ORIGINAL PAPER

Estimating the health effects of PM_{10} on the population of Sanandaj City during 2010–2014 using AirQ model

Shadi Kohzadi[1], Ata Amini[2], Behzad Shahmoradi[1,✉], Shahab Mohammadi[3], Shivaraju H.P.[4]

1. Department of Environmental Health Engineering, Environmental Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran
2. Kurdistan Agricultural and Natural Resources Research and Education Center, AREEO, Sanandaj, Iran
3. Department of Environmental, Kurdistan Province, Sanandaj, Iran
4. Department of Water and Health, Faculty of Life Sciences, J.S.S University, Sri Shivarathreshwara Nagara, Mysore-570015, Karnataka, India

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ABSTRACT

One of the air pollutant indices includes particulate matter with aerodynamic diameter less than or equal to 10 μg/m^3 (PM_{10}). Particulate matter has extensive effects on the respiratory and cardiovascular systems. Dissemination of such particles for a longer period can lead to increased mortality and hospitalization. In this study, the data of PM_{10} pollutant were gathered from the Kurdistan Department of Environment. Furthermore, PM_{10} effects on the total mortalities, cardiovascular mortalities, respiratory mortalities, and hospitalizations caused by respiratory and cardiovascular diseases were analyzed using AirQ software. The results reported the highest mean concentration of PM_{10} in 2014. This software predicted a total death toll of 57, 60, 57, 51, and 55 cases per 100,000 people during 2010–2014, respectively. Moreover, it was estimated that 3.4, 8, 1.2, 10.8, and 11.5 percent of all deaths could be attributed to the concentrations >20 μg/m^3 of PM_{10}. Due to the lack of suitable database for recording death toll attributable to air pollutants, this software could be considered as an alternative for estimating the health effects of air pollutants.

Keywords: Air pollution; PM_{10}; cardiovascular disease; respiratory disease

Introduction

In recent years, air pollution has become a major health concern due to the substantial increase in various air pollutants.[1-3] Dust occurrences are defined as natural events with substantial particulate matter (PM) concentrations, generally occurring in arid, semiarid, or desert areas,[4] primarily resulting from low vegetation cover and strong surface winds.[5] Dust events produce large-scale or even global transport of large amounts of mineral dusts every year.[6] It was reported that the annual mean particulate matter with aerodynamic diameter <10 μm concentration was 98 μg/m^3 during the study period (2006–2010); this is almost five times higher than the World Health Organization (WHO) recommended annual level of particulate matter concentration (20 μg/m^3), above which the mortality risk is expected to increase.[7] Several previous studies have reported the association between air pollution and health outcomes.[8-12] Health effects of short-term and long-term exposure to particulate matter have attracted scientific attentions and numerous studies have been conducted in high risk areas. Meng et al. reported a relationship between the particulate matter and hospitalizations due to upper respiratory tract infection, pneumonia, hypertension, and cardiovascular diseases.[13] Due to the distinct anatomy of the pulmonary system and lungs, particles >10 μm can be excreted from airways with the help of mucosa; however, particles lesser than 10 μm can enter the terminal airways and accumulate in the pulmonary spaces for longer duration.[14] Therefore, PM_{10} particles can affect the pulmonary function, and it is well-known that the cardiac and circulatory system is closely associated with the pulmonary system. People

✉ *Behzad Shahmoradi*
bshahmorady@gmail.com

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with competent pulmonary and cardiovascular systems can generally fight air pollution; however, PM_{10} adversely affects these systems, more susceptible being patients with pulmonary and cardiac disease, old age, and children.[15]

Three core mechanisms have been recognized to foster the extrapulmonary effects on the cardiovascular system: I) release of proinflammatory and vasoactive mediators from PM-stimulated cells of the lung; II) influence on the autonomic nervous system induced by PM interactions with lung receptors; and III) direct translocation of PM, in particular ultrafine particles (0.1 μm), into the blood stream. Cardiovascular diseases associated with air pollution include myocardial infarction, stroke, heart failure, arrhythmias, and venous thromboembolism.

The adverse health effects of exposure to ambient air pollution have been studied in several researches; each assessing various complications, especially those of the respiratory and cardiovascular systems.[7, 16-18] Although both gaseous air pollutants (e.g., O_3, NO_2, SO_2) and particulate matters (PM) can instigate adverse health effects, the most compelling evidence implicates PM as an important risk factor for diseases in humans.[19] In addition, the overall evidence presently indicates that the greatest adverse effects of PM occur in the cardiovascular system, although it was once believed to pose a health risk predominantly to the lungs.[16, 20-21]

Due to the proximity of the west and southwest regions of Iran with large deserts of neighboring countries, the number of dusty days in these areas, where most dust storms occur in summer and spring, is considerable and has increased in recent years.[22] Due to its specific climate, topographical conditions, and close proximity to the dust-producing countries, Sanandaj, with a population about 450,000 has been affected by dust pollutions in recent years, in spring and summer seasons, especially from 2010 onward.[23] No classified data is available on the mortalities due to air pollution in Sanandaj and most of the mortality cases have not been studied scientifically. Therefore, the considering the application of a suitable software such as AirQ is essential. This software was introduced in 2004 by WHO and has effectively estimated the deaths attributed to air pollutants in several places such as Iran and European countries.[23-25] Therefore, the present study aimed to use AirQ software in order to estimate the health effects of PM_{10} on Sanandaj citizens.

