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The Health Effects of Particulate Matter (PM2.5) in the Ambient Air of Urmia City, Iran

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ABSTRACT

International Agency for Research on Cancer (IARC) has defined outdoor air pollution as a mixture of particulate matters, specifically those that are considered carcinogenic to humans (IARC Group 1). Outdoor air pollution contains various pollutants that are resulted from natural and human sources. The present study aimed to evaluate exposure to particulate matter (PM2.5) and its effects on human health in the northwest of Iran during 2015-2016 using the AirQ model. Data were collected from online monitoring stations in Urmia city, and total mortality was estimated using the AirQ model. The annual mean PM2.5 concentrations was 23 μg/m3, which was higher than the recommended limit (10 μg/m3) by the World Health Organization (WHO). In addition, total mortality at the central relative risk of 1.015 was calculated to be 143 cases. The main sources of PM2.5 were the combustion of fossil fuels and also salty dust storms due to climate change and drying of Urmia Lake. Therefore, development of green spaces and extensive desertification activities are recommended for the control of this extremely challenging phenomenon**.**

Introduction

In recent years, air pollution due to anthropogenic activities and natural phenomena, such as dust storm, has been led to human mortality across the world. Although, air pollutants in concentrations lower than the standard level have insignificant adverse effects on health, they could threaten sensitive populations (1). Nowadays, there are growing concerns regarding the air pollution in cities due to the presence of harmful substances, such as O_3, NO_2, as well as the trend in the distribution and size of particulate matters in air (2, 3).

In the past two decades, several epidemiological studies have demonstrated that air pollution in cities can cause respiratory and cardiovascular diseases, chronic bronchitis, and even death (4, 5). In 2000, the global mortality rate associated with air pollution was reported to be one per a million, while in 2012, approximately 1.3 million deaths were reported due to air pollution, more than 50% of which occurred in Asia (6). Despite of unclear findings regarding the biological mechanisms of the air pollutants with significant effects on human health, these effects could be attributed to the potential oxidation of the various parts of air cells or the active pathways inside cells (7).

According to reports of the World Health Organization (WHO), particles smaller than 10 micron (PM_{10}) could be influential factors in mortality and respiratory and cardiovascular diseases, such as asthma, bronchitis, cardiac arrest, and reduced pulmonary function. In some European cities, the mortality is mainly attributed to the air pollution mainly PM_{10}, so that increased PM_{10} concentration of 10 $\mu g/m^3$ increases mortality by 6% (8).

With the remarkable development of urban areas and increased number of transportation vehicles in recent decades, the air quality in Iran has had a plunging trend. Several studies have confirmed severe air pollution levels in the cities in Iran, including Tehran, Isfahan, Arak, Mashhad, and Tabriz. Furthermore, PM_{10} is the main influential factor in the air pollution in these cities (9).

According to the studies in Delhi (India), Beijing (China), and some cities in Malaysia, air pollution is at an alarming rate in more than 80% of the days in a year, and PM_{10} is reported as main pollutant. There is similar status in Iran due to the presence of industries, transportation, and growing population; industries and urban traffic are considered to be the main sources of air pollution in Iran (10-13).

The present study aimed to assess the health effects of the particle matter smaller than 2.5 micron ($PM_{2.5}$) in the ambient air of Urmia city, Iran.

Materials and Methods

Studied Area

This descriptive-ecological study was done in Urmia city, the center of West Azerbaijan Province (Figure 1). Required data were obtained from the Environmental Office of West Azerbaijan province during March 2015-February 2016.

AirQ Software

The assessment of health effects of PM_{10} was performed in accordance with the WHO guidelines (8) using the AirQ software version 2.2.3 (14). The software was designed to estimate the effects of pollutants on human health in a specific period and location and is accessible on the WHO website:

http://www.euro.who.int/eprise/main/WHO/Progs/AIQ/activities/20050223_5.

In AirQ software, calculations are performed based on the risk estimation from similar studies to determine the long-term effects of pollutants and risk estimation from chronological studies to determine the mortality and diseases associated with pollutants. This model was originally prepared for the Environmental Health in Central Europe; however, modification of the coefficients renders it useful for other countries as well. According to the information in Table 1, the coefficients of base incidence (BI) are calculated for the health effects of pollutants on various age groups. Considering that the Iranian population is younger than the European population, the values are smaller in our country (14).

