

## Effect of Exposure to PM<sub>10</sub> on Cardiovascular Diseases Hospitalizations in Ahvaz, Khorramabad and Ilam, Iran During 2014

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### ABSTRACT

Particulate matter with an aerodynamic diameter less than or equal to 10 $\mu$ m (PM<sub>10</sub>) has the great adverse endpoints on human health. The aim of this study was to assess the hospital admissions (HA) due to cardiovascular diseases (CVD) attributed to PM<sub>10</sub> among people living in the cities of Ahvaz, Khorramabad and Ilam, during 2014. In this study, Air Quality Health Impact Assessment (AirQ<sub>2.2.3</sub>) software proposed by the World Health Organization (WHO) to assess of health impacts of atmospheric pollutants was used. To evaluate human exposure and health outcome of PM<sub>10</sub>, 24-hour data was taken from the Departments of Environment of Ahvaz, Khorramabad and Ilam. We acquired an input file for the software from raw data and quantified PM<sub>10</sub> by the AirQ<sub>2.2.3</sub> model. The annual averages in three study areas illustrated that PM<sub>10</sub> concentration in Ahvaz and Ilam with values of 534.77 and 60.45 $\mu$ g/m<sup>3</sup>, were the highest and lowest in 2014, respectively. The number of excess cases for HA due to CVD in Ahvaz, Khorramabad, and Ilam was estimated 508, 144 and 66 persons, respectively. The most percentage of person-days was attributable to the concentration interval of 130-139 $\mu$ g/m<sup>3</sup> of PM<sub>10</sub>, whereas this was for Khorramabad and Ilam 60-69 and 40-49 $\mu$ g/m<sup>3</sup>, respectively. The comparison of PM<sub>10</sub> concentrations with NAAQS standard was revealed the annual average of particulate matter concentrations in Ahvaz was higher than standard. Therefore, the efforts should be conducted in the governmental scale to prevent pollution and reduce PM<sub>10</sub> emission from various sources, such as transport and industries and also control dust entering the country by spreading mulch and development of green space.

**Key words:** Cardiovascular Diseases, PM<sub>10</sub>, AirQ<sub>2.2.3</sub> model.

### INTRODUCTION

Ambient air pollution because of industrialization and increase of population is one of the major environmental issues in the current century, especially in developing countries [1-3]. According to World Health Organization (WHO) reports, 800,000 people were died each year over the world due to cardiovascular and respiratory diseases, which are attributed to air pollution [4, 5]. Almost of 150,000 of these deaths, occur in Asia south. Epidemiologic studies showed that several of chronic and acute health endpoints include hospitalizations, respiratory and cardiovascular diseases were attributable to outdoor air pollution [6]. They are increasingly most common health problems and albeit a variety of risk factors have been identified and introduced as the most common causes of commencing or exacerbation, the role of air pollution is irrefutable [7]. Several studies have

illustrated the contribution of air pollutants in hospitalizations, morbidities and mortalities owing to cardiopulmonary diseases, which have been adopted by large prospective cohort studies [8, 9]. Among ambient atmospheric pollutants, particulate matter (PM) is the pollutant with the most undesired harmful impacts [10]. Numerous studies have reported there is a strong correlation between PM concentration and hospital admissions due to the chronic and acute cardiovascular diseases [1-3]. PM<sub>10</sub> is particulate matter with an aerodynamic diameter of 10 $\mu$ m or less, which has the great adverse impacts on the human health [11, 12]. Cardiovascular diseases are one of the leading causes of mortality and disease burden, globally due to exposure with PM<sub>10</sub>. The researches indicated that higher than 500,000 Americans were died per year because of cardiovascular diseases

