Published online 2016 September 5.

Research Article

Hospital Admission for Respiratory and Cardiovascular Diseases Due to Particulate Matter in Ilam, Iran

Seyed Mohammad Daryanoosh,¹ Gholamreza Goudarzi,² Atefeh Harbizadeh,³ Heshmatollah

Nourmoradi,⁴ Ata Allh Vaisi,⁵ Houshang Armin,⁶ Shahram Sadeghi,⁷ and Yusef Omidi Khaniabadi^{8,*}

¹Department of Environmental Health Engineering, School of Health, Lorestan University of Medical Sciences, Khorramabad, IR Iran

²Environmental Technologies Research Center (ETRC), Ahvaz Jundishapur University of Medical Sciences, Ahvaz, IR Iran

³Department of Environmental Health Engineering, Health Faculty, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, IR Iran

⁴Department of Environmental Health Engineering, School of Health, Ilam University of Medical Sciences, Ilam, IR Iran

⁵Ilam Monitoring Doe, Ilam, IR Iran

⁶Abadan School of Health Sciences, Abadan, IR Iran

⁷Environmental Health Research Center, Kurdistan University of Medical Sciences, Sanandaj, IR Iran

⁸Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, IR Iran

^{*} Corresponding author: Yusef Omidi Khaniabadi, Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, IR Iran. Tel: +98-353539648, E-mail: yusef_omidi@yahoo.com

Received 2016 January 10; Revised 2016 March 12; Accepted 2016 April 13.

Abstract

Background: Particulate matter with an aerodynamic diameter lower than 10 μ m (PM₁₀) has the most undesired adverse effects on human health. Several studies reported a strong correlation between PM levels and hospital admissions owing to chronic and acute respiratory and cardiovascular diseases.

Objectives: The current study aimed to estimate the effect of PM₁₀ as a primary pollutant on respiratory and cardiovascular hospitalizations in Ilam, Iran, in 2013.

Methods: PM₁₀ data was taken from the Ilam environmental protection agency. The annual morbidity including hospital admission for respiratory and cardiovascular diseases due to PM₁₀ exposure were estimated using relative risk (RR) and baseline incidence (BI) based on world health organization (WHO) databases for AirQ2.2.3 model.

Results: The results showed that the maximum level of PM_{10} was obtained in summer with a concentration of 491 μ g/m³. The cumulative number of excess cases admitted to the hospital for respiratory and cardiovascular diseases were 216 and 84, respectively. Approximately 3.95% of the cases hospitalized due to PM_{10} occurred during days with concentration levels lower than 20 μ g/m³. The highest rate of person-days related to PM_{10} that led to heath effect among Ahvaz inhabitants was in concentration levels of 40 - 49 μ g/m³.

Conclusions: To reduce the impacts of particulate matter on health status of people in Ilam, necessary training by health systems should be conducted for people, especially those with chronic lung and heart diseases, the elderly and children to reduce their activities on the dusty days.

Keywords: Respiratory Disease, Cardiovascular Diseases, Particulate Matter, AirQ Software

1. Background

Air pollution owing to industrialization, population and urbanization is one of the major environmental problems in the world, especially in the developing countries (1-3). In recent decades, several studies revealed that urban air pollution is a cause of mortality and morbidity (cardiovascular and respiratory symptoms, decrease in lung function, chronic bronchitis, etc.). World health organization (WHO) reported about 800,000 cardiovascular and respiratory deaths annually in the world due to urban air pollution (4-6). Epidemiological studies showed that air pollution, especially particulate matter with aerodynamic diameter $\leq 10 \ \mu m (PM_{10})$, has a serious impact on the human health (7-9). PM₁₀ can penetrate into the airways where they may exert adverse effects (10, 11). Several epidemiological studies showed an association between PM_{10} concentration in ambient air and respiratory diseases, pulmonary sicknesses and mortality among the exposed population (12). Results of the studies by the WHO showed that an increase of 10 μ g/m³ in particulate matter level can lead to an increase of 1% -3% in the mortality rate (13-15). Epidemiological researches illustrated that more than 500,000 Americans die each year owing to cardiovascular diseases associated with PM₁₀ (12, 16). Ilam, the capital city of Ilam province, is located in the West of Iran and high quantities of air pollution for decades as a result of urbanization and hence, population growth and increased traffic-related air pollution. In the recent years, because of the Middle East-

