

## 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

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### 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 PM<sub>10</sub> concentrations in Ilam, Iran, during 2013.

**Materials & Methods:** PM<sub>10</sub> data were taken from Ilam's Local Agency of Environment (I-LAE). The annual mortality, including total, cardiovascular, and respiratory due to PM<sub>10</sub> 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 PM<sub>10</sub> among the people. About 3.95% of mortalities were occurred in the days with concentration levels less than 20 µg/m<sup>3</sup>. The most percentage of person-days attributed to different levels of PM<sub>10</sub> was found to be in concentration of 40-49 µg/m<sup>3</sup>.

**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.

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## 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 (PM<sub>10</sub>) has a serious impact on the human health (9-12). PM<sub>10</sub> can penetrate into the airways where they may exert adverse effects (13-15). Numerous epidemiological studies also have shown an association between PM<sub>10</sub> 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  $\text{PM}_{10}$  (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  $\text{PM}_{10}$ . 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  $\text{PM}_{10}$  (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  $\text{PM}_{10}$  in Ilam, during 2013.

### Materials & Methods

#### Study area

Ilam ( $33^{\circ}36'N$ ,  $46^{\circ}36'E$ ), 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  $\text{PM}_{10}$  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):

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

(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 PM<sub>10</sub> were used in this study to assess the health impact in Ilam. The mortality rates associated with PM<sub>10</sub> 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 Shabsavani et al (9).

## Results

The highest and the lowest concentrations of PM<sub>10</sub> in Ilam are presented in Table 1. As seen, the annual average of PM<sub>10</sub> was equal to 77.67 µg/m<sup>3</sup>, during 2013. The summer average of PM<sub>10</sub> with an amount of 88.57 µg/m<sup>3</sup> was higher than winter with an average equal to 55.85 µg/m<sup>3</sup>. The annual maximum concentration of PM<sub>10</sub> in the summer was higher than winter, with the observed maximum concentration of 491 µg/m<sup>3</sup> in the summer.

**Table 1) The highest and the lowest concentrations of PM<sub>10</sub> in Ilam.**

Parameters	Value (µg/m <sup>3</sup> )
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

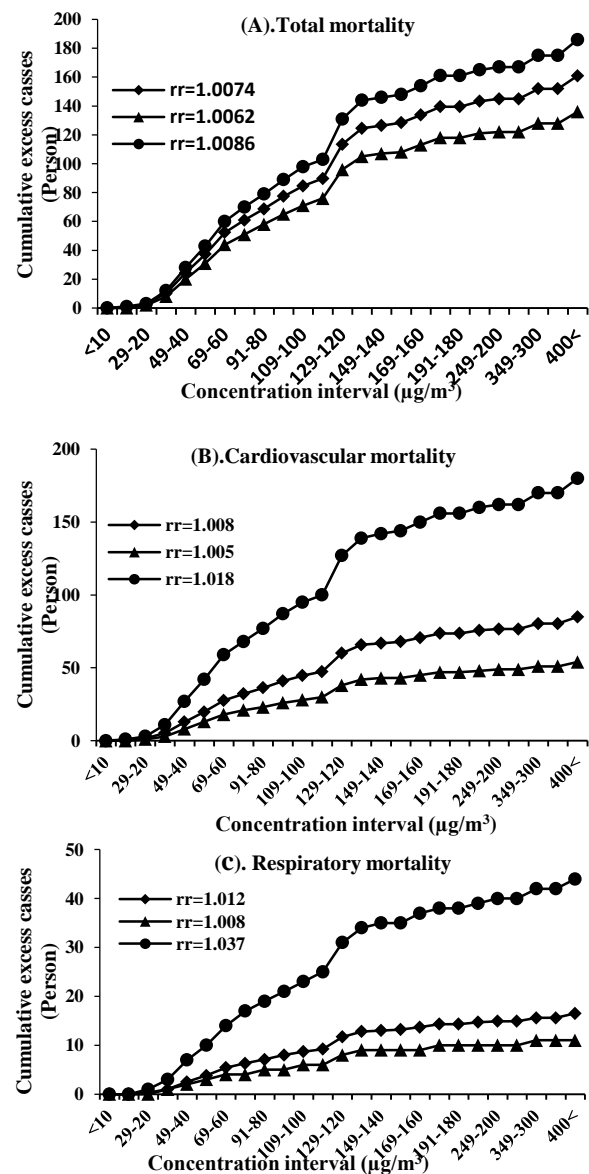
Table 2 shows the relationship between PM<sub>10</sub> concentrations and percentage of attributed proportion; also, the number of persons suffering from total, cardiovascular and mortality due to respiratory diseases according to the relative risk (RR) and baseline incidence (BI) proposed by WHO. As 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
<b>Total mortality</b>	543.5	1.0074 (1.0062-1.0086)	4.6568 (3.9313-5.3714)	161 (131-186)
<b>Cardiovascular mortality</b>	231	1.0080 (1.0050-1.0180)	5.0154 (3.1947-10.6189)	85 (55-180)
<b>Respiratory mortality</b>	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<sub>10</sub> 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 µg/m<sup>3</sup> related to the charts from estimated health effects. Moreover, about 3.95% of mortality rates associated with PM<sub>10</sub> was happened in the days with concentration less than 20 µg/m<sup>3</sup>, and 81.07% of these effects occurred due to PM<sub>10</sub> concentration lower than 120 µg/m<sup>3</sup>. More than 98% of cumulative number of total, cardiovascular, and respiratory mortality was occurred in the days with PM<sub>10</sub> concentration not exceeding 200 µg/m<sup>3</sup> in Ilam.