Materials and Methods

Sanandaj, with an estimated area of 3688 ha is located in Zagros Mountains with latitude of 47° 00′ E and 35° 32′ N and has a cold and semiarid weather. Its altitude is about 1450–1538 m above sea level. Data on PM_{10} from 1 January 2010 to 1 January 2015 was obtained from the Department of Environment, Kurdistan Province, Sanandaj, Iran. There are two monitoring stations within the city; hence, the available mean data for PM_{10}, i.e. annual mean, summer mean, winter mean, 98 percentile, annual maximum, summer maximum, and winter maximum concentrations of PM_{10} were used as the input data. Data of the nonaccidental hospital admissions and total respiratory and cardiovascular diseases admissions were collected from the Sanandaj public hospitals admission and archives offices. Moreover, the data collected were analyzed using AirQ (Ver. 2.2.3) software provided by WHO. Mortality rate and hospital admissions of the cardiovascular and respiratory patients related to PM_{10} were calculated by AirQ.

Results and Discussion

Figure 1 presents the PM_{10} concentrations (μg/m^3) for used in the AirQ model in years 2010–2014. Total nonaccidental mortalities in Sanandaj in 2010 were 2185 persons.

PM_{10} related mortalities based on AirQ model were 184 persons in 2010. Therefore, based on the model, 8.4% of the total mortalities in Sanandaj were attributed to the PM_{10} concentrations >20 μg/m^3. In 2011, total nonaccidental mortalities were 9000 and 3% of the total mortalities were attributed to PM_{10} concentrations >20 μg/m^3. In this year, despite the higher mean annual concentration of PM_{10}, mortalities related to its concentration were lower and this can be caused by the continuous

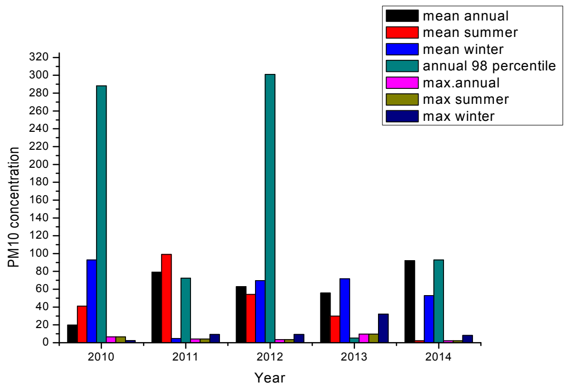

Fig. 1. PM_{10} concentrations (µg/m^3) as input in model in years 2010-2014

high levels of PM_{10} in 2010. Total nonaccidental mortalities in 2012, 2013, and 2014 in order were 2100, 2168, and 2124, respectively. Percentage of the total mortalities attributed to PM_{10} in these years was 10.2, 10.8, and 12.5%, respectively.

A similar study performed in Tehran, Iran, reported that 4% of the total mortality rate was associated with the PM_{10} concentrations >20 µg/m^3.[26] A study in China reported that the increased PM_{10} concentration was positively and significantly associated with a 1.05% increase in the adult respiratory mortality rate. This association was much more significant in the northern and colder cities, which was justified by burned coals used for heating in cold months.[1] Studies conducted in Europe and USA have reported a 10 µg/m^3 increase in PM_{10} have resulted in 1.0–2.4% increase in the hospitalizations due to respiratory diseases like chronic obstructive pulmonary disease and asthma, especially in patients aged above 65 years.[27-29]

Fig. 2 presents the health endpoints due to PM_{10} exposure and annual number of cases. In 2010, total mortality, respiratory disease death (RDD) and cardiovascular disease death (CVDD), cardiovascular disease admission (CVDA), and respiratory disease admission (RDA) related to PM_{10} were 5.9, 30.6, 29.9, and 77.5 per 100,000 cases; in 2011 were 6, 31.7, 31, and 80 per 100,000 cases; and in 2012 were 6, 30.4, 29.7, and 77 per 100,000, respectively. Total respiratory and CDA in 2012 were 862 and 486, respectively, and about 40% of the RDA and 27% of the CVDA were related to PM_{10} pollutant, according to the model. In 2013, the RDD, CVDD, CVDA, and RDA related to PM_{10} were 5.2, 27, 26, and 68 per 100,000 cases, respectively, whereas the data for 2014 were 5.6, 29, 28, and 73 per 100,000 cases, respectively; however, the hospital admission records reveal that the RDA and CVDA in 2013 were 1234 and 2247, respectively. The AirQ model estimation attributed to PM_{10} exposure was 24.7 and 5.2% for RDA and CVDA, respectively. Total RDA and CVDA in 2014 were 768 and 1423, respectively, out of which 43% of RDA and 9% of CVDA were related to PM_{10} exposure, according to the model.

