Association of Particulate Matter Impact on Prevalence of Chronic Obstructive Pulmonary Disease in Ahvaz, Southwest Iran during 2009–2013

Mehran Khaefi1, Sahar Geravandi2, Ghasem Hassani3, Ahmad Reza Yari4, Farhad Soltani5, Sina Dobaradaran6, Sasen Moogahi7, Mohammad Javad Mohammadi8,9, Mohammad Mahboubi8,10, Nadali Alavi10, Majid Farhadi9, Yusef Omidi Khaniabadi11

1 M.SC Environmental Engineering, Environmental & Occupational Health Center, Ministry of Health Medical & Education, Tehran, Iran
2 Razi Teaching Hospital, Clinical Research Development Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
3 Department of Environmental Health Engineering and Social Determinants of Health Research Center, Yasuj University of Medical Sciences, Yasuj, Iran
4 Anesthesiologist and Fellowship critical care medical, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
5 Health Research Institute, Infectious and Tropical Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
6 Department of Environmental Health Engineering, Faculty of Health and the Persian Gulf Marine Biotechnology Research Center, the Persian Gulf Research Center, Bushehr University of Medical Sciences, Bushehr, Iran
7 Abadan School of Medical Sciences, Abadan, Iran
8 Environmental and Occupational Hazards Control Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
9 Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

ABSTRACT

Air pollutants produced in environments have many detrimental impacts on human health. Chronic obstructive pulmonary disease (COPD) is a common worldwide respiratory disease. The aim of this study was to estimate the association between the load of particulate matters and the prevalence of COPD in Ahvaz, southwest of Iran, during 2009–2013. This epidemiological and used-model study was performed in Ahvaz. Particulate matter equal or less than 10 micro meters (PM10) was monitored by Ahvaz Environmental Protection Agency (AEPA). Sampling was performed hourly during the study period in 4 stations. In this study, 175200 (4 × 24 × 365 × 5) samples of air were taken and collected. Sampling and analysis were performed according to EPA guideline. We utilized the relative risk values and baseline incidence measures by the WHO (Middle East) drawn from Health Effects Association of Particulate Matter. Finally, prevalence of COPD attributed to particulate matter exposure was calculated by Air Q model. According to our findings, the prevalence of COPD attributed to particulate matters decreased during 2009–2013 and followed a decreasing trend. Accordingly, the yearly prevalence of COPD during the period 2009–2013 were 121, 111, 94, 102, and 98, and the yearly average PM 10 concentrations during the same period were 313.72, 281.98, 288.38, 278.12, and 242.29 µg m–3, respectively. Although the average of 5-year study was higher than WHO and NAAQS values, a descending trend for COPD indicates that the level of PM10 was diminished from 2009 to 2013. Therefore mitigating air pollutant particularly PM10 as one of the main hazards could be possibly led to remarkable decrease in the rate of mortality and morbidity particularly COPD attributed to PM10.

Keywords: Chronic obstructive pulmonary disease; Prevalence; Particulate matter; Iran.

INTRODUCTION

In the recent years, effects of air pollutants on human health, their damage to the environment and the rate of death in the public in the world has increased (Hajat et al.,
Results from different studies on particulate matters and different pollutants has raised thoughtful concerns regarding public health (Taghavirad et al., 2014; Goudarzi et al., 2015a; Gschwind et al., 2015; Madronich et al., 2015; Mašková et al., 2016; Mohammadi et al., 2016b; Yari et al., 2016). Transportation, urbanization, industries, economic development, domestic fuel burning, and vehicles in megacities are the main sources of generation and emission of particulate matters (Davar et al., 2014; Yan et al., 2014; Hou et al., 2015; Salvador et al., 2015; Soleimani et al., 2016; Omidi-Khaniabadi, et al., 2017b). According to different studies, particles have short-term and long-term effects on human health (Chan et al., 2015; Ostro et al., 2015; Mammigalani et al., 2016; Neisi et al., 2016). Previous studies have shown an association between the air pollutant, particularly PM$_{10}$ and diseases (Kloog et al., 2014; Andersen et al., 2015; Mandel et al., 2015; Goudarzi et al., 2016; Maleki et al., 2016). The most important damage from particles is penetration into the respiratory system that can lead to health effects in humans such as inflammation in pulmonary systems resulting in narrowing of the small airways and destruction of lung tissue known as emphysema (Geravandi et al., 2015a; Omlor et al., 2015; Rupf et al., 2015; Salgueiro-González et al., 2015; Naimabadi et al., 2016).

