Research Paper

Assessment of Health Impacts of PM$_{2.5}$ by AirQ+ Software in the City of Sanandaj, Iran (2018-2019)

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ABSTRACT

Background: Particulate or particle mattes in term of air pollution are particles with a diameter of 2.5 μm or less (PM$_{2.5}$). PM$_{2.5}$ is a natural source of air pollution and has harmful effects on citizens in Sanandaj City, located in the west of Iran.

Methods: In this study, the hourly data of concentration of PM$_{2.5}$ were taken from the Kurdistan Environmental Protection Agency. During the study period (2018-2019), the 24-hour concentration of PM$_{2.5}$ exceeded 339 times the average level. By AirQ+ software, the relationship between data and Relative Risk (RR), Baseline Incidence (BI), and Attributable Proportion (AP) were estimated. Then chronic obstructive pulmonary disease, lung cancer, ischemic heart disease, and brain stroke in the range of over 30 years were estimated.

Results: The main target of this study was to survey the relationship between PM$_{2.5}$ concentration and the death rate of citizens of this non-industrial city. The long-term health effect (more than 6 months) of PM$_{2.5}$ caused 326 deaths on average (except for accidents and poisoning).

Conclusion: Increase the concentration of PM$_{2.5}$ is one factor that affects a high percentage of mortality rate.

1. Introduction

In developed and developing countries, a major environmental risk factor is the air pollution that affects human health [1]. Based on the World Health Organization (WHO), air pollution is one of the main sources of environmental health risk factors. The relationship between morbidity and mortality due to respiratory and cardiovascular disorders is the most significant [2, 3].
There are many air pollutants in the world. Fine particulate matter (PM_{2.5}, particles with an aerodynamic diameter less than 2.5 μm) is one of them that researchers have studied more than the other pollutants in ambient air [4]. Particulate Matter (PM) is an essential part of air pollutants and, its acute and chronic health problems, such as cardiovascular and respiratory mortality and hospitalizations, are generally mentioned as their two side effects [5].

Approximately 4.2 million deaths in long-term exposures to ambient PM_{2.5} are among the statistical estimates of this pollutant. Therefore, PM_{2.5} and health risk are the fifth-ranking mortality risk factor globally [6]. In 2013, the International Agency for Research on Cancer (IARC) categorized particulate matter in Group 1 (carcinogenic group) when present in outdoor air pollution [7]. Adverse health effects of PM_{2.5} may be different, as the main sources, regions area, and PMs' chemical characteristics are not the same [8]. Some toxicological and epidemiological studies have discovered that PM can cause oxidative stress and inflammation on the human respiratory system [9, 10].

Morbidity and mortality rates due to cardiovascular diseases and respiratory problems are strongly associated with PM_{2.5} concentration [11]. In a cohort study, cardiovascular mortality increased by 8%-18% due to 10 μg/m³ increase of PM_{2.5} concentrations. However, a weak association was found between a similar amount of PM_{2.5} and respiratory mortality [12].

In the course of PM classification, there are two well-known sources: natural (such as dust and sea salt) and anthropogenic (such as vehicles, coal burning in power plants, and industry) [13]. The components of PM are complex, from heavy metals, elemental carbon to inorganic salts. In the range of organic components, Polycyclic Aromatic Hydrocarbons (PAHs) and biological components like fungi and spores may be present in PM structure [13, 14]. In a study published in 2015, during the dust storm in Sanandaj, the observations showed that 56.2% of total bacteria were Bacillus spp. and 28.6% of total fungi was Mycosporium spp [15].

Dust storms occur in Iran seasonally [16]. They usually happen in the summer, when two powerful main winds (Shamal and Levar) blow [17]. In the other seasons of the year, such as winter, they may occur as well [18]. Iran has two main natural sources of dust, inside and outside. Sahara, Iraqi and Syrian deserts, and Mesopotamia are three main regions located outside of Iran [19]. The Dasht-e Kavir, the Dasht-e Lut, the Jazmurian desert, the Dasht-e Kavir, and the Makran coast are inside main regional sources to generate dust particle matters [20]. Also, 15%-20% of the total global dust emissions are related to Middle Eastern Dust Storms (MEDS) or Arabic Dust Storm (ADS). The Arabian Peninsula, Iraqi plains, and southeast Iran are their origin [21].