Copyright © 2016, Ahvaz Jundishapur University of Medical Sciences. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (http://creativecommons.org/licenses/by-nc/4.0/) which permits copy and redistribute the material just in noncommercial usages, provided the original work is properly cited.

ern dust (MED) storms especially from the Arabian Peninsula, Kuwait and Iraq, the areas of South and Southwest of Iran are affected by PM_{10} . MED storms lead to thousands of hospital admissions due to cardiovascular and respiratory diseases (17). The air quality health impact assessment (AirQ2.2.3) software is a program used to assess the health impact of PM_{10} (7, 14, 18). This model is a valid and reliable tool proposed by the WHO to estimate the potential of short-term impacts of air pollution on the human health. Several studies were conducted by Nourmoradi et al. (17), Zhou et al. (2), Shakour et al. (10), Gharehchahi et al. (19), Schwartz et al. (11), Dockery et al. (20), Hosseini et al. (16), Mohammadi et al. (21), Chen et al. (22) and Martuzzi et al. (13) to assess the air quality in terms of particulate matter and its health risks on the human.

2. Objectives

The current study aimed to assess the association between PM_{10} concentration and hospital admission due to respiratory and cardiovascular diseases in Ilam in 2013.

3. Materials and Methods

3.1. Study Area

Ilam (33°36'N, 46°36'E), the capital city of Ilam province, is located in South-West of Iran. According to the latest census report, this city has a population of 170,000 persons. Ilam is developing and non-industrialized. Figure 1 shows the location of Ilam sampling station.

3.2. Health Impacts

The complete mean of diurnal variation of PM₁₀ concentrations (in 2013) of air pollution-monitoring station was obtained from Ilam environmental protection agency. The AirQ2.2.3 software, advanced by WHO European center for environment and health, was applied to the study (23, 24). The program is utilized to approximate the effects of exposure to definite air pollutant on the health of people settling in a certain time and region. The association is based on the attributable proportion (AP) defined as the portion of the health assessment results in a certain resident attributable to contact a given air pollutant (23). The AP was calculated by Equation 1:

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

Where AP and RR (cc) are the attributable proportion of the health endpoint and relative risk for a certain health impact in the group c of exposure, respectively. Moreover, P (c) is the proportion of the target population in the exposed group (18). The amount of various attributable to the population exposure can be found by the following equation, if the baseline frequency of the health impact in the studied population is identified (Equation 2).

$$E = I \times AP \tag{2}$$

Where IE and I are the amount of health impact related to the contact and the baseline frequency of the health endpoint in the population, respectively. Finally, considering the population size, the total number of excess cases associated with the exposure is identified by Equation 3.

$$NE = IE \times N \tag{3}$$

Where NE is the number of cases assigned to the exposure and N is the total number of assessed residents. The RR gives the increase in the possibility of the adverse endpoint associated with a given change in the exposure levels, and comes from time-series studies where day-today changes in air pollutants over long periods were related to daily mortality, hospital admissions and other public health indicators (23).

3.3. Inputs Adjustment

In the epidemiological studies, the relative risk (RR) is the possibility of developing a sickness resulted by the contact to a pollutant. The health endpoints associated with the PM_{10} were estimated using AirQ version 2.2.3. Exposure was assessed considering llam with a residential population of 170,000 persons. The model assumes that PM_{10} measured data are representative of the mean exposure of the people. Finally, the numbers of cases for hospital admissions for respiratory diseases and hospital admissions for cardiovascular diseases were calculated. The values of relative risk and related baseline incidence were accepted from data files of the AirQ2.2.3 software. The values of RR and BI were taken from the studies by Zallaghi et al. (18) and Shahsavani et al. (7) (Table 1).

