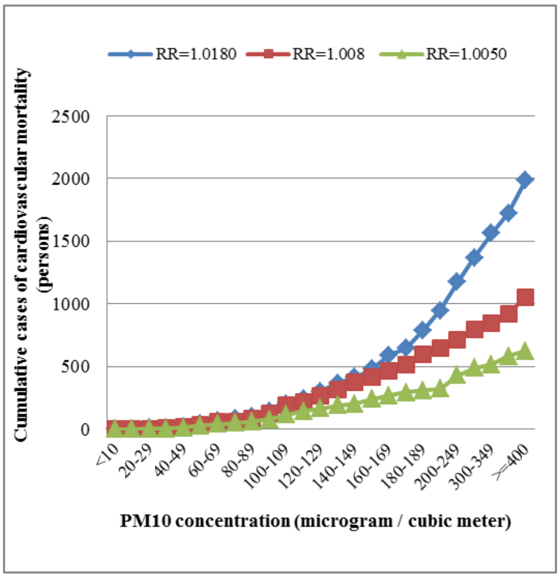

Fig. 2: relationship between cumulative of Cardiovascular deaths related to PM_{10}

Relative risk and estimated attributable proportion percentage were estimated in table 3 for respiratory mortality. BI of this health endpoint is 66 per 105, the estimated number of excess cases were 189 at centerline of relative risk (RR=1.0080 and AP=12. 6962%).

Respiratory mortality versus particulate matter concentration has shown in figure 3. Estimated cases which attributed to PM_{10} for respiratory mortality at lower, central and higher of RR were 89, 189 and 324, respectively.

Relative risk and estimated attributable proportion percentage for Hospital Admissions Respiratory disease were estimated in table 4. According to model's default, the baseline incidence (BI) of this health endpoint for PM_{10} was 1260 per 105 so the number of the estimated number of excess cases was estimated 2675 at centerline of relative risk (RR=1.0080 and AP=11. 8569%).

Table 3: Estimated relative risk indicators and the component exposure to PM_{10} cases attributable to respiratory mortality (BI= 66)

Indicator / Estimate	RR (Medium)	Estimated AP (%)	Estimated number of excess cases (persons)
Down	1.0050	8. 3318	89.3
Mean	1.0080	12. 6962	189
Up	1.0180	24. 6538	324.5

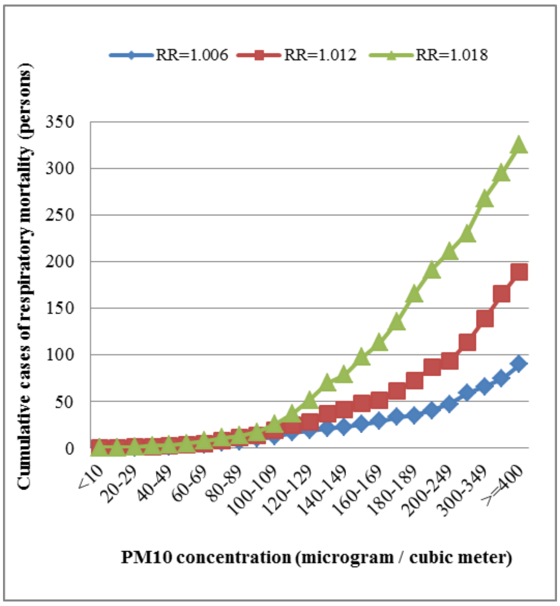

Fig 3: relationship between cumulative of Respiratory deaths related to PM_{10}

Table 4: Estimated relative risk indicators and the component exposure to PM_{10} cases attributable to Hospital admissions respiratory disease (BI= 1260)

Indicator / Estimate	RR (Medium)	Estimated AP(%)	Estimated number of excess cases (persons)
Down	1.0050	7. 4158	1551.7
Mean	1.0080	11. 8569	2675
Up	1.0180	22. 8965	3864

Hospital Admissions Respiratory Disease versus particulate matter concentration has shown in figure 4. Estimated cases which attributed to PM_{10} for Hospital Admissions Respiratory disease at lower, central and higher of RR were 1551, 2675 and 3864, respectively.

