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The relationship between air pollution exposure and chronic obstructive pulmonary disease in Ahvaz, Iran

Gholamreza Goudarzi[1], Sahar Geravandi[2], Mohammad Javad Mohammadi[3], Shokrollah Salmanzadeh[4], Mehdi Vosoughi[5], Mohammad Sahebalzamani[6]

1 Associate Professor, Environmental Technologies Research Center, Department of Environmental Health Engineering, School of Public Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
2 MSc Student, Department of Nursing, Islamic Azad University, Tehran Medical Sciences Branch, Tehran AND Razi Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
3 PhD Candidate, Department of Environmental Health Engineering, School of Public Health, Razi Hospital Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
4 Assistant Professor, Infectious and Tropical Diseases Research Center AND Razi Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
5 PhD Candidate, Department of Environmental Health Engineering, School of Public Health, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
6 Assistant Professor, Islamic Azad University, Tehran Medical Sciences Branch, Tehran, Iran

Original Article

Abstract

BACKGROUND: Air pollutants can have harmful effects on human health. Chronic obstructive pulmonary disease (COPD) is represented by a spectrum of obstructive airway diseases. The aim of this study was to evaluate the relationship between air pollution exposure and COPD in Ahvaz, Iran.

METHODS: The present epidemiological study was performed in Ahvaz city. Data were obtained from the Ahvaz Department of Environment (ADoE). Sampling was performed for 24 hours in 4 stations. Raw data processing was performed using Microsoft Excel software, and after the impact of meteorological parameters, data were converted as input file into the model. Data analysis was performed using SPSS for Windows.

RESULTS: The results of this study showed that the annual average PM_{10} concentration during 2012 was 727 $\mu g/m^3$. According to the research findings, the two stations of Bureau of Meteorology and the city center had the highest and the lowest PM_{10} concentrations during 2012, respectively. The results showed a strong correlation between visits to a hospital due to COPD and PM_{10} emission in Ahvaz city. Approximately, 6.2% of hospital admissions for COPD occurred when the PM_{10} concentration was higher than 30 $\mu g/m^3$.

CONCLUSION: The findings of the present study showed that the total mean of particle matter was higher than the standard concentration. The higher percentage of hospital admission could be the result of the dust storm, higher average PM_{10}, and sustained high concentration days in Ahvaz.

KEYWORDS: Chronic Obstructive Pulmonary Disease (COPD), Air Pollution, Ahvaz

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Introduction

Air pollutants can have harmful effects on the human health. The significance of this issue lies in the damaging impacts of high, potentially harmful pollutant levels produced in the environment on human health.[1-3] The main sources of PM_{10} are transportation, urbanization, industries, economic development, domestic fuel burning, and vehicles in megacities.[4] The adverse health effects of air pollution may be classified into 2 classes; short-term and long-term effects.[5]

Corresponding Author:
Mohammad Javad Mohammadi
Email: mohamadi.m@ajums.ac.ir

In recent years, several hundred epidemiological studies have shown a relationship between air pollution, typically particle matter in the air of urban areas, and diseases, pulmonary damage, and mortality among the population.[6-11] Particulates are the deadliest form of air pollution due to their ability to penetrate deep into the lungs, and can have health effects on humans..[12-13] The World Health Organization (WHO) reported that a 10 micrograms increase of aerosols increases the mortality rate by 1 to 3%.[8] The main symptoms of chronic obstructive pulmonary disease (COPD) include shortness of breath, cough, and sputum production.[14-16] Long-term exposure to sources of air pollution causes an inflammatory response in the lungs resulting in the narrowing of the small airways and breakdown of lung tissue known as emphysema.[14,17] The results of previous studies show that COPD affects 329 million people or nearly 5% of the population worldwide. In 2011, it ranked as the fourth leading cause of death, killing over 3 million people.[18] Hospital admissions have been recognized as a sensitive marker for assessment of air pollution effects on human health.[19-20] In another study conducted in Taiwan, an association was found between air pollutant levels and hospital admission in patients suffering from ischemic stroke, chronic obstructive pulmonary disease, and asthma exacerbation.[21] Dockery et al., in a cohort study, have shown the adverse health impact of long-term air pollution exposure in 6 US cities.[22] This study demonstrated that chronic exposure to air pollutants is independently related to cardiovascular mortality.[22] Isabelle performed health impact assessment of air pollution in México.[23] Based on the results of this study, with an increase of 20 μg/m^3 in pollution, the risk of death increased by 82%.[23] In Another study, an estimated 413 hospital admissions were attributed to PM_{10} in the 8 major Italian cities, in 1998.[24] In similar study, Mohammadi studied the association between COPD and PM_{10} levels in Ahvaz, Iran, in 2009.[25] Moreover, Goudarzi studied the association between COPD and PM_{10} levels in Tehran, Iran, in 2009.[26] Zalaghi studied the association between COPD and PM_{10} levels in Ahvaz, Bushehr and Kermanshah, Iran, in 2010.[27]