 Table 1. Relative Risk With 95% Confidence Intervals Used for Evaluation of Health Effects

Short-Term Effects	BI	RR (95% CI) per 10 μ g/m 3
Hospital admissions for respiratory diseases	436	1.0080 (1.0048 - 1.0112)
Hospital admissions for cardiovascular diseases	1260	1.0090 (1.0060 - 1.0130)

Abbreviations: BI, baseline incidence; RR, relative risk.



4. Results

The results presented in Table 2 showed that the annual average of PM₁₀ in Ilam during the study was 77.67 μ g/m³. The summer average concentration of PM₁₀ with the value of 88.57 μ g/m³ was higher than that of winter by a mean of 55.85 μ g/m³. The annual maximum concentration of PM₁₀ was higher in the summer than the winter, with the observed maximum concentration of 491 μ g/m³ in the sum-

mer.

Table 3 shows the relationship of PM₁₀ concentrations with the percentage of attributed proportion, and the number of people admitted to hospital for respiratory or cardiovascular diseases according to the relative risk (RR) and baseline incidence (BI) presented above (Table 1). Accordingly, the cumulative numbers of estimated excess cases with hospital admission due to respiratory or cardiovascular diseases were 216 and 84, respectively.

Parameters	Values, μ g/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. The Highest and Lowest Concentrations of PM₁₀ in Ilam

Table 3. The Attributable Proportion and Cumulative Number of Estimated Excess Cases

Short-Term Effect	Estimated AP, %	Cumulative Number of Excess Cases
Hospital admissions for respiratory diseases	3.0708 (5.0154 - 6.8835)	216 (132 - 296)
Hospital admissions for cardiovascular diseases	5.6072 (3.8093 - 7.9023)	84 (57 - 118)

Figure 2 indicates the results of quantification of hospitalizations and the numbers of consequences obtained from AirQ software explication versus PM₁₀ concentration interval in Ilam. Figure 2 shows charts based on the cumulative number of each health outcome and number of excess cases in three styles (5%, 50% and 95% RR). There are three curves for each chart (including lower, medium and upper). The middle curve corresponds to a RR of the central. Lower curve is in relation to a RR of 5% (underestimate) and the upper curve is associated with a 95% RR (overestimate). Also, based on Figure 2, the cumulative number of hospital admissions for respiratory and cardiovascular diseases in the central relative risk, as idle curve, was 216 and 84 persons, respectively, in Ilam. In addition, there was a steep increase in the concentrations of higher than 120 μ g/m³ related to charts of the estimated hospitalizations. Moreover, about 3.95% of hospital admissions associated with PM₁₀ happened on days with concentration levels less than 20 μ g/m³ and 81.07% of these effects occurred due to PM_{10} concentrations lower than 120 $\mu g/m^3$. More than 98% of the cumulative number of hospital admissions for respiratory and cardiovascular diseases occurred on days with PM₁₀ concentration not exceeding 200 μ g/m³ in Ilam. The highest percentage of person-days that people in Ilam were exposed to different concentrations of PM_{10} was 40 - 49 μ g/m³, which affected inhabitants of Ilam.



Figure 2. The Quantification of Hospital Admissions Versus PM₁₀ Concentration

5. Discussion

In the current study, hospital admissions due to exposure to particulate matter (PM₁₀) using the WHO method in Ilam was assessed by AirQ2.2.3 model. This software is applied in several epidemiological studies in the world to evaluate health impacts of air pollutants (25-28). Hospital admissions due to respiratory and cardiovascular diseases were estimated based on short-term exposure to PM₁₀. Based on the description of model, three ranges of relative risk including upper, central and lower were considered. The annual means of 24-hour, summer, winter and 98 percentile were 77.67, 88.57, 55.85 and 257.6 μ g/m³, respectively. The mean of PM₁₀ in Ilam was lower than that of national ambient air quality standard (NAAQS) with 24-hour average standard of 150 μ g/m³. Zallaghi et al. illustrated that the annual, summer, and winter mean concentration of PM₁₀ in Kermanshah were 89.54, 117.91 and 60.06 μ g/m³, respectively (18). Nourmoradi et al. reported that the mean concentration of annual, winter and summer of PM₁₀ in