Eighty percent of people 65 years and older have one or more chronic diseases, and about 50% of these groups have activity limitation. Based on the results of studies, COPD observed in 329 million people or nearly 5% of the globe population. It is expected to become the 5th leading cause of the burden of diseases worldwide by 2020 (Fletcher et al., 2011; Lim et al., 2013). In 2011, COPD ranked as the fourth-leading cause of death, killing over 3 million people (Organization, 2014). A study conducted by the World Health Organization showed that an increase of 10 micrograms in the amount of aerosols causes 1 to 3 percent increase in the mortality rate (Mirhosseini et al., 2013). Shortness of breath and cough are the main symptoms COPD (Fishman, 2005; Cazzola et al., 2007; Swadron et al., 2008). In another investigation which was done in Taiwan, there was a relationship between air pollutants concentration and hospital admission rate in patients suffering from ischemic stroke, COPD, and asthma exacerbation (Tsai et al., 2003). Accordingly, a study conducted in six cities in the United States demonstrated a relationship between long-term air pollution and health status. This study indicated that long term exposure to air pollutants was independently association with cardiovascular mortality (Dockery et al., 1993). Moreover, another study in Mexico evaluated the health impact of air pollution. Results of this study showed 82 percent increase in the risk of death with a 20 $\mu$g m$^{-3}$ increase in the concentration of particles (Romieu et al., 2003). In similar works, Mohammadi et al. (2009), Zallagh et al. (2010) and Goudarzi et al. (2015b) studied the association between COPD and PM$_{10}$ levels in different cities in Iran.

To date, Ahvaz has been well known for environmental concerns such as air pollution, solid waste management, wastewater collection systems, and potable water. In recent decade, Ahvaz has suffered from a Tran’s boundary source of dust storm. Different aspects of dust storm have been well documented (Soleimani et al., 2013; Goudarzi et al., 2014b; Mohammadi et al., 2015). The aim of this study was to assess the potential effects of particulate matter exposure on human health (COPD) in Ahvaz city (southwest of Iran) during 2009 to 2013.

**METHODS**

The present study is an epidemiological study which correlate concentration of PM$_{10}$ to chronic obstructive pulmonary disease (COPD). We processed PM$_{10}$ data by the use of Excel software and Air Q model. This study was aimed to assess the potential effects of PM$_{10}$ exposure on prevalence of COPD. This estimation was based on calculating relative risk (RR) and attributable proportion (AP). The present study has two main stages including measurement of PM$_{10}$ and using the model. Sampling was conducted in 4 stations by AEPA. The AEPA used beta attenuation method for PM$_{10}$ concentration in ambient air. This is a direct reading method which provide a quick and precise reading for concentration of particulates specially PM$_{10}$ (Maleki et al., 2016). In this study, data was processed in a VBA program of excel to reach to daily mean, maximum, minimum, standard deviation and 98 percentiles. Finally, data were adjusted as compatible as input file for Air Q model (Geravandi et al., 2016; Marzouni et al., 2016). It was defined as the fraction of the health outcome in a certain population attributable to exposure to a given atmospheric pollutant. Obtained value then was multiplied by population ($10^7$) (Geravandi et al., 2015b; Mohammadi et al., 2016a). AP is proven causative correlation between outcomes and given air pollutant. To find out excess cases, we could calculate distribution of cases attributed to pollutants in terms of concentration intervals (Geravandi et al., 2015b).

Relative risk (RR) is the ratio of the probability of the outcome happening in the exposed population versus a non-exposed group (Goudarzi et al., 2015a; Dobaradaran et al., 2016). It is a very useful to know the association between a disease and an environmental factor under study (Goudarzi et al., 2015a). Relative risk is computed by dividing the incidence rate among individuals exposed to given pollutant by the incidence rate among people not exposed to that certain pollutant (Dobaradaran et al., 2016). Population Prevented Fraction (PPF) is related to circumstances where exposure to a given pollutant is protective (Goudarzi et al., 2014a).

The primary and secondary standard of particulate matter concentration according to National Ambient Air Quality Standard (NAAQS) 24-hour is 150 $\mu$g m$^{-3}$ (Krutilla et al., 2015). The standard of particulate matter concentration according to European Air Quality Standards (EUAAQS) 24-hour is 50 $\mu$g m$^{-3}$ and 1 year is 40 $\mu$g m$^{-3}$ (Beelen et al., 2014).