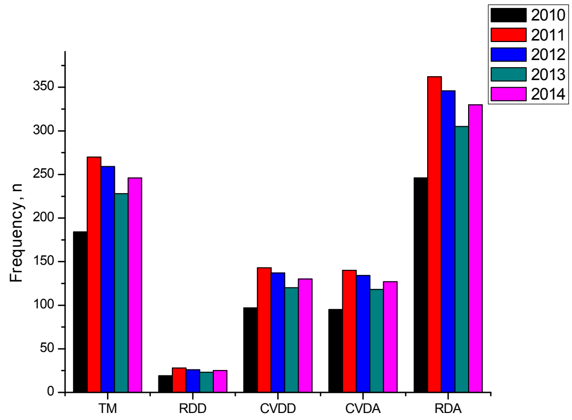

Fig. 2. Health endpoints because of PM_{10} exposure and annual number of cases (TM: Total mortality; RDD: Respiratory disease death; CVDD: Cardiovascular disease death; CVDA: Cardiovascular disease admission; RDA: Respiratory disease admission)

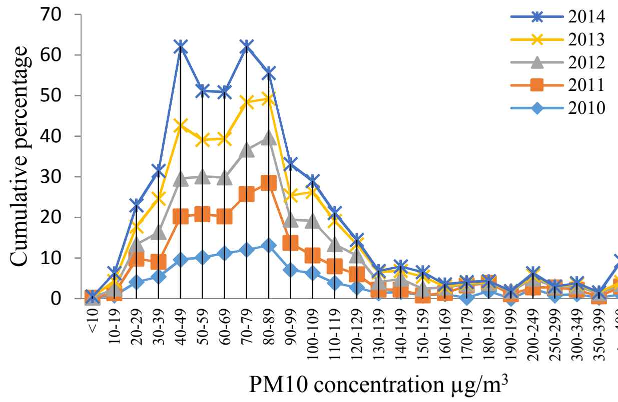

Fig. 3. Cumulative percentage of days in which people were exposed to different concentrations of PM_{10}

Fig. 3 presents the accumulative percentage of time in which people were exposed to different concentrations of PM_{10}. These data were used to estimate the short-term health effects of PM_{10} exposure. The highest percentage of person–days PM_{10} concentrations were 80–89, 80–89, 80–89, 40–49, and 40–49 $\mu g/m^3$ in 2010, 2011, 2012, 2013, and 2014 respectively, which represents the maximum exposure days to PM_{10} at these concentrations. Figure 3 depicts that in higher PM_{10} concentrations, the number of exposure days decreased, which indicates that maximum days of the year reported a low PM_{10} concentration. Figure 4 represents the accumulative percentage of cases with PM_{10} health consequences at different PM_{10} concentrations. As can be concluded, at PM_{10} concentrations of 80–89 $\mu g/m^3$, both case and person–days percentages are higher per cubic meter (Fig. 4).

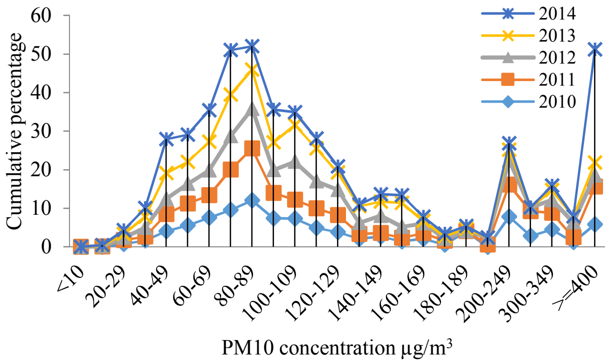

Fig. 4. Cumulative percentage of cases that are exposed to different concentrations of PM_{10}

In a study carried out in 28 European countries, it was reported that 17–30% of population was exposed to PM_{10} at concentrations above certain Europe and WHO reference concentrations (20 and 40 $\mu g/m^3$, respectively).[30] Other studies reported that short-term exposure to PM_{10} concentration above 10 $\mu g/m^3$ increased the mortality rate by 5%.[31,32]

Conclusion

The data of the PM_{10} concentration was gathered from the Kurdistan Department of Environment. Furthermore, PM_{10} effects on the total mortalities, cardiovascular mortalities, respiratory mortalities, and hospitalizations caused by respiratory and cardiovascular diseases were analyzed using the AirQ model. Percentage of the total mortalities attributed to the PM_{10} concentrations >20 $\mu g/m^3$ in 2010–2014 were 3.4, 8, 1.2, 10.8, and 11.5 respectively. PM_{10} mean annual concentration in 2011 was higher compared with other years. Therefore, accordingly the amount of mortality and hospital admissions of the cardiovascular and respiratory disease were higher. This study reported that PM_{10} concentration was associated with the increased cardiovascular diseases and to a greater extent with respiratory mortalities.

Conflict of Interests

Authors have no conflict of interests.

Limitations

1. Exact data of the cardiovascular and respiratory morbidity and mortality were not available in governmental hospitals in Sanandaj City.
2. There was just one PM_{10} recording station in Sanandaj and it was in the middle of the city.
3. Official bureaucracy for collecting data.

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