In this study, we estimate cardiovascular death, respiratory mortality and hospital admissions respiratory disease was associated with short and long term fluctuations in concentrations of PM_{10}, using AirQ model in Ahvaz, Iran. Sum of cardiovascular mortality attributed to Carbon monoxide in Ahvaz was 1055 cases in 2012. Results show that approximately Ahvaz with 4 percent is one of the most polluted cities. The higher percentage of these deaths perhaps could be the result of higher average PM_{10} or because of sustained high concentration dusty days in Ahvaz.

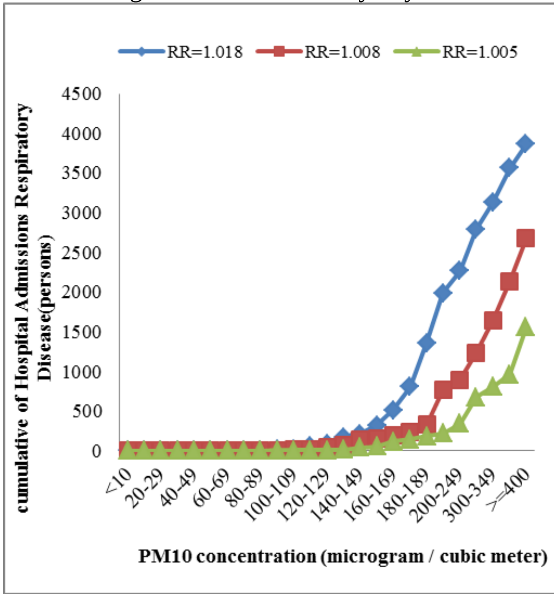

Fig 4: relationship between cumulative of Hospital Admissions Respiratory Disease related to PM_{10}

Table 1 shows that the maximum 24-hour average of summer and winter of Havashenasi and Naderi was the highest and the lowest stations during this year respectively. Relative risk, the percentage, attributed ratio and the cardiovascular death, respiratory mortality and hospital admissions respiratory disease attributed to the PM_{10} are estimated in Table 2-4. Figures 2 to 4 have illustrated PM_{10} concentrations versus related health endpoint and average concentrations in during years. Researchers showed the association of daily mortality and morbidity with short-term variations in the ambient concentrations of air pollutants [33-34]. Based on the results of this study, 15% of all cardiovascular death, respiratory mortality and hospital admissions respiratory disease were attributed to respiratory concentrations over 20µg/m^3. A study commissioned its cooperation on North American was conducted to among infants aged one month to one year 20 µg/m^3 increases in average 24-hr PM_{10} the risk of deaths was increased by 82 percent. However, these estimates were based on only 41 deaths [35]. Review and meta-analysis were conducted to determine the effects of short-term exposure on mortality that increasing 10µg/m^3 showed estimated by the Bangkok 1/7 percent, Mexico 1/83 percent, Santiago 1/1 percent, inchoan, 0/8 percent, Bryson Australia 1/6 percent [36-40]. High percentage of the observed health endpoints in this study was associated with high concentration of measured PM_{10} and phenomenon dust storm in Ahvaz. In similar work Zallaghi and Associates to evaluate the health effects of PM_{10} by using of Air Q model in south west of Iran (kermanshah-bushehr) during 2010. Based on the results of this study, in Kermanshah 12 percent of cardiovascular diseases and 17 percent Respiratory diseases was attributed to PM_{10} concentrations over 30µg/m^3 [28]. The results this study shows that concentration of PM_{10} in Ahvaz is very high compared to Kermanshah and bushehr city. Also Zallaghi exploited AirQ model to estimate the PM_{10} hygienic effects in bushehr during 2010. Based on their results, almost 14 percent of cardiovascular diseases and 19 percent Respiratory diseases were attributed to PM_{10} concentrations over 20µg/m^3 [42]. Based on the results of my study health effects was the relatively higher because of concentration was higher than in Ahvaz city. Tominz and Associates to evaluate the health effects of PM_{10} by using of Air Q model in Trieste city during 2005, Italy. Based on the results of this study, 1/8 percent of all respiratory mortality and 2/5 percent of all deaths were attributed to respiratory concentrations over 20µg/m^3 [43]. Results of this study are different to compare with Italy because of the geographic, demographic, and climate characteristics. In another similar work Goudarzi and Associates to evaluate the health effects of PM_{10} by using of Air Q model in Tehran city during 2008. Based on the results of this study, 4 percent of all respiratory mortality was attributed to PM_{10} concentrations over 20 µg/m^3 [27]. In another similar work Zallaghi and associates evaluated the health effects of PM_{10} by using of Air Q model in bushehr city during 2011. Based on the results of this study, 15 percent of cardiovascular diseases and 20 percent Respiratory diseases was attributed to PM_{10} concentrations over 10µg/m^3 [43]. Also Zallaghi *et al* evaluated the health impact by using AirQ Model in Tabriz. . Based on the results of this study, 6 percent of all cardiovascular and Respiratory mortality was attributed to PM_{10} concentrations over 10µg/m^3 [17].