From the past to present, Ahvaz has been well known for its industries as well as its environmental pollution. In the last decade, an anthropogenic source of air pollution (dust storm) has been added to its other environmental problems.[28] The physical, chemical, and biological characteristics of dust storm have been well documented.[28,29] The aim of this study was to assess the potential relationship between COPD and PM_{10} exposure in Ahvaz city (located in South-Western Iran) during the year 2012.

Materials and Methods

This was an epidemiological study. PM_{10} data was analyzed using Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) and AirQ model. The present study assessed the potential effects of PM_{10} exposure on human health. The rate of COPD attributed to PM_{10} exposure in Ahvaz in 2012 was calculated based on relative risk (RR) and attributable proportion.

Ahvaz, with a population of approximately 1 million residents and an area of 8152 km^2, is the capital of Khuzestan Province. It is located between 48 degree to 49°29′ east of Greenwich meridian and between 31^o and 45′ min to the north of the equator.[1] The location of the study area and sampling station are displayed in figure 1. Sampling was performed for 24 hours in 4 stations. The sampling stations were in downtown "Naderi", the Old School of Public Health "Behdasht Ghadim", Bureau of Meteorology "Havashenasi", and the Head office of Ahvaz Department of Environment (ADoE) "Mohitzist". In this study, 4 × 365 samples of Ahvaz's air were collected. Raw data processing using Excel software includes coding, averaging, and filtering. After the impact of meteorological parameters, data was converted into an input file for the AirQ model. The extent of the health effect attributed to PM_{10} was determined based on the

RR and attributable proportion. The attributable proportion is multiplied at baseline incidence and divided by 10^5. Attributable proportion is defined as the fraction of the health outcome attributable to exposure to a given atmospheric pollutant in a certain population. Obtained value should be multiplied by the population (10^6). Attributable proportion is proven causative correlation between health consequences and air pollutant exposure. Attributable proportion was calculated using the following formula:

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

where AP is the attributable proportion, p(c) is the population of the city, and RR is relative risk.

In the present study, the default model that attributes cases of COPD to PM_{10} exposure was used. In addition to total attributable cases, we could estimate the distribution of attributable cases in terms of concentration intervals of the pollutant.[30]

The RR is a ratio of the probability of the event occurring in the exposed group versus a nonexposed group. The RR is a measure of association between a disease or condition and a factor under study. It is calculated by dividing the incidence rate among those exposed to the factor by the incidence rate among those not exposed to the factor. The population prevented fraction refers to situations where exposure to a factor is protective.[31]

RR = Incidence in the exposed / Incidence in the nonexposed

Indeed, uncertainty of the effect (and the range of estimated effects) is larger due to exposure assessment errors and non-statistical uncertainties of the concentration-response function. Thus, there may be an increase in death toll due to increase in the concentration of pollutants. The primary and secondary standard of particulate matter according to the National Ambient Air Quality Standard (NAAQS) for 24 hours is 150 $\mu g/m^3$.[32] The standard of particulate matter according to the European Air Quality Standards (EU AQS) for 24 hours is 50 $\mu g/m^3$ and 1 year is 40 $\mu g/m^3$.[33]

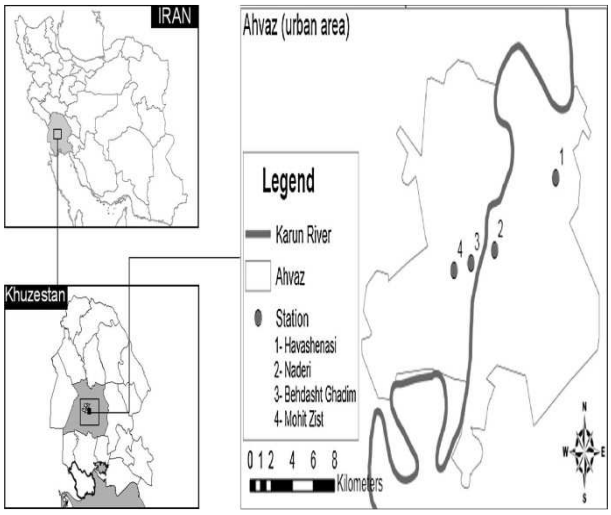

Figure 1. Location of the study area and sampling stations in Khuzestan Province (Ahvaz city), in the South West of Iran.[34]