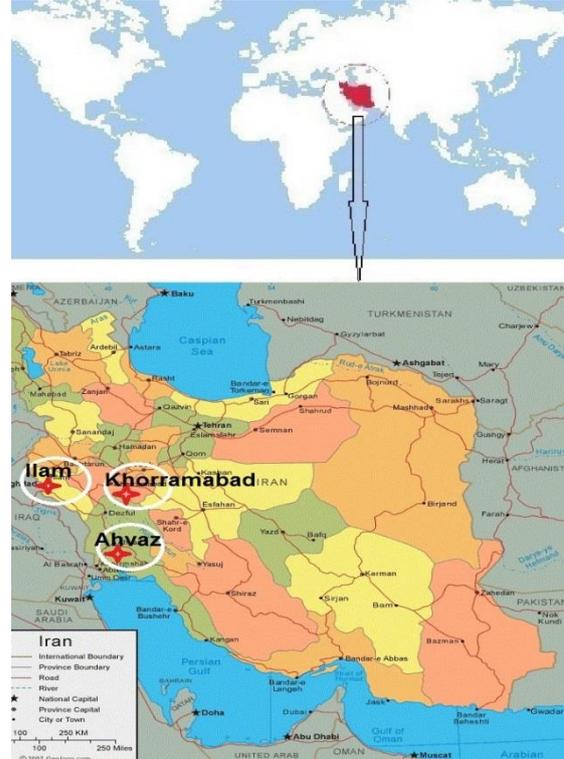
associated with  $PM_{10}$  [13-15]. In recent years, the areas of south, west and southwest of Iran have been affected to exposure by Middle-Eastern Dust (MED) storms, especially from the Arabian Peninsula and Iraq, which lead to thousands of hospital admissions for cardiovascular diseases [16-19]. Several studies have been conducted to the investigation of the relationship between air quality in terms of  $PM_{10}$  concentration and hospital admissions for cardiovascular diseases. In a study, Fattore *et al.* [20] showed a relationship between the  $PM_{10}$  concentrations and cardiovascular diseases using AirQ<sub>2.2.3</sub> software in two municipalities in an industrialized area of Northern Italy. Shahsavani *et al.* [7] reported that high concentrations of particulate matter due to dust events over the study period caused hospital admissions for cardiovascular diseases in Ahvaz. Zhou *et al.* [21] showed that there is a significant association between  $PM_{10}$  concentrations and mortality from cardiopulmonary diseases in Chinese men. Also, similar studies have been conducted by Gharehchahi *et al.* [22], Brook *et al.* [23], Schwartz *et al.* [24], Brauer *et al.* [25] and Dockery *et al.* [26]. The aim of this study was to assess the impacts of  $PM_{10}$  exposure on hospital admissions (HA) for cardiovascular diseases (CVD) using AirQ<sub>2.2.3</sub> software model in capital cities of Ahvaz, Khorramabad and Ilam, Iran during 2014.

## MATERIALS AND METHODS

The cities of Ahvaz (31°20' N, 48°40' E), Khorramabad (33°29'N, 48°21'E) and Ilam (33°36'N, 46°36'E) are the capital cities of Khuzestan, Lorestan and Ilam province located in southwest of Iran. Fig. 1 shows the location of these cities in the map of Iran.

At the period of conducting this research, the diurnal  $PM_{10}$  data from January through December of 2014 were obtained from sampling stations that belonged to the Department of Environment of each city. A specialized model, the Air Quality Health Impact Assessment (AirQ<sub>2.2.3</sub>) tool, developed by WHO European Center for Environment and Health, and proposed by World Health Organization (WHO) was used to assess the potential impact of  $PM_{10}$  exposure on HA due to CVD of people living in Ahvaz, Khorramabad and Ilam during 2014. This model was run and used for the present study [20, 27]. This program is used to the short-term exposure to air pollutants on the health of people living in a certain time and region [3, 28].  $PM_{10}$  data was processed to provide 24-hour mean, annual average, maximum, and other statistical parameters. Processed  $PM_{10}$  data were entered into the AirQ<sub>2.2.3</sub> software to calculate the number of excess cases of HA due to CVD. In this software, assess the health impact of air pollutants is based on the calculation of the attributable

proportion (AP), which is described as the portion of the health result in a certain residents attributable to contact to a given air pollutant [3, 20].



**Fig: 1:** Location of Ahvaz, Khorramabad and Ilam in Iran map

The AP was calculated by the following equation:  $AP = \frac{\sum\{(RR(c)-1) \times P(c)\}}{\sum[RR(c) \times P(c)]}$  (1)

Where: AP and RR (cc) are the attributed proportion of the health impact and the relative risk for a certain health endpoint in the group c of exposure, respectively. Also, P (c) is the quantity of the target population in group c of exposure [29]. The amount attributable to the population exposure can be calculated from the Eq. 2, if the baseline frequency of the health effect in the studied population is identified [3, 30].