Based on WHO guidelines, the average concentration of PM_{2.5} is 38.02 μg/m³ in 24 hours, and the Iranian standard is 10 μg/m³ annual concentration [22, 23]. United States Environmental Protection Agency (USEPA) recommended PM_{10} average concentration of 35 μg/m³ for 24 hours [24].

Previous versions of the World Health Organization’s (WHO’s) was AirQ 2.2.3 tool that has been published to estimate the health effects of air pollution and health impact assessment [25]. The main sources used in these two software versions are based on concentration-response functions and methodology to estimate pollutants’ effect on human beings [26]. Based on this or the last version of the software, several studies in Iran have estimated the side health effects of PM_{10} [27]. For example, in 2018, the increased hospital admission in Sanandaj was reported because of the short-term effects of PM_{10} [28]. It must be mentioned that a few studies have considered the health effects of PM_{2.5}, as a pollutant in Iran [29]. Determination strategies and plans of air pollution control devices, economic costs of deaths, hospitalizations, and other air pollution plans can help to make any decision for overcoming and control of air pollution in Iran and other countries [30].

This study aimed to estimate all mortality causes, including Chronic Obstructive Pulmonary Disease (COPD), Ischemic Heart Disease (IHD), Lung Cancer (LC), Brain Stroke (BS), and other deaths due to exposure to PM_{2.5} in Sanandaj City from January 2018 to December 2019 using AirQ+ software.

2. Materials and Methods

Type of study

This research was a descriptive-analytic study (interpretation of historical data to understand better changes that have occurred) by using AirQ+ software. The software was used to evaluate the long-term mortality rate over the age of 25 and 30 years attributed to the concentration of PM_{2.5} in Sanandaj City. As all the data were analyzed and collected daily, the study’s duration and data collection was two years, from 2018 to 2019.
Location of study and PM$_{2.5}$ data collection

Sanandaj (the capital of Kurdistan Province) is located on the border of Iraq in the west of Iran with approximately 63688 km$^2$ area and an altitude of 1500 m above sea level. Its population was 414069 people, according to the report of the Statistical Center of Iran Inhabitants in 2018. There is one station for air pollution analyses in this city. So, all the data about air pollution were taken from this station located approximately in the center of Sanandaj. Figure 1 is the map of Sandandaj.

Data collection

The hourly data of PM$_{2.5}$ concentration were taken from the Kurdistan Environmental Protection Agency (KEPA). The Beta attenuation method was used to detect the concentration of PM$_{2.5}$ from January 1, 2018, to December 31, 2019. The number of days that concentration of PM$_{2.5}$ and other pollutants, such as Co, SO$_2$, PM$_{10}$, O$_3$, and NO$_2$, were more than AQI>100 (Air Quality Index) are presented in Table 1.

Table 2 shows the number of days in each month when the index of PM$_{2.5}$ raised more than AQI. It must be mentioned that dust particles come from the ADS to Iran in all months of years, especially in warm seasons such as spring and summer.

AirQ+ software

AirQ+ software was presented by the WHO of Europe Branch (2016) to qualitatively analyzes data on air pollution. By using this software, long-term (>6 months) and short-term (≤6 months) effects of pollutants (PM10, PM$_{2.5}$, O$_3$, and NO$_2$) on human beings are calculated. Table 3 shows the health effects of each pollutant measured by AirQ+ [31].

Population data and estimated diseases and death

Whole data about mortality, COPD, IHD, LC, and BS were taken from the Kurdistan Center of Diseases Control (KCDC) between January 2018 and December 2019. This center collected data online and daily as death certificates must be approved by physicians present in health care centers, hospitals, and emergency centers. In this way, missing data in this part of the study were limited strictly. Data on population rate were collected from the Population and Family Center of Kurdistan University of Medical Sciences. The population data were separated into two groups, 30-60 and over 60 years old. It must be mentioned that the background concentration had no health effect [32].

To simulate the short- and long-term health effects of air pollutants, like the previous version of AirQ2.2.3 software, AirQ+ employs epidemiological data, including Relative Risk (RR) values, Attributed Proportion (AP), and Baseline Incidence rate (BI) together with in-situ air pollution data (from monitoring station or modeling) of an exposed population data [33].

