Original article

Hospital admission of exposure to air pollution in Ahvaz megacity during 2010–2013

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ABSTRACT

Introduction: Criteria air pollutants have been a serious problem for humans because of increased disease rates, treatment costs and death.

Objective: The aim of this study was to estimate the health endpoint of Ahvaz Megacity Criteria Air Pollutants (MCAP) in humans during 2010–2013. Criteria Air Pollutants (CAP) were monitored by Ahvaz Environmental Protection Agency (AEPA).

Methods: This study, evaluated the health effects which are related to particle mater (PM₁₀), Ozone (O₃), nitrogen dioxide (NO₂) and sulfide dioxide (SO₂) by descriptive analysis and AirQ model. Sampling according to EPA guideline was done and baseline incidence (BI) and relative risk (RR) measures by the World Health Organization (WHO) for Middle East region were used in order to estimate the health endpoint association of CAP.

Results: Result of this study is useful for better understanding of relationship between exposure to criteria air pollution and health effects. Hospital Admission (HA) were Hospital Admission Respiratory Disease (HARD), Hospital Admission for Chronic Obstructive Pulmonary Disease (HACOPD), Hospital Admission Cardiovascular Disease (HACD). According to the result of this study, the annual cases of hospital admission during 2010–2013 were (PM₁₀: 3116, 3246, 3026 and 2895; O₃: 37, 42, 51 and 72; NO₂: 10, 13, 21 and 25; SO₂: 25, 31, 35 and 42), the average annual level of CAP in the same period were (PM₁₀: 281.98, 288.38, 278.12 and 242.29; O₃: 66.52, 72.67, 102.27 and 223; NO₂: 28.7, 31, 37 and 41; SO₂: 78.92, 91.07, 92.75 and 112.3 µg/m³), respectively. Based on the results, the average of 4-year study was higher than NAAQS and WHO values. The concentration of exposure to criteria air pollutants can increased morbidity and mortality between residential in Ahvaz megacity. **Conclusion:** Results of our study can be very important for government, medical, public health and scientific. Also, this study can help to government for adoption of laws which are related to air pollution and achieve international air quality standards. Hence, it is necessary to reduce emission of criteria air pollution sat national management level.

1. Introduction

Nowadays, the most important agents that threaten the humans and

environment in Iran are petroleum, gas, petrochemical, transportation, dust storm and population growth.^{1–14} Breathing of air pollutants can be induced different health endpoint.^{15–26} The effects of air pollution on

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human health is one of the important issues that have addressed by several studies. Large studies conducted cities across the United States (U.S), Europe and in Asia reported of strong evidence about the deadly impact of air pollutants. Based on the result of these studies, risk of premature death increased with higher levels of criteria air pollutants.^{27–31} Short-term and long-term exposure to criteria pollutants can be disorders in respect with the function of large organs in body such as lung, eyes, brain, and heart.

Based on the result of different studies the main sources of emission and generation of criteria air pollutants in megacities are industries, economic development, domestic fuel burning, urbanization, transportation and vehicles.^{32–37} According to the result of several studies, the most important symptoms of criteria air pollutants increases hospital admission rates increase, coughing, reduced lung function, respiratory infections, coughing, asthma attacks, chronic obstructive pulmonary disease, eye irritation, increased respiratory and cardiovascular disease, heart stroke, respiratory and cardiovascular death in people region inhalation.^{35–62}

Dockery et al. studied the relationship between exposure to criteria air pollutants and health endpoint. According to the result of this study cardiovascular mortality was independently associated with exposure to air pollutants.⁶³ In similar works Zallaghi et al. and Mohammadi et al. studied the health endpoint in different cities in Iran caused by concentration of PM₁₀.^{64,65}

Bell et al. studied the health endpoint due to exposure to ground level ozone (GLO).⁶⁶ In 2004 Gryparis et al. studied the exposure to environmental GLO pollution sources and their health effects on human.⁵⁵ In a similar work, Glad et al., in 2012 associated the relation between prevalence hospital admission and effects of gender and ethnicity with ambient ozone levels.⁶⁷ Assessment of short term exposure to high GLO concentration and enhance rate of hospital admission caused repository and cardiovascular diseases on human which is conducted by Rich et al., in 2006.⁶⁸

Khaefi et al. studied PM₁₀ effect on prevalence of COPD in Ahvaz, Khuzestan province of Iran during 2009–2013.⁸ Goudarzi et al., in 2016 evaluated the HARD related to SO₂ on Ahvaz citizenship.¹⁷ In 2015 by Labelle et al., the evaluation of HARD and exposure to SO₂ in industrial area in Quebec, Canada was done.⁶⁹ Also, Lipmann et al. in Detroit, USA, studied the association of sulfur dioxide level and health effects on human.⁷⁰ Tsai et al. studied the relationship between HARD and daily stroke admissions and NO₂ in Kaohsiung, Taiwan.⁶⁰ In another study by Zallaghi et al. the level of nitrogen dioxide in urban air was studied in order to assess the health of citizens of west and southwest cities of Iran.⁶¹