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

Where; IE and I are the rate of the health impact attributable to the contact and the baseline frequency of the health outcome in the population under study, respectively. Finally, considering the population size, the total number of excess cases attributable to the exposure is specified by Eq. (3).

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

Where; NE is the number of persons attributed to the  $PM_{10}$  exposure and N is the total number of evaluated residents [3, 31]. The RR gives the increase in the possibility of the adverse endpoint relation to a given change in the exposure levels, and comes from time-series studies where day-

today changes in air pollutants over long periods were associated to daily mortality, hospital admissions and other public health indicators. The RR values used for PM<sub>10</sub> analysis were resulting from the studies of Fattore *et al.* [20] and Nourmoradi *et al.* [3]. The diurnal concentrations of PM<sub>10</sub> were used in the study. The HA for CVD associated with the PM<sub>10</sub> was calculated by relative risk and baseline incidence using AirQ<sub>2.2.3</sub> model [20, 32].

## RESULTS AND DISCUSSION

Table 1 shows the data of PM<sub>10</sub> concentrations as annual mean, summer and winter means as well as 98 percentile and the maximum amounts in summer and winter. The concentration of PM<sub>10</sub> in these cities illustrated that PM<sub>10</sub> level in Ahvaz and Ilam with the annual mean of 901.85 and 69.45 $\mu\text{g}/\text{m}^3$  was highest and lowest, respectively. The annual average of PM<sub>10</sub> concentration in Ahvaz was higher than the National Ambient Air Quality Standard with 24-h amount of 150 $\mu\text{g}/\text{m}^3$ . The levels PM<sub>10</sub> showed that the maximum of annual mean with values of 6041 and 688 $\mu\text{g}/\text{m}^3$  in 2014 was observed in Ahvaz and Ilam as highest and lowest, respectively. Increase of PM<sub>10</sub> concentration in these cities can be linked to the Middle-Eastern Dust (MED) storms from arid areas such as Iraq, Kuwait and Saudi Arabia [7]. The average of annual PM<sub>10</sub> levels in the Chinese cities was 65, 141 and 94 $\mu\text{g}/\text{m}^3$  for Ansun, Beijing and Changchun [8]. Shahsavani *et al.* (2012) reported that the maximum PM<sub>10</sub> concentration was measured in summer of 2010 [7], whereas the maximum PM<sub>10</sub> level in the study of Zallaghi *et al.* (2014) was happened in winter season of 2013 in Ahvaz [33]. The results of this study are consistent with recent study.

Table 2 shows the relationship of PM<sub>10</sub> concentration and the percentage of attributed

proportion, relative risk and number of excess cases suffering from HA for CVD. As seen, the number of excess cases was estimated 508, 144 and 66 persons at centerline of relative risk (RR=1.009) for Ahvaz, Khorramabad and Ilam, respectively. The number of excess cases for HA because of CVD due to PM<sub>10</sub> exposed in Ahvaz and Ilam was highest and lowest, respectively in 2014, which this finding can be in relation to a higher ratio of PM<sub>10</sub> concentration in Ahvaz. RR had an important role in determination the number of HA due to CVD. In low amount of RR, the rate of HA is lower.

**Table 1:** Annual and seasonal average concentrations of PM<sub>10</sub> ( $\mu\text{g}/\text{m}^3$ )

Parameters	Ahvaz	Khorramabad	Ilam
Annual average	534.77	80.59	60.45
Summer average	257.57	102.90	69.45
Winter average	901.85	58.28	51.50
Annual maximum average	6041	476	688
Summer maximum average	1378.69	376	513
Winter maximum average	6041	476	688
98 percentile	1826	264.05	208.8

The lower value of RR can achieve if some control strategies for reducing PM<sub>10</sub> emission were used. Thus, the higher RR value might depict mismanagement in urban air quality. In similar work, Mohammadi *et al.* (2015) showed that the excess cases of HA for CVD were 20.3 persons in Shiraz city, during 2013 [19]. Hosseini *et al.* (2014) indicated that the HA due to CVD were calculated 108 persons in Kurdistan, during 2013 [29], which is consistent with the results of this study for Khorramabad and Ilam.