Khorramabad in 2014 were 58.28, 102.90 and 80.59 μ g/m³, respectively (12). Higher level of PM₁₀ during summer was probably caused by high temperature and high wind speed that led to increase of atmospheric turbulent and resuspension of dust from the blowing sand particles of the Middle Eastern areas (29). The annual mean and annual maximum of PM₁₀ in Meca, Saudi Arabia, were determined 195.5 and 782.1 μ g/m³ (29), which were more than the results of the current study. One limitation of the present study was that in the assessment of the software model, similar to other studies using this method, it was assumed that a causal correlation existed between the exposure to air pollution and health condition assessment results and there was no intervening factors affecting this relationship. In a similar study in Kurdistan, Hosseini et al. showed that then number of cases admitted to the hospital for respiratory and cardiovascular diseases were 118 and 305, respectively (16), which were higher than the results of the current study. Nourmoradi et al. illustrated that the number of admitted cases in the hospitals for respiratory and cardiovascular diseases in Khorramabad were 507 and 201, respectively (12), while these measures were 216 and 84 in the present study. Mohammadi et al. reported that the number of excess cases hospitalized for cardiovascular diseases were 32 in Shiraz in a middle RR and BI of 373.6 (21). In a study in Tallinn, Estonia, the total numbers of cases admitted to hospital for respiratory and cardiovascular diseases due to exposure to PM₁₀ were 71 and 204, respectively, with the 95% confidence interval (30). In another study, a significant association was found between PM₁₀ levels and hospital admission for respiratory disease with a centerline relative risk of 1.14 (1.01 - 1.29), especially in the cool season than in the warm season (22, 31). The results of the current study showed that 38.98% of the hospitalizations occurred in PM₁₀ concentration lower than 50 μ g/m³ and 93.79% for the cases admitted to the hospital for respiratory and cardiovascular diseases in PM₁₀ level not exceeding 150 μ g/m³. Yavari et al. showed that about 13% of the health endpoints attributed to PM₁₀ occurred in concentrations lower than 20 μ g/m³ (32), whereas, in the present study, only 3.9% of the cases were hospitalized in concentrations not exceeding 20 μ g/m³. The highest rate of person-days related to different levels of PM₁₀ was observed in the concentration interval of 40 - $49\mu g/m^3$, which caused hospital admissions due to respiratory and cardiovascular diseases in Ilam. Fattore et al. showed that the highest rate of days that people in Milano were exposed to different PM₁₀ levels was in concentration levels of 40 - 49 μ g/m³. This result was also consistent with the results of present study and the study by Hosseini et al. in Kurdistan in 2013 (16).

5.1. Conclusions

The current study aimed to estimate the number of excess cases attributed to PM₁₀ in Ilam, in 2013. The results of the study were in line with those of other researches and despite the limitations, indicated that this method offers an effective and easy tool helpful in decision-making. In addition, further studies with specific RR and BI according to geographical, climatic and statistical features were required. To reduce the health impacts of the particulate matter in Ilam, necessary trainings by healthcare systems should be provided for people especially those with chronic lung and heart diseases, the elderly and children. Furthermore, the attempts should be made in the governmental scale to control the Middle Eastern dust storms (MED) sources. Other implemented actions include increasing green beltway in Iran-Iraq borderline, management of water bodies and planting some new plants in the internal sources can be effective in the decreasing dust episodes.

Acknowledgments

The authors appreciate the vice chancellery for research at Lorestan University of Medical Sciences, Khorramabad, Iran, for financial support.