Simple definition of Relative Risk (RR) or rate ratio made it to used widely as a measure of association [32] and measured the probability of developing a disease relative to exposure (Equation 1):

\[ RR = \exp \left( \beta (X - X_0) \right) \]

where $\beta$ is a factor that regulates the rate of RR increment, $X$ ($\mu g/m^3$) is the estimated PM concentration, and $X_0$ ($\mu g/m^3$) is the reference level concerning of PM (0 $\mu g/m^3$) [34].

The long-term exposure to PM$_{2.5}$ and quantification of mortality due to adult COPD and IHD in the AirQ+ software is based on integrated exposure-response functions from European cohort studies (Equation 2) [31].

\[ \text{if } z \geq z_{cf}, \text{ then } RR(z) = 1 + \alpha \left[ 1 - \exp \left( -\gamma (z - z_{cf}) \delta \right) \right] \]

\[ \text{if } z < z_{cf}, \text{ then } RR(z) = 1 \]

where $z$ is the annual PM$_{2.5}$ concentration ($\mu g/m^3$), and $z_{cf}$ is the trumped-up PM$_{2.5}$ concentration, below which there is no risk. The coefficients $\alpha$, $\gamma$, and $\delta$ are pre-integrated AirQ+ factors [32]. The Attributed Proportion (AP) is the fraction of health endpoint in a population whose exposure to air pollutants [35]. Using the RR values for a specific health endpoint and PM$_{2.5}$ «c,» the AP is calculated. P(c) is the fraction of the population exposed to PM$_{2.5}$ (Equation 3):

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

The rate of health outcome attributable to PM$_{2.5}$ exposure (IE) is calculated as (Equation 4):

\[ IE = BI \times AP \]

IE is the rate of the health impact attributable risk to the PM$_{2.5}$ exposure, and BI is the baseline incidence which is calculated per 100000 inhabitants [32].
Remove the confounding variables

Missing data were omitted and considered confounding data. As the zero data were recorded by pollution measuring devices, failure to declare a pollutant concentration does not mean the absence of a pollutant, but the values in the range were not measured by the device.

3. Results and Discussion

In each city or region, the necessary information for the data analysis is the sources of PM$_{2.5}$. In all cities, traffic or transportation systems will be an essential source of emission of pollutants, but, in each city, local emission of PM$_{2.5}$ is different from other cities due to dust storms or industrial activities. In recent years, some of the cities located in the western and southern of Iran, such as Sanandaj and Ilam in the west, and Ahvaz in the southwest, have been exposed to MEDS. An increase in the high death rate in these cities is attributable to PM emission or MEDS phenomenon [36].

AirQ+ is a software tool for quantifying the impact of air pollution, the attributable proportion of items, the number of attributable items singly and per 100000 at-risk populations, the fraction of cases in the range of pollutant concentration, and air pollutant concentration in the discussion of cumulative distribution. Due to the assessment’s objectives, different estimates in various ways can be used [37].

Table 1. The number of days that concentration of pollutants was more than AQI>100 (Air Quality Index)

<table>
<thead>
<tr>
<th>Month</th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>CO</th>
<th>SO$_2$</th>
<th>O$_3$</th>
<th>NO$_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>59</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>75</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>121</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>September</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>December</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total year</td>
<td>353</td>
<td>16</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
As mentioned before, the last version of AirQ+ was Air2.2.3 software. This software calculates PM$_{10}$ instead of PM$_{2.5}$. The estimated relationship between PM$_{10}$ and its short-term health effects using Air2.2.3 software showed 375 deaths (4.13% of total death) in Sanandaj citizens in 2015. Also, the percentage of respiratory mortality (0.2%), hospital admission respiratory (4.45%), cardiovascular mortality (4.45%), and hospital admission cardiovascular (4.98%) were estimated by AirQ 2.2.3 [38]. Table 4 presents the Baseline Incidence (BI) for these groups estimated for total mortality, COPD, LC, IHD, and BS. Based on the data from Table 1, PM$_{2.5}$ is the main source (95.14% of all six pollutants) of air pollution in Sanandaj.