In the last decade development of heavy industries (petroleum, gas, oil, steel and pipe), dust phenomenon, climate change, annual rainfall reduction, rapid population growth, abundant waste production, lack of proper waste treatment systems and sewage are the most important risks that threaten the human, plant and animal environment.^{6,12,14,19,71–73} The purpose of this study was the potential effects of criteria air pollutants exposure assessment on hospital admission in Ahvaz megacity during 2010–2013.

2. Methods

2.1. The study area

This study is a descriptive and used model study. In this study was performed in 2010–2013 to estimate and correlate concentration of PM₁₀, O₃, NO₂ and SO₂ to hospital admission in Ahvaz megacity citizenship, Iran. Air Q model and Excel are used for processing, analysis and number of hospital admission caused by exposure to criteria air pollutants.

Evaluation to health endpoint of PM₁₀, O₃, NO₂ and SO₂ exposure was done by relative risk (RR), baseline incidence (BI) and attributable proportion (AP). The part of health endpoint which can be related to

the criteria air pollutants exposure in Ahvaz megacity residential is the attributable proportion implies and in baseline incidence was divided to 10⁵.^{74,75} In the parameter screen, AP was calculated regarding to concentration of criteria air pollutants, BI and RR. Based on studied event incidence in the population in its place as the baseline is defined Baseline Incidence (BI).⁷⁶ The baseline incidence was calculated, using Equation (1)

$$BI = \frac{\sum \{ [RR(c) - 1] \times p(c) \}}{\sum [RR(c) \times p(c)]} \quad (1)$$

Where: p(c) is the proportion of Ahvaz population in category c of exposure and RR(c) is the relative risk for category c of exposure. It is a very useful to know the association between a disease and an environmental factor under study. Amount of RR was calculated as following formula^{77–79}:

$$RR = \frac{\text{Incidence in the exposed population}}{\text{Incidence in the non exposed population}} \quad (2)$$

2.2. Geographical features of Ahvaz

Ahvaz is a city with an area of 185 square kilometers that is the capital of Khuzestan Province (Southwest of Iran and Northern of Persian Gulf) in Iran and is located at 31°20' N and 48°40' E.^{3,6,8,11,14} Ahvaz with an area of 140 square kilometers and a population of approximately 1.3 million is one of the megacities of Iran. Location of station in Ahvaz are presented Fig. 1.

2.3. Data collection

We, in this study was correlate the concentration of PM₁₀, O₃, NO₂ and SO₂ to Hospital Admission (HA) during the period 2010–2013. According to the report of International Classification of Diseases (ICD-10), the number of hospital admission (HA) included: Hospital Admission Respiratory Disease (HARD- J44.8), Hospital Admission for Chronic Obstructive Pulmonary Disease (HACOPD- J44.1), asthma attacks (AA- J44) and Hospital Admission Cardiovascular Disease (HACD- I51.6), diagnosed by emergency doctors⁸⁰ and was estimated by Air-Q model (baseline incidence, relative risk and attributed proportion). Meteorological phenomenon occurs when a strong wind blows loose sand and dirt from a dry surface in arid and semi-arid regions is defined as a dust storm.⁸¹

Fig. 1. Located of sampling stations in Ahvaz megacity.

Table 1Criteria air pollutants concentrations ($\mu\text{g}/\text{m}^3$) and cases of hospital admission assessment of CAP on Ahvaz megacity inhabitants, 2010–2013.

Year	air pollutants	Annual mean	RR	HA (AP)
2010	Particle mater	281.98	RR = 1.0044 (1–1.0049)	3116
	Sulfide dioxide	78.92	RR = 1.01 (1.006–1.014)	25
	Ozone	66.52	RR = 1.0080 (1.004–1.012)	37
	Nitrogen dioxide	28.7	RR = 1.0038 (1.0004–1.0094)	10
2011	Particle mater	288.38	RR = 1.0044 (1–1.0049)	3246
	Sulfide dioxide	91.07	RR = 1.01 (1.006–1.014)	31
	Ozone	72.67	RR = 1.0080 (1.004–1.012)	42
	Nitrogen dioxide	31	RR = 1.0038 (1.0004–1.0094)	13
2012	Particle mater	278.12	RR = 1.0044 (1–1.0049)	3026
	Sulfide dioxide	92.75	RR = 1.01 (1.006–1.014)	35
	Ozone	102.27	RR = 1.0080 (1.004–1.012)	51
	Nitrogen dioxide	37	RR = 1.0038 (1.0004–1.0094)	21
2013	Particle mater	242.29	RR = 1.0044 (1–1.0049)	2895
	Sulfide dioxide	112.3	RR = 1.01 (1.006–1.014)	42
	Ozone	223	RR = 1.0080 (1.004–1.012)	72
	Nitrogen dioxide	41	RR = 1.0038 (1.0004–1.0094)	25
Total Average	Criteria air pollutants	129.24	–	792.93

RR: is a ratio of the probability of the event occurring in the exposed group versus a non-exposed group.