CONCLUSION

Although the results of this study are in line with results of other researchers around the world, since the geographic, demographic, and climate characteristics are different, there is still high need to further studies to specify local RR and BI. Larger relative risks for air pollution were mostly found in the elderly except for PM_{10} and for death-cause cardiovascular, respiratory and Hospital Admissions respiratory disease which showed larger relative risk. High percentage of the observed health endpoints was associated with high concentration of measured PM_{10}. Unfortunately, due to lack of databases and the lack of indicators amounts, to estimate the health effects of air pollutants actually are required epidemiologic studies for accurate calculation of RRs and BIs. Also Careful monitoring of particulate matter, public education, control and optimization of urban traffic, application of technical methods for decrease PM in purpose source such as use mulch in Iraq and regulations urban development will have an important role in controlling air pollutants including particulate matter.

CONFLICT OF INTERESTS

Authors do not have any conflict of interests.

AKNOWLEGMENT

The authors would like to thanks to Ahvaz Jundishapur University of Medical Sciences for their financial support.

REFERENCES

[1] Mirhosseini SH, Birjandi M, Zare MR, Fatehizadeh A. Analysis of Particulate matter (PM_{10} and $PM_{2.5}$) concentration in Khorramabad city. Int J Env Health Eng, 2012; 1(7): 1–4.

[2] Goudarzi G, Mohammadi M J, Ahmadi Angali K, Neisi AK, Babaei A, Mohammadi B, Soleimani Z. & Geravandi S. Estimation of Health Effects Attributed to NO2 Exposure Using AirQ Model. Arch Hyg Sci, 2012;1(2):59-66.

[3] Goudarzi G, Mohammadi M, Angali K, Mohammadi B, Soleimani Z, Babaei, A, Neisi A & Geravandi S. Estimation of Number of Cardiovascular Death, Myocardial Infarction and Chronic Obstructive Pulmonary Disease (COPD) from NO_2 Exposure using Air Q Model in Ahvaz City During 2009. Iranian Journal of Health and Environment. 2013; 6(1): 91-102 (In Persian).

[4] Pope C A, Dockery D W. Health effects of fine particulate air pollution: lines that connect. J Air Waste Manag Assoc 2006, 56 (6): 709-42.

[5] Goudarzi G, Geravandi S, Naimabadi A, Mohammadi MJ, Neisi AK, sadat Taghavirad S. Cardiovascular deaths related to Carbon monoxide Exposure in Ahvaz, Iran. Iranian Journal of Health, Safety & Environment. 2014; 1(3):126-31.

[6] Baccarelli A, Barretta F, Dou C, Zhang X, McCracken JP, Diaz A, *et a*l., Effects of particulate air pollution on blood pressure in a highly exposed population in Beijing, China: a repeated-measure study, Environmental Health 2011; 10:108-18.

[7] Soleimani Z, Goudarzi G, Naddafi K, Sadeghinejad B, Latifi S M, Parhizgari N, *et al*. Determination of culturable indoor airborne fungi during normal and dust event days in Ahvaz, Iran. Journal of Aerobiologia, 2013; 29(2): 279–90.