References

- Goudarzi G, Geravandi S, Mohammadi MJ, Vosoughi M, Angali K, Zallaghi E, et al. Total number of deaths and respiratory mortality attributed to particulate matter (PM 10) in Ahvaz, Iran during 2009. *Int J Environ Health Engin.* 2015;4(1):33.
- Zhou M, Liu Y, Wang L, Kuang X, Xu X, Kan H. Particulate air pollution and mortality in a cohort of Chinese men. *Environ Pollut.* 2014;186:1-6. doi: 10.1016/j.envpol.2013.11.010. [PubMed: 24333659].
- Glorennec P, Monroux F. Health impact assessment of PM10 exposure in the city of Caen, France. J Toxicol Environ Health A. 2007;70(3-4):359– 64. doi: 10.1080/15287390600885039. [PubMed: 17365598].
- Omidi Y, Goudarzi G, Heidari AM, Daryanoosh SM, et al. Health impact assessment of short-term exposure to NO2 in Kermanshah, Iran using AirQ model. Environmental Health Engineering and Management Journal. 2016;3(2):91–7. doi: 10.15171/ehemj.2016.06.
- Sepahvand A, Godini H, Omidi Y, Tarrahi M, Rashidi R, Basiri H. Investigation of Fungal Bioaerosols and Particulate Matter in the Teaching-Medical Hospitals of Khorramabad City, Iran During 2015. [In Persian]. Iranian Journal of Health and Environment. 2016;9(1):115–26.
- 6. Daryanoosh SM, Goudarzi G, Khaniabadi YO, Armin H, Bassiri H, Khaniabadi FO. Effect of Exposure to PM10 on Cardiovascular Diseases Hospitalizations in Ahvaz, Khorramabad and Ilam, Iran During 2014. Iranian Journal of Health, Safety & Environment. 2016;3(1):428–33.
- Shahsavani A, Naddafi K, Jafarzade Haghighifard N, Mesdaghinia A, Yunesian M, Nabizadeh R, et al. The evaluation of PM 10, PM 2.5, and PM 1 concentrations during the Middle Eastern Dust (MED) events in Ahvaz, Iran, from April through September 2010. J Arid Environ. 2012;77:72-83.

- Pirsaheb M, Zinatizadeh A, Khosravi T, Atafar Z, Dezfulinezhad S. Natural airborne dust and heavy metals: a case study for kermanshah, Western iran (2005-2011). *Iran J Public Health.* 2014;**43**(4):460–70. [PubMed: 26005656].
- Weuve J, Puett RC, Schwartz J, Yanosky JD, Laden F, Grodstein F. Exposure to particulate air pollution and cognitive decline in older women. *Arch Intern Med.* 2012;**172**(3):219–27. doi: 10.1001/archinternmed.2011.683. [PubMed: 22332151].
- Shakour A, El-Shahat M, El-Taieb N, Hassanein M, Mohamed A. Health impacts of particulate matter in greater Cairo, Egypt. J Am Sci. 2011;7(3):840–8.
- Schwartz J, Slater D, Larson TV, Pierson WE, Koenig JQ. Particulate air pollution and hospital emergency room visits for asthma in Seattle. *Am Rev Respir Dis.* 1993;**147**(4):826–31. doi: 10.1164/ajrccm/147.4.826. [PubMed: 8466116].
- Nourmoradi H, Goudarzi G, Daryanoosh SM, Omidi-Khaniabadi F. Health Impacts of Particulate Matter in Air using AirQ Model in Khorramabad City, Iran. J Basic Res Med Sci. 2015;2(2):52–44.
- Martuzzi M, Galassi C, Forastiere F, Bertollini R. Health impact assessment of air pollution in the eight major Italian cities. WHO; 2002.
- Tominz R, Mazzoleni B, Daris F. [Estimate of potential health benefits of the reduction of air pollution with PM10 in Trieste, Italy]. *Epidemiol Prev.* 2005;29(3-4):149–55. [PubMed: 16454406].
- Schlesinger RB, Kunzli N, Hidy GM, Gotschi T, Jerrett M. The health relevance of ambient particulate matter characteristics: coherence of toxicological and epidemiological inferences. *Inhal Toxicol.* 2006;**18**(2):95–125. doi: 10.1080/08958370500306016. [PubMed: 16393926].
- Hosseini G, Maleki A, Amini H, Mohammadi S, Hassanvand MS, Giahi O, et al. Health impact assessment of particulate matter in Sanandaj, Kurdistan, Iran. J Adv Environ Health Res. 2014;2(1):54–62.
- 17. Nourmoradi H, Khaniabadi Y, Goudarzi G, Daryanoosh SM, Khoshgoftar M, Omidi F, et al. Air Quality and Health Risks Associated With Exposure to Particulate Matter: A Cross-Sectional Study in Khorramabad, Iran. *Health Scope*. 2016;**5**(2).
- Zallaghi E, Shirmardi M, Soleimani Z, Goudarzi G, Heidari-Farsani M, Al-Khamis G, et al. Assessment of health impacts attributed to PM10 exposure during 2011 in Kermanshah City, Iran. J Adv Environ Health Res. 2015;2(4):242–50.
- Gharehchahi E, Mahvi AH, Amini H, Nabizadeh R, Akhlaghi AA, Shamsipour M, et al. Health impact assessment of air pollution in Shiraz, Iran: a two-part study. J Environ Health Sci Engin. 2013;11(1):1.