**Table 2:** Relative risk, attributed proportion and number of excess cases estimated.

Study site	Indicator estimate	Relative risk	Estimated AP (%)	Estimated number of excess cases (persons)
Ahvaz	Lower	1.006	7.3101	351
	Mean	1.009	10.5786	508
	Upper	1.013	14.5940	700
Khorramabad	Lower	1.006	4.9015	98
	Mean	1.009	7.1764	144
	Upper	1.013	10.0955	201
Ilam	Lower	1.006	2.9939	45
	Mean	1.009	4.4247	66
	Upper	1.013	6.2679	93

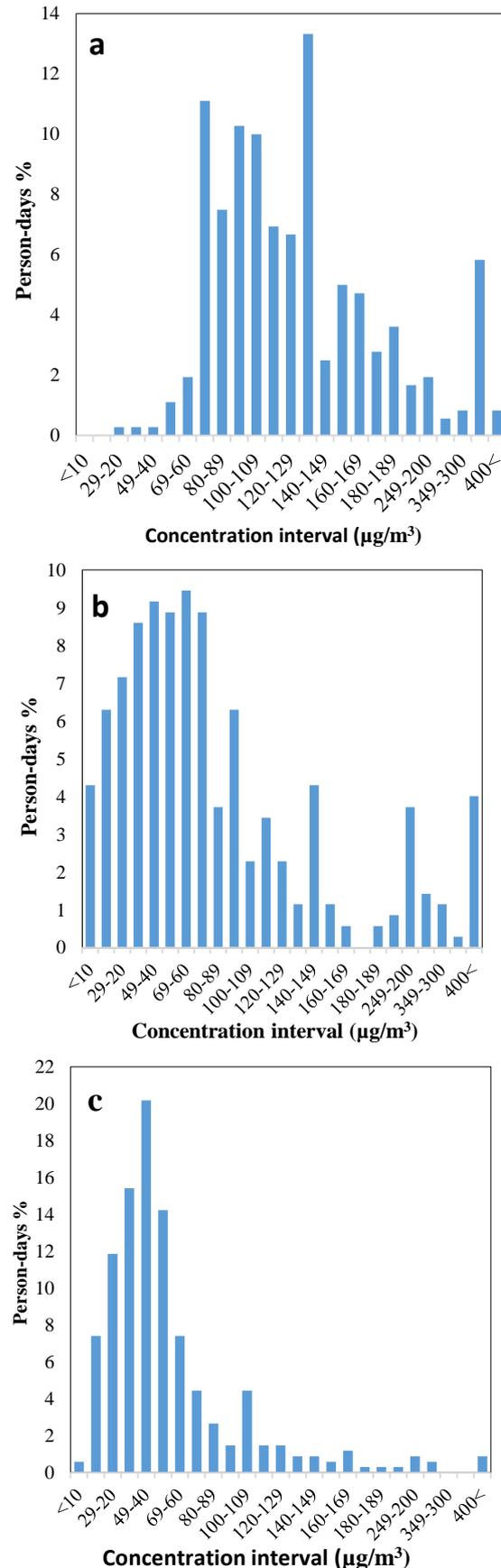
Fig. 2(a)-(c) shows the percentage of time that people were exposed to PM<sub>10</sub>, which led to the HA for CVD in cities of Ahvaz, Khorramabad and Ilam. According to the Fig. 2(a), the most percentage of person-days was in relation to the concentration interval of 130-139 $\mu\text{g}/\text{m}^3$  of PM<sub>10</sub> that caused to the HA for CVD in Ahvaz. In

addition, about 90% of HA due to CVD were calculated in days with PM<sub>10</sub> levels less than 200 $\mu\text{g}/\text{m}^3$ . The health effects of PM<sub>10</sub> concentrations below 20 $\mu\text{g}/\text{m}^3$  due to lack of contact with the population is zero. In other words, there is not one day in during the study that PM<sub>10</sub> concentration has been reaches below 20 $\mu\text{g}/\text{m}^3$ .

Only 3.89% of HA due to CVD were occurred in days with  $PM_{10}$  levels less than  $70\mu g/m^3$  and 99.17% occurred in the days when the  $PM_{10}$  concentration was lower than  $400\mu g/m^3$  in Ahvaz. A higher percentage of these hospitalizations perhaps could be the result of higher average of  $PM_{10}$  or due to sustained high concentration days in Ahvaz.