PM$_{2.5}$ raised 353 times more than the standard of the Air Quality Index. On the other hand, the concentration of PM$_{10}$ in March and December had the highest and lowest level, respectively. NO$_2$, O$_3$, and CO are pollutants whose concentration in the ambient air of Sanandaj did not make a problem as major pollutants in the list of Air Quality Index. Thus, there is no day that the concentration of them increases above the index.

### Table 2. PM$_{2.5}$ (μg/m$^3$) concentration raised more than AQI (Air Quality Index) in each day of the months

<table>
<thead>
<tr>
<th>Months</th>
<th>Good AQI (0-50)</th>
<th>Average AQI (50-100)</th>
<th>Unhealthy for sensitive persons AQI (101-150)</th>
<th>Unhealthy AQI (151-200)</th>
<th>Very unhealthy AQI (201-300)</th>
<th>Dangerous AQI (301-500)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>10</td>
<td>16</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>February</td>
<td>7</td>
<td>18</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>March</td>
<td>6</td>
<td>13</td>
<td>7</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>April</td>
<td>12</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>0</td>
<td>19</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>1</td>
<td>22</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>0</td>
<td>23</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>August</td>
<td>0</td>
<td>17</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>September</td>
<td>0</td>
<td>14</td>
<td>17</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>October</td>
<td>2</td>
<td>11</td>
<td>16</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>November</td>
<td>0</td>
<td>11</td>
<td>16</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>December</td>
<td>9</td>
<td>20</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>198</td>
<td>109</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 3. Health effects of each pollutant measured by AirQ+

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>PM$_{2.5}$</th>
<th>PM$_{10}$</th>
<th>NO$_2$</th>
<th>O$_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health effects</td>
<td>Mortality in adults (over 30 years old)</td>
<td>Chronic bronchitis in adults</td>
<td>Mortality due to all cases</td>
<td>Mortality due to respiratory system diseases</td>
</tr>
<tr>
<td></td>
<td>Mortality due to COPD in adults (over 30 years old)</td>
<td>Bronchitis in infant</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mortality due to lung cancer in adults (over 30 years old)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mortality due to IHD in adults (over 25 years old)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mortality due to brain stroke (over 25 years old)</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
According to the air quality standards, the concentration of PM$_{2.5}$ is 15 μg/m$^3$ for the annual average and 35 μg/m$^3$ for the daily average (the WHO guideline and European Union guideline). The annual average of PM$_{2.5}$ in this study was 5.79 times more than the standard, and the average daily concentration was 356 times more than the standard.

### Long-term exposure to PM$_{2.5}$ and health effects

The results of our study are illustrated in four categories as follows:

**1- The estimated mortality rate related to PM$_{2.5}$ concentration**

The association of long-term exposure to PM$_{2.5}$ and its side effects and mortality is an interesting subject that many researchers have studied [38]. PM$_{2.5}$ is one of the main ambient air pollutants that can increase mortality and morbidity risks, as a report of the Committee on the Medical Effects of Air Pollutants mentioned in 2018 [28]. Figure 2 displays the estimated relationships of low, average, and high range of PM$_{2.5}$ to mortality and four main diseases.

Apparently, PM$_{2.5}$ could increase mortality, COPD, LC, IHD, and BS. In this category, the portion of IHD is the most (66.6), and COPD is the lowest (25.3) on average. In Figure 3, the estimated attributable cases of mortality and four main diseases have been shown. As shown in Figure 3, an increase in the concentration of PM$_{2.5}$ is the main source of the increased rate of mortality. Total mortality (without accidents and poisoning) that happened in Sanandaj in 2018, according to KCDC reports, were 240.29 cases per 100000 deaths on average (Figure 4). The results of data analyses of AirQ+ software to estimate the number of death cases related to PM$_{2.5}$ was 520 cases as an average level.