In AirQ software, attributable proportion (AP) is the level of exposure to air pollution in a specific population at a specific time, which is calculated based on the Equation 1:

$$AP=SUM\{[RR(c)-1] \times p(c)\}/SUM\,[RR(c) \times p(c)] \quad (1)$$

where RR(c) is the relative risk of the health impact in the target group, and p(c) represents the population of the target group. By determining the BI in the target population, rate of the health outcome related to the exposure (IE) could be calculated using the Equation 2:

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

where I denotes the baseline frequency of the health endpoint in the population. Finally, the estimated number of cases attributed to the exposure (NE) in a population of 'N' could be determined using the Equation 3:

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

Exposure Assessment

Evaluation of exposure to $PM_{2.5}$ during one year was performed in accordance with the WHO guidelines. Initially, the obtained data were processed in Microsoft Excel software on two levels, followed by the estimation of the average and maximum seasonal and yearly exposure level (98 percentiles annually) and determining two main pollutants.

The population of Urmia city in different age groups was obtained from the Statistical Center of Iran (736,224 people). Finally, the collected data were analyzed using the AirQ software in accordance with the guidelines of WHO. In addition, the AP, mortality rate, and disease rate associated with $PM_{2.5}$ were determined.

Results and Discussion

The descriptive statistics of $PM_{2.5}$ concentrations are depicted in Figure 2. The annual mean $PM_{2.5}$ concentrations was 23 μg/m^3, which was higher than the recommended limit (10 μg/m^3) in the WHO guidelines. The maximum concentration of $PM_{2.5}$ was estimated at 26 μg/m^3 in winter. The most probable causes of the phenomenon were high-speed winds from the lake to the city in winter, combustion of fossil fuels in vehicles and residential areas. Highest monthly mean concentration was calculated to be 28 μg/m^3 in March. The days on which the population of Urmia is exposed to $PM_{2.5}$ concentrations are illustrated in Figure 3. According to this figure, the highest value of exposure to $PM_{2.5}$ was 10-19 μg/m^3 during 118 days. Therefore, it could be concluded that that the population of Urmia was exposed to higher $PM_{2.5}$ concentrations than the recommended levels by the WHO.

Table 1 shows the estimated values in the AirQ model about the effects of $PM_{2.5}$ on human health for total mortality due to respiratory diseases. According to our findings, the annual BI rate of total mortality in Urmia city was 403.82 per 100,000. Estimated cumulative total mortality is shown in Figure 4. Cumulative excess cases for total mortality was estimated 143 cases under circumstances with the relative risk of air pollution.

According to the reports in two urban areas in Northern Italy, $PM_{2.5}$ was the main influential factor in the health of inhabitants. In Trieste, a city in the northeast of Italy with 200,000 populations, short-term exposure to PM_{10} at concentrations of >20 μg/m^3 led to total mortality, cardiovascular mortality, and respiratory mortality in 52, 28, and six cases, respectively. Moreover, the findings indicated that 2.5% of respiratory mortalities and 1.8% of cardiovascular mortalities were associated with PM_{10} concentrations of >20 μg/m^3 (15). These findings are based on excess cases and consistent with the results of the present study in Urmia city (Iran).

In the other studies performed in 29 European cities, numerous Asian countries, and 20 American cities, it has been reported that the short-term adverse health effects due to the PM_{10} exposure are similar in developing and developed countries. On the other hand, the results were indicative of higher mortality rate by 0.72% when daily PM_{10} concentrations increased by 10 μg/m^3 (16-19).

Conclusion

According to the results, the concentration of $PM_{2.5}$ was higher than the recommended values by the WHO during several months and days in Urmia city. The main sources of PM were incineration fossil fuels, salty dust storms caused by climate change, and drying of Urmia Lake. Therefore, it is suggested that extensive activities (e.g., desertification) be carried out to control this extremely challenging phenomenon. Considering the long-term impacts of such activities, some midterm and short-term strategies must also be adopted to overcome the severe issue of air pollution in Urmia city.

