

Exposure to Particulate Matter and its Health Impacts (an AirQ Approach)

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A-R-T-I-C-L-E-I-N-F-O

Article Notes:

Received: Aug 21, 2016

Received in revised form:
Nov 24, 2016

Accepted: Dec 22, 2016

Available Online: Jan 1,
2017

Keywords:

Heart disease

Software

Particulate matter

Respiration disorders

Iran

A-B-S-T-R-A-C-T

Background & Aims of the Study: Recent studies indicated that particulate matter can have the lung irritation, chronic lung diseases, lung tissue, etc. The aim objective of this study was to assess the mortality associated with exposure to PM₁₀ concentrations in Ilam, Iran, during 2013.

Materials & Methods: PM₁₀ data were taken from Ilam's Local Agency of Environment (I-LAE). The annual mortality, including total, cardiovascular, and respiratory due to PM₁₀ were estimated, using AirQ2.2.3 software model. The relative risk (RR) and baseline incidence (BI) defaulted by WHO were used for this purpose.

Results: The number of excess cases for total, cardiovascular and respiratory mortality was estimated 161, 85 and 17 persons, respectively for a year exposure to PM₁₀ among the people. About 3.95% of mortalities were occurred in the days with concentration levels less than 20 µg/m³. The most percentage of person-days attributed to different levels of PM₁₀ was found to be in concentration of 40-49 µg/m³.

Conclusions: In order to diminish the health impacts of particulate matter in Ilam city, health training by health systems 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.

Please cite this article as: Daryanoosh SM, Goudarzi G, Mohammadi MJ, Armin H, Omid Khaniabadi Y, Sadeghi S. Exposure to Particulate Matter and its Health Impacts (an AirQ Approach). Arch Hyg Sci 2017;6(1):88-95.

Background

Air pollution due to industrialization, population, and urbanization is an important environmental problem in the world, especially in developing countries (1-4). World Health Organization (WHO) approximated that about 800,000 cardiovascular and respiratory death occurred per each year in the world due to urban air pollution (5-8). Epidemiological

studies showed that air pollution, especially particulate matter (PM₁₀) has a serious impact on the human health (9-12). PM₁₀ can penetrate into the airways where they may exert adverse effects (13-15). Numerous epidemiological studies also have shown an association between PM₁₀ concentration in ambient air and respiratory diseases, pulmonary sicknesses, and mortality among the exposed population (16-18). In a study conducted by WHO, the results

showed that an increase of $10 \mu\text{g}/\text{m}^3$ in particulate matter level can lead to an increase of 1-3% in mortality rate (19-21). Epidemiological researches also illustrated that higher than 500,000 deaths each year occurred due to cardiovascular diseases associated with PM_{10} (16,22).

Ilam, the capital city of Ilam province, a western city of Iran, is encountered to high quantities of air particulate matter. In the recent years, because of the Middle Eastern Dust (MED) storms especially from the Arabian Peninsula, Kuwait and Iraq, the areas of south, west and southwest of Iran have been influenced because of exposure to PM_{10} . MED storms have led to thousands of hospitalizations due to cardiopulmonary diseases (23). The Air Quality Health Impact Assessment (AirQ2.2.3) software is a program that has been used to assess the health impact of PM_{10} (9,20,24). This model is a valid and reliable tool proposed by WHO in order to estimate the potential of short-term impacts of air pollution on the human

health. Several studies have been conducted by Nourmoradi *et al* (16,23), Zhou *et al* (25), Shakour *et al.* (13), Gharehchahi *et al* (26), Schwartz *et al* (14), Dockery *et al.* (27), Mohammadi *et al* (28), Chen *et al* (29) and Martuzzi *et al* (19) to assess the air quality in terms of particulate matter and its health risks on the human.

Aims of the study:

In the present study, the AirQ2.2.3 software was applied to assess the total, cardiovascular and respiratory mortality attributed to PM_{10} in Ilam, during 2013.

Materials & Methods

Study area

Ilam ($33^{\circ}36'\text{N}$, $46^{\circ}36'\text{E}$), the capital of Ilam province and a western Iranian city has a total population of 170,000 persons. Ilam is developing and non-industrialized. Fig. 1 shows the location of Ilam and sampling station.