AP: is defined as the part of health effects which can be attributed to the pollutant exposure in population.

2.4. Ethical considerations

Air Q model and Excel were used for analysis, sampling and data collection.

3. Results

The results of criteria air pollutants concentrations and cases of hospital admission are presented for each pollutants in Table 1. As it has shown in Table 1 the trend for yearly concentration of criteria air pollutants and number of hospital admission were decreased in Ahvaz megacity during 2010–2013.

During the time of study, concentration of criteria air pollutants (O_3 , PM_{10} , SO_2 and NO_2) were higher in 2010 than in 2013. Also, among criteria air pollutants PM_{10} has the greatest impact on the Number of hospital admission. Calculated number of cases were related to O_3 , PM_{10} , SO_2 and NO_2 at central RR (1.0080, 1.0044, 1.010 and 1.0038) during 2010–2013. Central RR can be a reasonable indicator of current situation in view of criteria air pollutants health effects.

As Fig. 2 indicates, PM_{10} and NO_2 were the highest and the lowest concentration between criteria air pollutants during 2010–2013. A

downward trend is observed in PM_{10} . Rising trend of concentrations was observed about SO_2 , O_3 and NO_2 pollutant (Fig. 2).

Cumulative number of hospital admission cases related to criteria air pollutants during 2010–2013 illustrated in Fig. 3.

Based on the result of Fig. 3, year of 2011 had the maximum number of HA and year of 2013 had the minimum number of HA attributed to CAP in the period of study.

Average concentrations of criteria air pollutants during 2010–2013 illustrates in Fig. 4. It should be noted that box plot shows the minimum, quarter₁, median, quarter₃ and maximum concentrations of PM_{10} , SO_2 , O_3 and NO_2 . Based on Fig. 4, level of PM_{10} is higher than another criteria air pollutants.

4. Discussion

Nowadays criteria air pollutants cause many complications on humans and the environment. In this study, HA of exposure to PM_{10} , O_3 , NO_2 and SO_2 was evaluated by Air Q model in Ahvaz megacity inhabitants, Iran. Emission CAP especially PM_{10} increase of health effects between inhabitants because of paying attention to decreasing emission air pollutant is very vital. According to the result our study, the number

Fig. 2. Trend of concentrations criteria air pollutants in Ahvaz megacity, southwest of Iran, during 2010–2013.

Fig. 3. Cumulative number of hospital admission cases related to criteria air pollutants (a: number of HA related to PM₁₀, b: number of HA related to SO₂, c: number of HA related to O₃, d: number of HA related to NO₂).

of HA attributed to particle matter, ozone, nitrogen dioxide and sulfide dioxide in 2010 (3116, 37, 10 and 25), 2011 (3246, 42, 13 and 31), 2012 (3026, 51, 21 and 35) and 2013 (2895, 72, 25 and 42), respectively; in which the maximum was 2011 due to the highest concentration of PM₁₀ among these years and CAP. According to the result of this study, the yearly average CAP concentrations during the same period were PM₁₀: 281.98, 288.38, 278.12 and 242.29; O₃: 66.52, 72.67, 102.27 and 223; NO₂: 28.7, 31, 37 and 41; SO₂: 78.92, 91.07, 92.75 and 112.3 µg/m³, respectively. According to the result of this study, the average concentration of criteria air pollutants was higher than region standard and WHO guidelines values. The trend of concentrations criteria air pollutants and number of hospital admission in the period of study in Ahvaz megacity presented in Table 1. Result our study showed that the number of HA related to PM₁₀ during 2010–2013 was decreased and another CAP were increase; this can be due to decreases in concentration of PM₁₀ and increase level of O₃, NO₂ and SO₂.

Fig. 4 depicts box plot concentrations of criteria air pollutants during 2010–2013. The high concentration of CAP can be the result of production of development of transportation facilities and industrial processes and dust storm in recent years. The same results were found for CAP which were 2–3 times higher than the WHO guideline value. High concentration of measured criteria air pollutants in this study was associated with high number of hospital admissions in Ahvaz megacity inhabitants of Iran during 2010–2013.