**Geographical Features of Ahvaz**

Ahvaz, the capital city of Khuzestan Province, has suffered from dust storm during this and last decade. It is also famous in view of particulate matter concentration, in which
most of researchers announced Ahvaz as the most polluted city overall the world (Goudie, 2014). Many industries such as steel, gas and petroleum have activity inside the city. Ahvaz, with an area of 140 square kilometers, is located between 48° and 49°29′ east of the Greenwich meridian and, 31° and 45′ minutes north of the equator, and with a population of approximately 1 million has coped with many environmental problems such as salinity of potable water, lack of wastewater collection systems as well as air pollution (Geravandi et al., 2015b; Goudarzi et al., 2016; Yari et al., 2016). Sampling was performed hourly in four stations where are listed from 1 to 4. The name of each station has written in Fig. 1.

RESULTS

As it has shown in Table 1 from 2009 to 2010 the trend for yearly concentration of PM10 was decreased, but from 2010 to 2011 the average concentration for PM10 increased. Finally, we observed a mild decrease in the average concentration of PM10 from 2011 to 2013. The yearly mean, summer maximum and winter maximum of PM10 concentrations have been presented in Table 1. During 2009 to 2013, concentration of PM10 was higher in summer than in winter. Also, Number of COPD cases related to PM10 concentrations is presented in Table 1. Calculated number of cases related to PM10 at central RR (1.0044) during 2009 to 2013 was 121, 111, 94, 102 and 98, respectively. Central RR can be a reasonable indicator of current situation in view of PM10 health effects. Overall, Table 1 shows that the trend of the number of COPD cases related to PM10 concentration was decreasing during 2009 to 2013.

As Fig. 2 indicates, no day during 2009 to 2013 has seen a PM10 concentration below 10 µg m⁻³. Rising trend of cases of COPD with increasing concentrations of PM10 in 30–150 µg m⁻³ has a uniform pattern. Fig. 3 shows cumulative number of COPD cases attributed to particulate matter during 2009 to 2013. Maximum number of COPD was in year 2009 and minimum number of COPD cures in year 2011.

DISCUSSION

Nowadays air pollution is one of several important issues that threaten the public health. In this study, we estimated COPD of exposure to PM10 by using Air Q model in Ahvaz,

![Fig. 1. Location of the study area and sampling stations in Khuzestan Province (Ahvaz city), southwest of Iran.](image)

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual mean</th>
<th>Summer Maximum</th>
<th>Winter Maximum</th>
<th>HACOPD RR = 1.0044 (1–1.0049)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>313.72</td>
<td>530</td>
<td>364</td>
<td>121</td>
</tr>
<tr>
<td>2010</td>
<td>281.98</td>
<td>489</td>
<td>317</td>
<td>111</td>
</tr>
<tr>
<td>2011</td>
<td>288.38</td>
<td>503</td>
<td>306</td>
<td>94</td>
</tr>
<tr>
<td>2012</td>
<td>278.12</td>
<td>436</td>
<td>283</td>
<td>102</td>
</tr>
<tr>
<td>2013</td>
<td>242.29</td>
<td>355</td>
<td>263</td>
<td>98</td>
</tr>
<tr>
<td>Average</td>
<td>280.89</td>
<td>462</td>
<td>306</td>
<td>105</td>
</tr>
</tbody>
</table>

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.
Iran. The result of this study showed that number of COPD in 2009, 2010, 2011, 2012 and 2013 was 121, 111, 94, 102 and 98 cases, respectively, in which the maximum was for 2009 due to the highest concentration of PM$_{10}$ among these years. Fig. 2 depicts average PM$_{10}$ levels versus related outcome during 2009 to 2013. The high concentration of PM$_{10}$ can be the result of production of dust storm and development of transportation facilities and industrial processes in recent years. Based on the results of different studies, decreasing PM$_{10}$ concentration decreases the number of COPD cases. Results of our study showed that AP during 2009 to 2013 was decreased, and this can be due to decreases in concentration of PM$_{10}$. According to WHO report, Ahvaz city has the highest PM$_{10}$ concentration among all cities in the world. Based on our field observations in Khuzestan especially Ahvaz there were many dust event days during these 5-years study that concentration of PM$_{10}$ was above WHO and NAAQS values. Therefore we expect...
an increase a burden of disease because of incoming dust.

The lower level of RR may indicate the progress of urban air quality by implementing emission control policies. Therefore the higher RR can imply mismanagement in urban air quality strategies. As a result, three domains of RR based on model's default were considered for estimating outcomes attributed to PM$_{10}$.