According to the Fig. 2(b), the most percentage of person-days was in association with the concentration interval of  $60-69\mu g/m^3$  of  $PM_{10}$ , which caused to the HA due to CVD in Khorramabad. Based on Fig. 2(b), 10.6% of HA for CVD occurred in days that  $PM_{10}$  levels were less than  $20\mu g/m^3$ . The cumulative number of excess cases for Khorramabad estimated 144 persons at centerline RR. In 2014, about 95.7% of the health effects occurred on the days when the  $PM_{10}$  concentration was lower than  $350\mu g/m^3$ . In addition, 10.6% of hospitalizations because of CVD were calculated in days with  $PM_{10}$  levels less than  $20\mu g/m^3$  and 89.4% was in relation to  $PM_{10}$  concentrations less than  $200\mu g/m^3$ .

Based on Fig. 2(c), the most percentage of person-days in Ilam was in relation to the level interval of  $40-49\mu g/m^3$  of  $PM_{10}$ . Moreover, 8.01% of health effects are corresponds to the days with concentrations below  $20\mu g/m^3$  and 97.63% was estimated for  $PM_{10}$  levels lower than  $200\mu g/m^3$ . Furthermore, 90.21% of the excess cases of hospitalizations for CVD were attributable to  $PM_{10}$  concentrations of lower than  $110\mu g/m^3$  in Ilam. Moreover, at the centerline indicator estimate ( $RR=1.009$ ), the number of excess cases for this city was estimated 66 persons. This showed a reduction of 14 persons in comparison with 2013 [34]. In a similar study, Yavari *et al.* (2007) demonstrated that about 13% of the total number of cardiovascular diseases was associated with  $PM_{10}$  concentration of higher than  $20\mu g/m^3$  [35]. Zhou *et al.* (2014) also showed that there was a significant relationship between every  $10\mu g/m^3$  increase in  $PM_{10}$  concentration with risks of cardiovascular and respiratory mortalities [21]. In a study by Guo *et al.* (2010), there was an approximate 0.23% increase in hospital admissions per  $10\mu g/m^3$  increase in the  $PM_{10}$  concentration [36], and in other study by Chen *et al.* (2010) in North China, there was 0.036% increase in HA per  $10\mu g/m^3$  increase in the  $PM_{10}$  concentration [37]. A comparison between the results of this study with other studies showed that higher health effects rate in Ahvaz, Khorramabad and Ilam cities was resulted to higher average of  $PM_{10}$  levels or an increase in the number of days of exposure to this pollutant.



**Fig. 2:** Relationship between Cumulative cases of the hospital admissions for CVD versus  $PM_{10}$  interval in (a) Ahvaz, (b) Khorramabad and (c) Ilam.

## CONCLUSION

High percentage of the hospital admissions (HA) for cardiovascular diseases (CVD) was observed associated to a high concentration of measured particulate matter (PM<sub>10</sub>) using the AirQ<sub>2.2.3</sub> software model in Ahvaz, Khorramabad and Ilam cities (Iran). Although the results of this study are in line with results of other researches around the world, since the geographic, demographic and climate properties are different, there is still high need to further studies to specify local RRs. In order to reduce the health effects of particulate matter, health training by health organizations should be conducted to public people especially persons with chronic lung and heart diseases, elderly and children to reduce their activities in the dusty days. Moreover, the efforts should be developed in the governmental scale to the control dust entering to the country by spreading mulch and development of green space is essential.

## ETHICAL ISSUE

In this study, the University of Medical Sciences of Lorestan ethics committee approved the present study protocol and researches explained all procedures.

## CONFLICT OF INTERESTS

Authors do not have any conflict of interests.

## AUTHORS' CONTRIBUTIONS

Study concept, design and critical revision of the manuscript for important intellectual content: Seyed Mohammad Daryanoosh, Gholamreza Goudarzi, and Yusef Omid Khaniabadi. Drafting of the manuscript, advisor, and performing experimental studies: Gholamreza Goudarzi and Yusef Omid. Data collected: Houshang Armin, Fatemeh Omid Khaniabadi, and Hassan Basiri.

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