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Table 1. Baseline Incidence (BI), Relative Risk (RR) with 95% Confidence Interval, Estimated Attributable Proportion (AP), and Number of Annual Excess Cases Due to Short-term Exposure to $PM_{2.5}$ (>10 μg/m^3)

Health Endpoints	Pollutant	BI*	RR (per 10 μg/m³)	AP Percentage (Uncertainty Range)	Number of Excess Cases (Uncertainty Range)**
Total Mortality	$PM_{2.5}$	403.82	1.015 (1.011-1.019)	1.920 (1.415-2.420)	143 (105-180)

** Crude rate per 100,000 inhabitants per year; **obtained using lower and upper RR values*

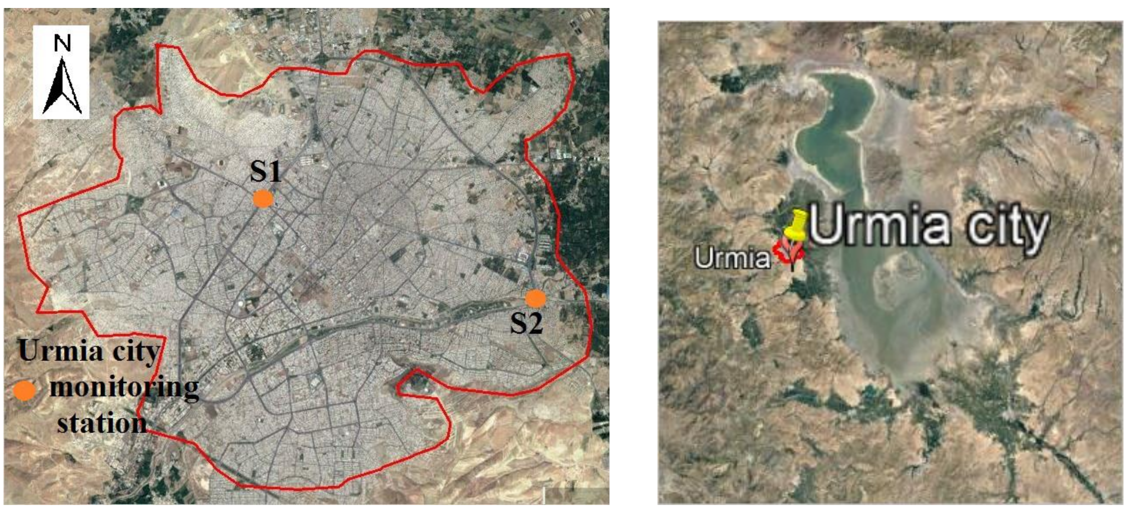

Figure 1. Map of Studied Area and Air Quality Monitoring Station (S1 and S2)