[8] Scapellato ML, Lotti M. Short-term effects of particulate matter: An inflammatory mechanism? Crit Rev Toxicol, 2007; 37:461-87. [9] Ritz B, Yu F, Fruin S, et al. Ambient air pollution and risk of birth defects in Southern California. Am J Epidemiol. 2002; 155 (1): 17–25.

[10] Clancy L, Goodman P, Sinclair H, *et al.* Effects of air-pollution control on death rates in Dublin, Ireland: an intervention study. Lancet. 2002; 360 (9341): 1210–14.

[11] Kelly F J. Oxidative stress: its role in air pollution and adverse health effects. Occup Environ Med. 2003; 60(8):612–16.

[12] Goudarzi G, Zallaghi E, Saki A, Neisi AK, Ahmadi Angali K, Mohammadi MJ, et al. Cardiopulmonary Mortalities and Chronic Obstructive Pulmonary Disease Attributed to Ozone Air Pollution. Archive of Hygiene Sciences Journal. 2013; 2(2):62-67.

[13] Schwartz J. The distributed lag between air pollution and daily deaths. Epidemiology 2000;11(3):320-26.

[14] US Environmental Protection Agency. National Ambient Air Quality Standards (NAAQS): for air pollutant. US Environmental Protection Agency, 2014. Available from: http://www.epa.gov/air/criteria.html

[15] Valavanidis A, Fiotakis K, Vlachogianni T. Airborne particulate matter and human health: Toxicological assessment and importance of size and composition of particles for oxidative damage and carcinogenic mechanisms. J Environ Sci Health C Environ Carcinog Ecotoxicol Rev, 2008;26:339-62.

[16] Geravandi S, Mohammadi MJ, Goudarzi Gh, Ahmadi Angali K, Neisi AK, Zalaghi E. Health effects of exposure to particulate matter less than 10 microns (PM_{10}) in Ahvaz. Journal of JQUMS, 2014; 18(5): 45-53 (In Persian).

[17] Zallaghi E, Goudarzi G, Geravandi S, Mohammadi MJ, Vosoughi Niri M, Vesyi E, et al. Estimating the prevalence of cardiovascular and respiratory diseases due to particulate air pollutants in Tabriz air. Scientfic J Ilam University of Medi Sci, 2014; 22 (1): 84-91 (In Persian).

[18] Bateson T F, Schwartz J. Who is sensitive to the effects of particulate air pollution on mortality? A case-cross over analysis of effect modifiers. Epidemiology. 2004;15(2):143-49.

[19] Izzotti A, Parodi S, Quaglia A, Farè C, Vercelli M. The relationship between urban air pollution and shortterm mortality: quantitative and qlitative aspects. Eur J Epidemiol. 2000;16(11):1027-34.

[20] Pope C A, Burnett R T, Thun M J, Calle E, Krewski D, Ito K, *et al.* Lung cancer, Cardiopulmonary, Mortality, and long term exposure to fine particulate air pollution. JAMA. 2002; 287(9):1132-41.