Results

According to the research findings, the yearly average PM_{10} concentrations during 2012 were 727 $\mu g/m^3$. Table 1 shows that the annual average of PM_{10} concentration in Ahvaz is higher than the EU AQS (50 $\mu g/m^3$) standard and also much higher than the NAAQS standard (150 $\mu g/m^3$). The annual mean, spring mean, summer mean, winter mean, autumn mean, and the 98 percentile of PM_{10} concentration in these stations have been presented in table 1.

In terms of morbidity, hospital admission for COPD based on PM_{10} concentration is shown in table 2. Estimated number of excess cases for of hospital admission due to COPD attributed to PM_{10} exposure at lower, average, and higher confidence interval of RR was 993, 1602, and 2143, respectively. Average RR is corresponded to 1602 as predicted number of excess cases and it can be a good representative of the real situation in standpoint of the health effects of PM_{10}.

Table 1. Highest and lowest concentrations of PM_{10} ($\mu g/m^3$) corresponding to stations in Ahvaz during 2012

Parameter \ Stations	Ahvaz (mean ± SD)	Lowest station (Downtown) (mean ± SD)	Highest station (Bureau of Meteorology) (mean ± SD)
Annual	727.65 ± 47.3	624.32 ± 38.3	821.6 ± 48.90
Spring	985.04 ± 38.43	763.50 ± 50.1	1364.7 ± 60.40
Summer	646.61 ± 46.38	521.63 ± 39.5	810.0 ± 38.97
Autumn	348.00 ± 28.3	287.36 ± 16.8	425.2 ± 32.30
Winter	922.42 ± 58.63	810.36 ± 54.3	1234.8 ± 66.89
Annual 98 percentile	2663.53 ± 86.5	2244.62 ± 76.9	3412.6 ± 104.30

SD: Standard deviation

Table 2. Relative risks, attributable proportions and number of people suffering from chronic obstructive pulmonary disease (COPD) due to PM10 exposure

Estimate \ Indicator	RR (Medium)	AP (%)	Attributable excess cases (persons)
Low	1.0048	15.2453	993.40
Average	1.0080	22.7156	1602.41
High	1.0112	19.8952	2143.50

RR: relative risks; AP: Aattributable proportions

As figure 2 indicates, despite the RR of the health effects of exposure to PM_{10} concentrations below 20 µg/m³, due to lack of contact with the population, the concentration is 0. In other words, PM_{10} concentration has not been below 20 µg/m³ on any day in 2012. The rising trend of hospital admission cases due to COPD with increasing concentrations of PM_{10} between 60 to 180 µg/m³ has a uniform trend.

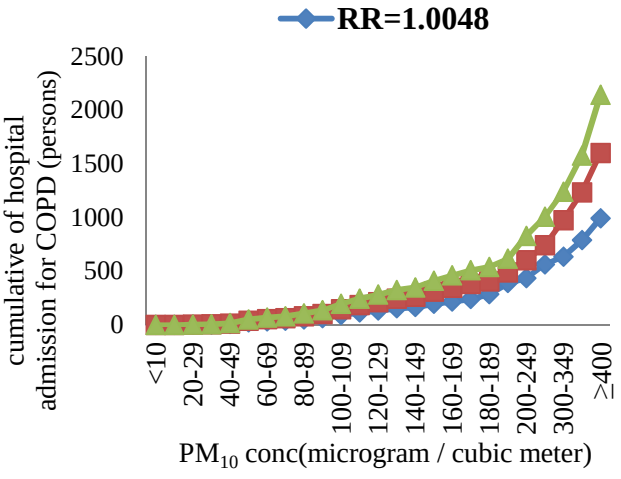

Figure 2. Relationship between cumulative numbers of hospital admission due to COPD based on PM10 concentration