Figure 1) The study area and sampling station

Health impacts

Daily data of PM_{10} during 2013 were obtained from air pollution-monitoring station of Ilam's Local Agency of Environment (I-LAE). The AirQ is a tool that advanced by WHO European Center for Environment and Health for estimation of health impact of air pollution

(30,31). This program is utilized to assess the health impact of exposure to air pollution (32). The association is based on the attributable proportion (AP), which is defined as the portion of the health result in a certain residents attributable to contact to a given air pollutant (30,33). The AP is calculated by Eq. (1):

$$AP = \sum \left(\left[\frac{RR(c) - 1}{RR(c)} \right] * P(c) \right) / \sum [RR(c) * P(c)]$$

(1)

Where; AP and RR (cc) are attributable proportion of the health endpoint and the relative risk for a certain health impact in group c of exposure, respiratory (16,34). Moreover, P (c) is the proportion of the target population in exposed group (24). The amount of attributable to the population exposure can be founded by following equation, if the baseline frequency of the health impact in the studied population is identified.

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

Where; IE and I are the amounts of the health impact attributable to the exposure and the baseline frequency of the health endpoint in the population, respectively. Finally, considering the population size, the number of excess cases attributable to the exposure can be identified by Eq. (3).

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

Where; NE is the number of person attributed to the exposure and N is the total number of assessed residents. The RR gives increase in possibility of adverse endpoint associated with a given change in the exposure levels, comes from time-series studies where day-today changes in air pollutants over long periods were relation to daily mortality, hospital admissions and other public health indicators (30).

Inputs adjustment

Daily averages of PM₁₀ were used in this study to assess the health impact in Ilam. The mortality rates associated with PM₁₀ were estimated using AirQ Version: 2.2.3. Finally, the numbers of persons for total, cardiovascular, and respiratory mortality were calculated. The values of RR and BI were taken from the studies of Khaniabadi et al (24) and Shahsavani et al (9).

Results

The highest and the lowest concentrations of PM₁₀ in Ilam are presented in Table 1. As seen, the annual average of PM₁₀ was equal to 77.67 µg/m³, during 2013. The summer average of PM₁₀ with an amount of 88.57 µg/m³ was higher than winter with an average equal to 55.85 µg/m³. The annual maximum concentration of PM₁₀ in the summer was higher than winter, with the observed maximum concentration of 491 µg/m³ in the summer.

Table 1) The highest and the lowest concentrations of PM₁₀ in Ilam.

Parameters	Value (µg/m ³)
Annual average	77.67
Summer average	88.57
Winter average	55.85
Annual maximum	491.0
Summer maximum	491.0
Winter maximum	194.63
98 percentile	257.6

Table 2 shows the relationship between PM₁₀ concentrations and percentage of attributed proportion; also, the number of persons suffering from total, cardiovascular and mortality due to respiratory diseases according to the relative risk (RR) and baseline incidence (BI) proposed by WHO. As it can be seen, the cumulative number of estimated excess cases for total mortality was about 161 persons. Moreover, as shown in this table, the cumulative number of estimated excess cases for cardiovascular and respiratory mortality was 85 and 17 persons, respectively.

Table 2) Relationship between relative risk (RR), attributable proportion (AP), and cumulative number of excess cases (Part/billion).

Short-term effect	BI*	RR **	Estimated AP (%)	Cumulative number of excess cases
Total mortality	543.5	1.0074 (1.0062-1.0086)	4.6568 (3.9313-5.3714)	161 (131-186)
Cardiovascular mortality	231	1.0080 (1.0050-1.0180)	5.0154 (3.1947-10.6189)	85 (55-180)
Respiratory mortality	48.4	1.0120 (1.0080-1.0370)	7.3391 (5.0154-19.6277)	17 (12-45)

*BI=baseline incidence, **RR=relative risk

Fig. 2 indicates the results of quantification of health impacts and the number of consequences obtained from the software explicated versus PM_{10} concentration interval in Ilam. Fig. 2 also shows charts based on the cumulative number of each health outcome and the number of excess cases in three styles (5, 50, and 95% RR). There are three curves for each chart (include lower, medium, and upper). The middle curve is corresponds to a RR of centerline. Lower curve is in relation to a RR of 5% (underestimate), and the upper curve is associated with a 95% RR (overestimate). Based on Fig. 2, the cumulative number of total death, cardiovascular death, and respiratory mortality in central relative risk is calculated equal to 161, 85, and 17 persons in Ilam, respectively. In addition, there is a steep increase in concentrations of higher than 120 $\mu g/m^3$ related to the charts from estimated health effects. Moreover, about 3.95% of mortality rates associated with PM_{10} was happened in the days with concentration less than 20 $\mu g/m^3$, and 81.07% of these effects occurred due to PM_{10} concentration lower than 120 $\mu g/m^3$. More than 98% of cumulative number of total, cardiovascular, and respiratory mortality was occurred in the days with PM_{10} concentration not exceeding 200 $\mu g/m^3$ in Ilam.