[21] Reed M D, Gigliotti A P, McDonald J D, Seagrave J C, Seilkop S K, Mauderly J L. Health effects of subchronic exposure to environment levels of diesel exhaust. Inhal Toxicol. 2004;16(4):177-93.
[22] Pan Z, Molhave L, Kjaergaard S K. Effects on eyes and nose in humans after experimental exposure to airborn office dust. Indoor Air. 2000;10(4),237-45.
[23] Krzyzanowski M, Cohen A, Anderson R. Quantification of health effects of exposure to air pollution. Occup Environ Med. 2002;59(12):791-3.
[24] World Health Organization. AQG Air Quality Guidelines for Europe, 2nd edition. Copenhagen: WHO Regional Office for Europe, WHO Regional Publications, European Series, 2000; 91(2): 175-9.
[25] Dockery D W, Pope C A, Xu X, *et al*. An association between air pollution and mortality in six US cities. N Engl J Med. 1993;329(24):1807-8.
[26] Mohammadi M J. Studied hygienic effects of air pollution in town Ahvaz in 2009 with model Air Q. MSc Thesis. Ahvaz Jundishapur University of Medical Sciences. 2009 (In Persian).
[27] 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. PhD Thesis, Tehran University of Medical Sciences; 2007 (In Persian).
[28] Zalaghi E. Survey of health Effects of Air Pollution Ahvaz, Bushehr and Kermanshah with Use of AIRQ Model. MSc Thesis, Islamic Azad University, Science and Research Branch, Ahvaz; 2010 (In Persian).
[29] Goudarzi G, Shirmardi M, Khodarahmi F, Hashemi-Shahraki A, Alavi N, Ankali K, Babaei AA, Soleimani Z & Marzouni MB. Particulate matter and bacteria characteristics of the Middle East Dust (MED) storms over Ahvaz, Iran. Aerobiologia, 2014; 30(1): 333-7.
[30] Mark A. Kaelin and Manuel Bayona. Attributable Risk Applications in Epidemiology. College Entrance Examination Board .3rd ed. Upper Montclair, University Press; 2004: 6-7. [31] Rockhill B, et al. Use and misuse of population attributable fractions. J Public Health, 1998; 38:15-19.
[32] World Health Organization. AQG Air Quality Guidelines for Europe, 2nd edition. Copenhagen: WHO Regional Office for Europe, WHO Regional Publications, European Series, 2000; 91(2): 175-9. Available from: www.who.int.
[33] Hoek G, Brunekreef B, Verhoeff A, van Wijnen J, Fischer P. Daily mortality and air pollution in The Netherlands. J Air Waste Manag Assoc 2000; 50(8): 1380–89.
[34] Gryparis A, Forsberg B, Katsouyanni K, Analitis A, Touloumi G, Schwartz J, Samoli E, Medina S, Anderson HR & Niciu E. M.. Acute effects of ozone on mortality from the â€œair pollution and health: a European approach. American journal of respiratory and critical care Medicine, 2004; 170(10): 1080-1087.
[35] Commission for Environmental Cooperation of North America. Health Impacts of Air Pollution on Morbidity and Mortality among Children of Ciudad Juarez, Chihuahua, Mexico, 2003.
[36] Ostro B, Chestnut L, Vichit-Vadakan N, Laixuthai A. The impact of particulate matter on daily mortality in Bangkok, Thailand. J Air and Waste Manage Associ, 1999; 49(9): 100-107.
[37] Castillejos M, Borja-Aburto VH, Dockery DW, Gold DR, Loomis D.. Airborne coarse particles and mortality, J Inhal Toxico, 2000; 12(1): 67-72.
[38] Ostro B, Sanchez JM; Aranda C, Eskeland GS. Air pollution and mortality: results from a study in Santiago, chile, J Exposure Analysis and Env Epide, 1996; 6: 67-114.
[39] Hong VC, Leem JH, Ha EH, Christiani DC. PM_{10} exposure, gaseous pollutants, and daily mortality in Inchon, South Korea. Environ Health Perspect 1999 Nov; 107 (11): 873-8
[40] Simpson RW, et al. Associations between outdoor air pollution and daily mortality in Brisbane, Australia, J Arch of Env Health, 1997; 52 (6): 442-454.
[41] Zallaghi E, Goudarzi G, Geravandi S, Mohammadi MJ. Estimate of cardiovascular and respiratory diseases related to PM_{10} pollutant in bushehr air, 2010, (by AIR Q model). 16th the national conference on environmental. Tabriz University of Medical Sciences; 2013 (In Persian).
[42] Tominz R, Mazzoleni B, Daris F. Estimate of potential health benefits of the reduction of air pollution with PM10 in Trieste, Italy, J Epide Preven, 2005; 29 (3): 149-55.
[43] Zallaghi E, Goudarzi G, Geravandi S, Mohammadi MJ. Estimate of cardiovascular and respiratory diseases related to PM_{10} pollutant in bushehr air, 2011, (by AIR Q model). 16th the national conference on environmental. Tabriz University of Medical Sciences; 2013(In Persian).