Discussion

In recent decades, air pollution is considered to be a serious threat to the environment, and quality of life and health of people. In this study, we estimated the effects of exposure to PM_{10} air pollution, such as COPD, using the AirQ model in Ahvaz. Figure 2 illustrates PM_{10} concentrations based on related health endpoint and average concentrations during different seasons. These cases can be the result of produced dust storm, transportation, and industrial processes. The major sources of PM_{10} that can increase COPD are the result of dust storms, and human interventions particularly road traffic, stationary combustion, and industrial processes. Ahvaz has been well known for its industries such as petroleum steel and power stations. In the last decade, an anthropogenic source of air pollution has been added to other environmental problems. Based on the results, the number of excess cases of hospital admission for COPD attributed to PM_{10} at average RR was 1602 persons. The lower level of RR may be an indication of the improvement of urban air quality by the implementation of emission control strategies. Therefore, higher RR can signify mismanagement in urban air quality.

The increase in the developing world between 1970 and 2000 is believed to be related to increasing rates of smoking in this region, an increasing population, and an aging population due to fewer deaths from other causes such as infectious diseases.[35] In some countries, the rate of mortality has decreased in men, but increased in women.[36] This is most likely due to the similar rates of smoking in women and men. Moreover, COPD is more common in older people.[14,37] In the United States, approximately 6.3% of the adult population, totaling approximately 15 million people, has been diagnosed with COPD.[38]

As the results showed, 3 ranges of RR based on the model's default were considered for assessing the health effects of PM_{10}. Furthermore, BI values were obtained from the model's default. In addition, spring and autumn had the highest and the lowest PM_{10} concentrations during 2012, respectively. The study was performed on the 1 million residents of Ahvaz and based on BI of 1260 per 100,000 people in 2012. Furthermore, 63% of COPD cases occurred on days with pollutant level not exceeding 60 $\mu g/m^3$. Based on the results of this study, 6.2% of all cases of hospital admission for COPD was attributed to respiratory PM_{10}. In a similar study by Goudarzi et al, the AirQ model was used to estimate the health effects of PM_{10} on potential COPD in Tehran (capital of Iran).[34] Based on their results, almost 3.6% of all cases of COPD are attributed to PM_{10} concentrations greater than 30 $\mu g/m^3$.[34] In 2011, there were approximately 730,000 hospitalizations in the United States due to COPD.[39] The results of this study showed that very high concentration of PM_{10} in Ahvaz can result in high rates of hospitalizations. Furtheremore, Mohammadi found that approximately 4.1% of hospital admissions due to COPD occurred when the PM_{10} concentration was higher than 20 $\mu g/m^3$.[25] High percentages of the observed health endpoints in this study were associated with high concentrations of measured PM_{10} in Ahvaz. The WHO has emphasized the effects of air pollutant concentrations on COPD.[40] In addition, the results of this study demonstrates the impact of air pollution on an increased incidence of COPD. Zalaghi performed a survey on the health effects of air pollution in Ahvaz, Bushehr, and Kermanshah in 2010.[27] Based on the results, approximately 4.8, 2.4, and 1.7% of COPD cases in Ahvaz, Kermanshah, Bushehr, respectively, were attributed to PM_{10}.[27] Based on the results of the present study, the number of cases of hospitalization was relatively higher because of the higher concentration air pollution in Ahvaz city.

The major limitations of this study were the lack of databases and indicators, which forced us to use the figures provided by the WHO (Middle East region) for calculated health effects attributed to PM_{10}. Therefore, to estimate the health effects of air pollutants, epidemiologic studies are required for accurate calculation of RRs and BIs. Accordingly, cost-effective measures and management schemes should be considered to abate air pollution concentrations and/or reduce exposure of the general population to air pollutants. Finally, the survey results show that implementation of basic actions to the control PM_{10} entering into the stratosphere by decreasing of emission particle matter and development of green space is essential.

Conclusion

According to the present research findings, 6.2% of hospital admissions for COPD were attributed to respiratory PM_{10}. High percentages of observed health endpoints were associated with high concentrations of PM_{10}. Thus the use of methods to decrease PM_{10} concentration in neighboring countries, such as actions to reduce industrial emissions to air, alternative energy sources such as solar cooking and electrical heating, and appropriate health and environmental monitoring are recommended. Considering Limited available prerequisite building, calculated duration of disease attributable to air pollution, and estimated health effects of air pollutants, which are

epidemiological indicators, the calculation of these indicators by experts is recommended. Thus, further studies assessing the development in health status are necessary.

Conflict of Interests

Authors have no conflict of interests.

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