Based on their results, almost 3.6% of all cases of COPD were attributed to PM$_{10}$ concentrations greater than 30 µg m$^{-3}$ (Goudarzi et al., 2007). Results of this study are different compared with ours because of the differences in geographic, demographic, and climate characteristics. Also, an investigation by Geravandi et al. (2015a) showed that approximately 4.1 percent of hospital admissions for COPD happened when the PM$_{10}$ concentration was over 20 µg m$^{-3}$. High percentage of the calculated outcomes in this study was associated with high concentration of measured PM$_{10}$ in Ahvaz. Zalaghi (2010) in their study on health impacts of air pollution in Ahvaz, Bushehr and Kermanshah in 2010 observed that all cases of COPD were 4.8% in Ahvaz, 2.4% in Kermanshah, and 1.7% in Bushehr, approximately. The results of this study showed that concentration of PM$_{10}$ in Ahvaz was higher compared to Kermanshah, and Bushehr.

It is noteworthy to express that chemical and biological contents of aerosols particularly PM$_{10}$ as the representative of dust is at paramount of importance. Previous investigation in Ahvaz revealed that load of bacteria increased during dust events in compared with normal days (Soleimani et al., 2016). Regarding to chemical composition of PM$_{10}$ and its impact on human and animal (Rezaei et al., 2014; Dianat et al., 2016a, b; Naimabadi et al., 2016) many disorders could be posed as detrimental effect of dust pollution on ecosystem. Further research is recommended to clarify long term effects of Ahvaz air pollution especially particulates and attributed diseases to convince authorities to implement practical measures for mitigating air pollutants.

**Limitations and Strengths**

We used the common coefficient related to COPD. After running long term and successive investigation to localize these coefficient the best policy for such studies is to consider these specific indices which are based on the characteristic our population and very compatible to the pattern of urban air pollution in developing countries. For achieving the reliability and validity of model one of the approach is to observe health end points registries at hospitals, but because of weakness in health registry it was impossible to reach at this time. Keep in mind the results and findings of present study is calculated by using the model which is definitely based on prediction.

**CONCLUSION**

Models are used to simplify the sophisticated or complicated cases, but in reverse side there is an old belief that, all models are wrong; some models are useful. According to the present research findings, we observed a high prevalence of COPD attributed to PM$_{10}$ in Ahvaz at first year of study (2009) and it was decreased with a slight trend to the end of study (2013). High percentage of the observed COPD cases in 2009 was associated with high concentration of measured PM$_{10}$ and the lowest cases of mentioned outcomes observed in 2011. The major limitations of this study were shortcoming in databases and the lack of local epidemiological parameters, so, in our study, the values of the WHO (Middle East) for estimated health outcomes related to PM$_{10}$ levels were used. Therefore, to assess the health impact of air pollutants on human accurately, epidemiologic studies for accurate calculation of RRs and BIs are needed. Defining policies for decreasing particles in source at neighboring countries, actions to reduce emissions to air in industries, using green fuels such as solar and electrical energy, implementing appropriate health measures, development of green spaces, and environmental monitoring can be effective in reducing PM$_{10}$ concentration. We suppose that for calculating health indicators, epidemiologic studies be done, and rate of exposure to air pollutants and their health effects be measured. Further studies would allow assessing the development in health status more precisely.

**CONFLICT OF INTERESTS**

Authors have no conflict of interests.

**ACKNOWLEDGEMENT**

The authors would like to thank student Research Committee, Ahvaz Jundishapur University of Medical Sciences for providing financial supported by the grant: (95s82) of this research.

**AUTHORS CONTRIBUTIONS**

Study concept, design and critical revision of the manuscript for important intellectual content: Mohammad Javad Mohammadi, Mehran Khaefi, Sahar Geravandi, Ghasem Hassani, Farhad soltani, Sina Dobaradaran, Sasan Moogahi, Nadali Alavi, Ahmad Reza Yari, Mohammad Mahboubi, Majid farhadi and Yusef Omid Khaniabadi; drafting of the manuscript and advisor; doing experiments Mohammad Javad Mohammadi.

**FINANCIAL DISCLOSURE**

We have no financial interests related to the materials in the manuscript.

**FUNDING/SUPPORT**

This work was financially supported by grant: (95s82) from Vice- Chancellor for research Affairs of Ahvaz Jundishapur University of Medical Sciences.

**REFERENCES**

A study of the combined effects of physical activity and air pollution on mortality in elderly urban residents: The Danish Diet, Cancer, and Health Cohort. 


BMC Public Health 11: 612.


Received for review, June 1, 2016

Revised, October 7, 2016

Accepted, December 6, 2016