**Figure 2) The quantification of health effects versus PM<sub>10</sub> concentration (A, B,C)**

Fig. 3 illustrates the percentage of time that people in Ilam were exposed to different concentrations of PM<sub>10</sub> that led to health effect among affected groups. Based on this figure, the most percentage of person-days related to different level of PM<sub>10</sub> was found to be in the concentration of 40-49 μg/m<sup>3</sup>, which resulted to health impacts in Ilam.

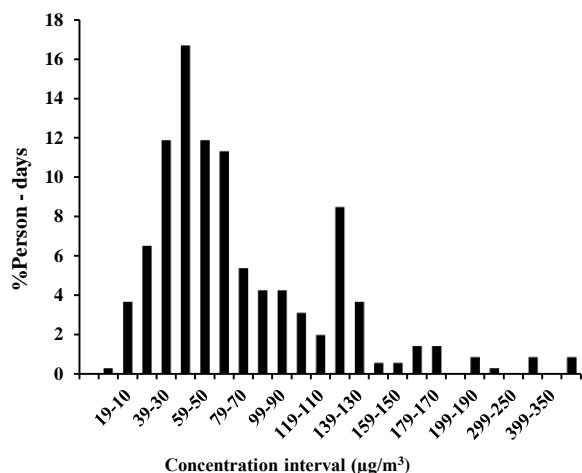


Figure 3) Percentage of days that people in Ilam were exposed to PM<sub>10</sub> concentrations

## Discussion

In this cross-sectional study, the mortality rates due to exposure with particulate matter (PM<sub>10</sub>) were assessed using WHO method in Ilam. AirQ2.2.3 software tool has been applied in several epidemiological studies in the world to evaluation of health impacts of air pollutants (35-38). Total mortality, death due to cardiovascular diseases and respiratory death were estimated attributed to short-term exposure to PM<sub>10</sub>. Based on description of model, three ranges of relative risk include upper (95% CI), central, and lower (5% CI) were considered.

The maximum of annual average of 24-hour, summer mean, winter mean, and 98 percentile were estimated 77.67, 88.57, 55.85 and 257.6 μg/m<sup>3</sup>, respectively. The mean average of PM<sub>10</sub> in Ilam was lower than National Ambient Air Quality Standard (NAAQS) with 24-h

average standard of 150 μg/m<sup>3</sup>. Zallaghi *et al.* illustrated that the annual, summer and winter average concentrations of PM<sub>10</sub> in Kermanshah were 89.54, 117.91 and 60.06 μg/m<sup>3</sup>, respectively (24). Nourmoradi *et al.* reported that the average concentrations of annual, winter and summer of PM<sub>10</sub> in Khorramabad were obtained 58.28, 102.90 and 80.59 μg/m<sup>3</sup>, respectively (16).

According to the results of model, the cumulative number of total mortality was calculated 161 persons, which is higher than the results of Mohammadi *et al.* in Shiraz during 2012 (28), Goudarzi *et al.* in Ahvaz during 2009 (1), and Zallaghi *et al.* in Kermanshah (24). Total mortality in the study of Fattore *et al.* (2011) was 4.4 persons (30), which is lower than the results of present study. In a similar study in Kurdistan, Hosseini *et al.* (2014) showed that total mortality, cardiovascular mortality, and mortality for respiratory death were estimated 228, 120, and 23 cases, respectively (22); which is in consist with the results of this study. Nourmoradi *et al.* (2015) illustrated that total, cardiovascular, and respiratory mortality in Khorramabad were estimated 320, 304, and 72 cases, respectively (16); while these parameters were 161, 85 and 17 persons in Ilam. Mohammadi *et al.* (2015) reported that the rate of total and cardiovascular mortality have estimated zero and 7.9 persons in Shiraz in a middle RR equal 1 and BI equal 454.3 (28). The results of this study showed that 38.98% of total mortality occurred in PM<sub>10</sub> concentration lower than 50 μg/m<sup>3</sup> and 93.79% of total mortality and death due to cardiovascular and respiratory diseases were occurred in PM<sub>10</sub> level not exceeding of 150 μg/m<sup>3</sup>. Yavari *et al.* (2007) indicated that about 13% of total number of death happened in the days with PM<sub>10</sub> level lower than 20 μg/m<sup>3</sup> (39), whereas only 3.9% of health outcomes in Ilam were in concentration not exceeding 20 μg/m<sup>3</sup>. The most percentage of person-days related to different level of PM<sub>10</sub> was observed in concentration interval of 40-49 μg/m<sup>3</sup> that

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 PM<sub>10</sub> levels was in concentration interval of 40-49 µg/m<sup>3</sup>. 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 PM<sub>10</sub> 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

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### Conflict of Interest:

The authors stated no conflict of interest.

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