Burnett et al. studied preliminary analysis of PM₁₀ and possible hospital admissions to humans in Toronto, Canada. They reported that exposure to PM₁₀ can caused increase 40.4% of hospital admissions on citizenship.⁸² Geravandi et al., in 2015 studied hospital admissions and exposure of them to PM₁₀. According to the result of this study,

approximately 4.1% of hospital admissions was happened when the PM₁₀ concentration was over 20 µg/m³.⁸³ In a similar work Zalaghi et al., in 2010 were investigated health impacts of air pollution in Ahvaz, Bushehr and Kermanshah, Iran. They showed that 5.1%, 2.7% and 1.9% of hospital admissions in Ahvaz, Kermanshah and Bushehr were happened when PM₁₀ concentration was over 20 µg/m³.⁶⁵ The results of this study showed that concentration of PM₁₀ in Ahvaz was very higher in compared to standards that the most reasons of this issue can be dust storm.

In 2000, Lippmann et al. in USA, studied the health effects of exposure to sulfur dioxide. Based on their result, levels of exposure showed a meaningful association between SO₂ and health endpoint on human. Also, they reported the increase of 10 µg/m³ in SO₂ was associated with an increase of 2% in hospital admissions.⁷⁰ Results of our study are very higher in compared with these studies because of being heavy industries in Ahvaz megacity.

In another study in 6 Italian cities, Biggeri et al. reported a significant relationship between SO₂ and health effects on citizenship. It was observed that an increase of 10 µg/m³ in sulfur dioxide was associated with an increase of 2.4% in hospital admissions.⁸⁴

Existing heavy industries and high sulfur dioxide emitters particularly in winter can be related to high percentage of the hospital admissions in Ahvaz.

In a similar work Glad et al. studied the health endpoints of ambient ozone concentrations on human. According to the result of this study, the increase of each 20 µg/m³ GLO can increase 2.5% the hospital admission.⁶⁷ In 2004, Bell et al. studied relationship between GLO and health endpoint in 95 megacities of U.S. They reported that exposure to GLO could be increased risk to human health such as hospital

Fig. 4. Box plot concentrations of criteria air pollutants ($\mu\text{g}/\text{m}^3$) during 2010–2013.

admissions and daily deaths (10-ppb increase in level of GLO was related to a 0.52% increase in daily deaths).⁶⁶ Shavrina et al. in their study found that there is a significant relationship between exposure to GLO and hospital admission's increase and respiratory diseases.⁸⁵ This result is similar to result our study. Grypariset al studied the relation between health endpoints of ground level ozone in 23 European cities. They demonstrated that there is significant relationship between the increase level of ozone and number of hospitalization, repertory and cardiovascular disease (increase $10 \mu\text{g}/\text{m}^3$ level of GLO was associated with a 0.45% and 1.13% in the number of cardiovascular and respiratory deaths).⁵⁵ Differences in geographic, demographic, and climate characteristics are the main reasons compared with ours results in this study.

In 2003 Tsai al studied the relation between nitrogen dioxide and health effects in Taiwan. They found that there is a relation between exposure to NO_2 and hospital admission in Kaohsiung, Taiwan.⁶⁰ Findings were shown that a $10 \mu\text{g}/\text{m}^3$ increase in levels of nitrogen dioxide was related to an increase of 2.5% in hospital admission.⁶⁰ In another study conducted in West and Southwest Cities of Iran, there was a relation between nitrogen dioxide levels and health effects.⁶¹ According to their results, approximately 3.4% in Kermanshah, and 2.1% of number of hospital admission were related to nitrogen dioxide.⁶¹ Result of this study showed that number of hospital admission was higher because of people who are living in Ahvaz megacity had the higher exposure with NO_2 compare to above area.

4.1. Limitations and strengths

The major limitations of this study were the usage of coefficient RR and BI (reported by WHO) related to hospital admission. Shortcomings in Iranian health registry system, was the biggest problem in accurate estimation of health effects resulting from exposure to air pollutants in this study. In order to solve registry problem, epidemiologic studies and long-term cohort studies are needed for calculate RR and BI specifically for this area.

5. Conclusion

Increase of the number of hospital admission and another health effects related to criteria air pollutants between citizen and paying attention to decreasing emission and concentration of this pollutants is very important. Based on the results of this study, level of CAP was higher than the WHO guideline value. Climate change, emissions from transportation, heavy industries (petroleum, oil, gas and steel), demographic and dust storm are the most important factors that have created adverse weather conditions and a high concentration of criteria air pollutants in Ahvaz megacity, Iran.

Development of green spaces, actions to reduce emissions to air in industries, using green fuels, decreasing particles in source at neighboring countries, application of modern automobiles, implementing appropriate health measures and careful monitoring are the best

activities that will have important roles in decreasing the amount of criteria air pollutants.

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Declaration of competing interest

No potential conflict of interest was reported by the authors.

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