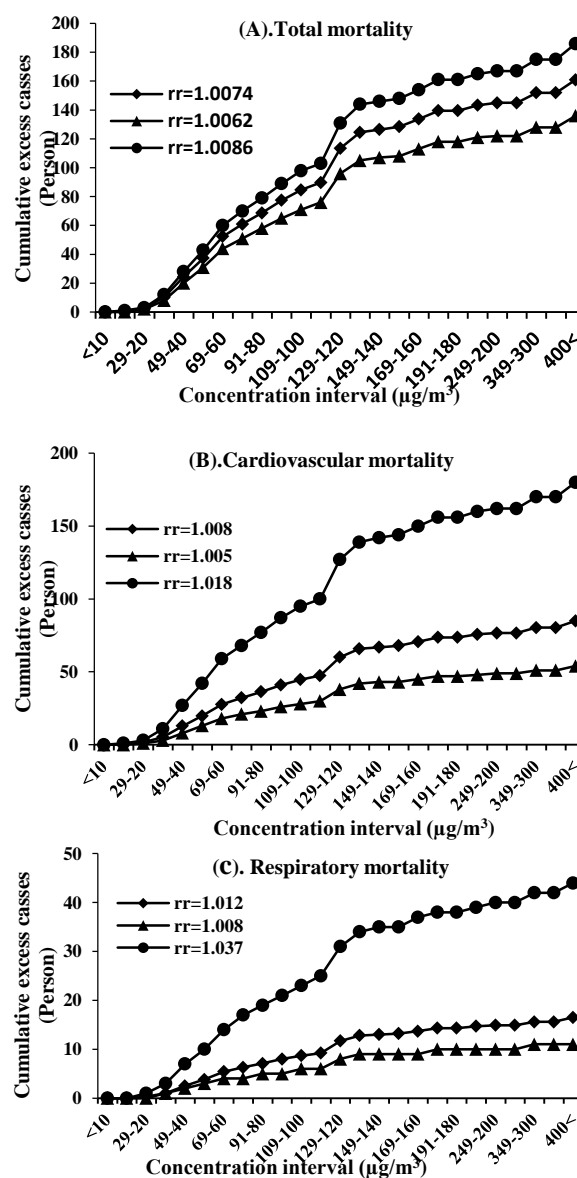
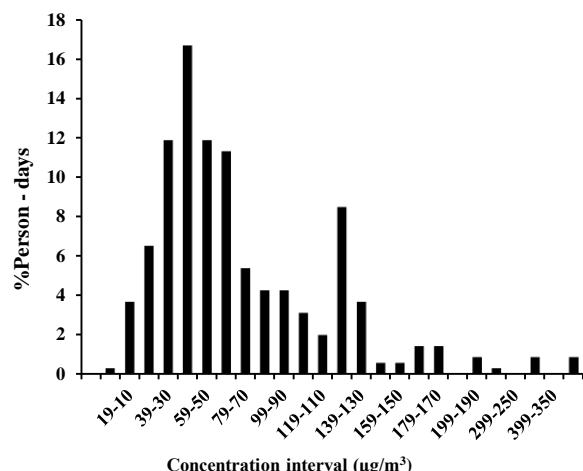


Figure 2) The quantification of health effects versus PM_{10} concentration (A, B, C)

Fig. 3 illustrates the percentage of time that people in Ilam were exposed to different concentrations of PM_{10} that led to health effect among affected groups. Based on this figure, the most percentage of person-days related to different level of PM_{10} was found to be in the concentration of $40-49\mu g/m^3$, which resulted to health impacts in Ilam.



caused to the health impacts in Ilam. Fattore et al. (2011) illustrated that the most percentage of days that people in Milano were exposed to different PM₁₀ levels was in concentration interval of 40-49 µg/m³. This result also is in consistent with the results of Hosseini et al (2014) in Sanandaj, Iran, during 2013 (22).

Conclusion

In this study AirQ2.2.3 software and the approach proposed by World Health Organization (WHO) have been used to provide quantitative data on impact of PM₁₀ on the health of people living in a certain area. The results show that cardiovascular mortality has an important role in the cumulative number of total mortality. The results also are in line with those of other researches and despite the limitations, indicate that this method offers an effective and easy tool, helpful in decision-making. In addition, further researches with specific RR and BI according to geographical, climatic and statistical features are required. In order to diminish the health impacts of particulate matter in Ilam city, health training by health care systems should be conducted to public people especially persons with chronic lung and heart diseases, elderly and children. Furthermore, the attempts should be conducted in the governmental scale in order to control of Middle Eastern dust storms (MED) sources.

Footnotes

Acknowledgments:

The authors wish to thank the Ilam's Local Agency of Environment (I-LAE).

Funding/Support

This study was financially supported by Ahvaz Jundishapur University of Medical Sciences.

Conflict of Interest:

The authors stated no conflict of interest.

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