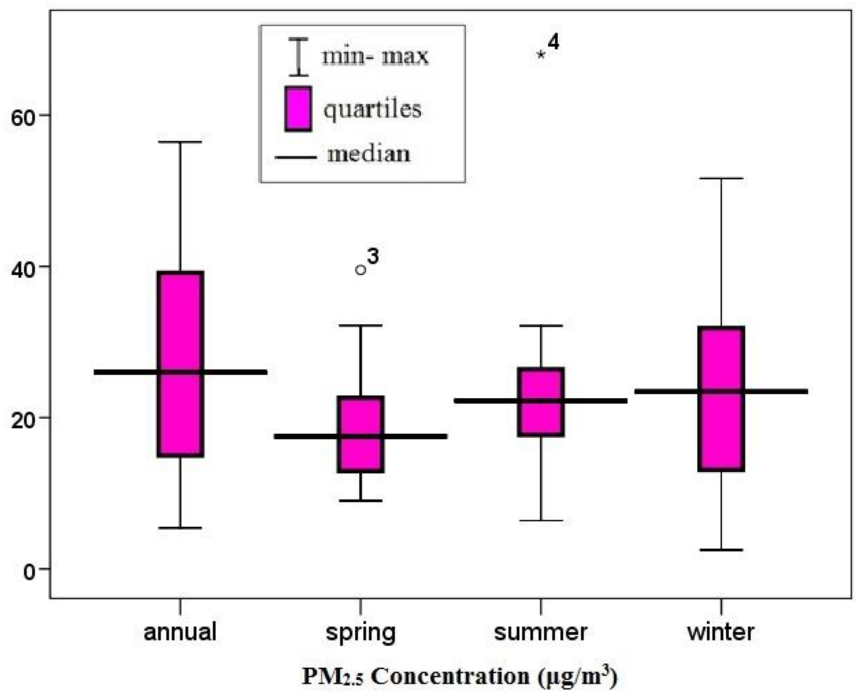

Figure 2. Box Plot of Descriptive Statistics of $PM_{2.5}$ Concentrations in Urmia, Iran (2015-2016)

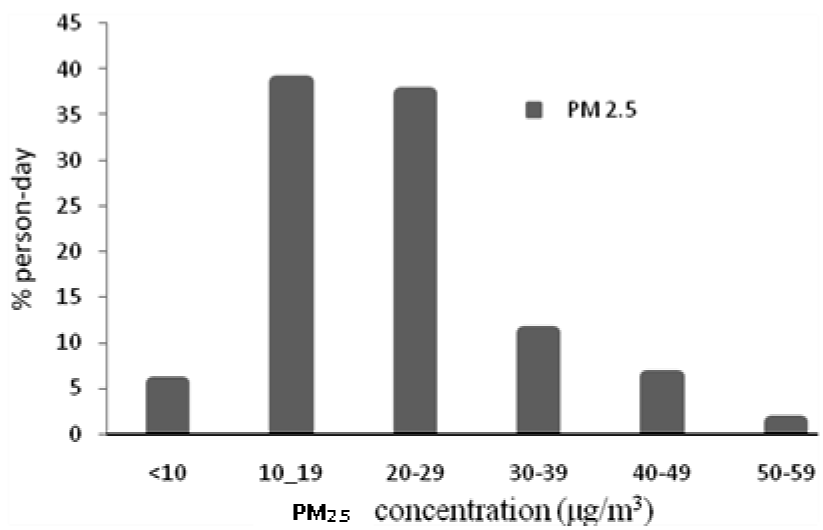

Figure 3. Proportion of Cases Exposed to Various $PM_{2.5}$ Concentrations

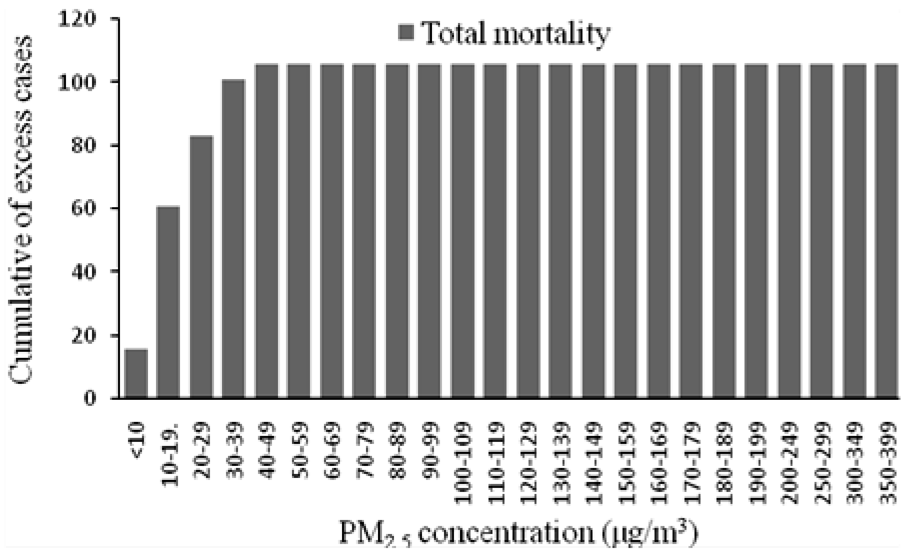

Figure 4. Estimated Cumulative Total Mortality

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