- Dockery DW, Pope C3. Acute respiratory effects of particulate air pollution. Annu Rev Public Health. 1994;15:107-32. doi: 10.1146/annurev.pu.15.050194.000543. [PubMed: 8054077].
- 21. Mohammadi A, Azhdarpoor A, Shahsavani A, Tabatabaee H. Health Impacts of Exposure to PM 10 on Inhabitants of Shiraz, Iran. *Health Scope*. 2015;**4**(4).
- Chen R, Pan G, Kan H, Tan J, Song W, Wu Z, et al. Ambient air pollution and daily mortality in Anshan, China: a time-stratified case-crossover analysis. *Sci Total Environ*. 2010;**408**(24):6086–91. doi: 10.1016/j.scitotenv.2010.09.018. [PubMed: 20889186].
- Fattore E, Paiano V, Borgini A, Tittarelli A, Bertoldi M, Crosignani P, et al. Human health risk in relation to air quality in two municipalities in an industrialized area of Northern Italy. *Environ Res.* 2011;**111**(8):1321– 7. doi: 10.1016/j.envres.2011.06.012. [PubMed: 21764052].
- 24. Mohammadi MJ, Godini H, Khak MT, Daryanoosh SM, Dobaradaran S, Goudarzi G. An Association between air quality and COPD in Ahvaz, Iran. Jundishapur J Chron Dis Care. 2015;4(1).
- Dehghani M, Anushiravani A, Hashemi H, Shamsedini N. Survey on air pollution and cardiopulmonary mortality in shiraz from 2011 to 2012: an analytical-descriptive study. *Int J Prev Med.* 2014;5(6):734–40. [PubMed: 25013693].
- Jeong SJ. The impact of air pollution on human health in Suwon City. Asian J Atmospher Environ. 2013;7(4):227–33.
- Krzyzanowski M. Methods for assessing the extent of exposure and effects of air pollution. Occup Environ Med. 1997;54(3):145–51. [PubMed: 9155775].
- 28. Goudarzi G, Geravandi S, javad Mohammadi M, Ghomaishi A, Salmanzadeh S. Health endpoints caused by PM10 Exposure in Ahvaz, Iran. *Iran J Health Safety Environ*. 2014;**1**(4):159–65.
- 29. Habeebullah TM. Health impacts of PM10 using AirQ2. 2.3 model in Makkah. J Basic Appl Sci. 2013;9:259.
- Orru H, Maasikmets M, Lai T, Tamm T, Kaasik M, Kimmel V, et al. Health impacts of particulate matter in five major Estonian towns: main sources of exposure and local differences. *Air Qual Atmospher Health*. 2011;4(3-4):247–58.
- Guo Y, Tong S, Zhang Y, Barnett AG, Jia Y, Pan X. The relationship between particulate air pollution and emergency hospital visits for hypertension in Beijing, China. *Sci Total Environ*. 2010;**408**(20):4446–50. doi: 10.1016/j.scitotenv.2010.06.042. [PubMed: 20638709].
- Yavari AR, Sotoudeh A, Parivar P. Urban environmental quality and landscape structure in Arid Mountain environment. *Int J Environ Res.* 2007;1(4):325–40.