Based on the results of another article (the relationship between PM$_{10}$ and mortality rate by using AirQ2.2.3 software in Sanandaj during 2015) which was produced by the authors of this article, the estimated cases is 375 per 100000 deaths [39]. Therefore, the rate of mortality based on PM$_{2.5}$ is more than PM$_{10}$. Of course, it must be

### Abbreviations

LC, Lung Cancer; IHD, Ischemic Heart Disease; BS, Brain Stroke; COPD, Chronic Obstructive Pulmonary Disease.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rate of the Population Between 30-60 Years</th>
<th>Rate of the Population over 60 Years</th>
<th>Number of Death Between 30-60 Years</th>
<th>Number of Death over 60 Years</th>
<th>Baseline Incidence (BI) in 100000 Persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total mortality</td>
<td>326</td>
<td>1078</td>
<td>649</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality due to LC</td>
<td>10</td>
<td>25</td>
<td>16.176</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality due to COPD</td>
<td>179433</td>
<td>36902</td>
<td>2</td>
<td>36</td>
<td>18.95</td>
</tr>
<tr>
<td>Mortality due to IHD</td>
<td>2</td>
<td>39</td>
<td>18.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality due to BS</td>
<td>2</td>
<td>14</td>
<td>6.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Estimated attributable proportion of PM$_{2.5}$ to mortality and diseases

LC, Lung Cancer; IHD, Ischemic Heart Disease; BS, Brain Stroke; COPD, Chronic Obstructive Pulmonary Disease.
Acknowledged that some part of PM<sub>10</sub> is PM<sub>2.5</sub>. On the other hand, an essential reason for the greater impact of smaller particles on the lungs and other side effects is the possibility of their easier and deeper entry into the lungs compared to larger particles.

**The estimate of the COPD incidence related to PM<sub>2.5</sub> concentration**

COPD is a group of conditions that affect the lungs’ structures in many ways; the most important of these effects are emphysema, asthma, and chronic bronchitis [40]. In a long-term follow-up prospective cohort study by Cui Guo et al. performed in Taiwan, it was found that increased incidence of COPD and lower lung function is associated with an increase in ambient PM<sub>2.5</sub> [41].

By increasing 10 μg/m<sup>3</sup> of PM<sub>1.5</sub>, 2.5% (95% CI, 1.5%–3.5%) increase in COPD mortality and 3.1% (95% CI, 1.6%–4.6%) increase in COPD hospitalizations was observed [42]. Also, a case-crossover study in Shanghai was shown that a 10 μg/m<sup>3</sup> increase in PM<sub>10</sub>, SO<sub>2</sub>, and NO<sub>2</sub> could increase COPD mortality by 0.6%, 3.3%, and 4.2%, respectively [43]. In our study, the estimated attributable average cases of COPD were 10. Low and high levels of COPD were 6 and 14, respectively.

**The estimate of the lung cancer incidence related to PM<sub>2.5</sub> concentration**

A statistically significant positive correlation was seen between LC mortality and PM<sub>2.5</sub> concentration [44]. Long-term (between 3 and 4 years) exposure to PM<sub>2.5</sub> can increase the rate of LC fatalities estimated by the WHO reported in a range from 531036 to 532004, but the prevalence of this disease estimated by the American Cancer Society (ACS) was reported as 614860 cases [45]. It must be admitted that PM<sub>2.5</sub> from vehicle emissions is one of the main sources of increasing the LC risk rate significantly [46]. Besides, the risk of LC in males is more than...
in females, according to the mortality and incidence. One of the reasons for these differences is more exposure of men to tobacco smoke [47]. In this study, 5.17 LC cases in 100000 populations were calculated totally.

**The estimate of the IHD incidence related to PM\textsubscript{2.5} concentration**

An increase in IHD rate, in the range of 1.7% (95% CI, 1.5%-1.9%) is related to PM\textsubscript{2.5} and 2.0% (95% CI, 1.7%-2.3%) because PM\textsubscript{10} has the strongest effect of this pollutant on IHD daily rate [48]. Based on epidemiological studies, there is a statistical relationship between IHD and PM concentrations. In other words, long-term exposure to PM\textsubscript{2.5} increases IHD mortality (Hazard Ratios or HRs=1.36; 95% Confidence Intervals or CIs = 1.28-1.44) per 10 μg/m\textsuperscript{3} [49].

One of the risk factors for cardiovascular disease is air pollution, and the size of fine particulate has main effects [50]. Few new studies have focused on the function of particulate matter on men. Based on these research studies, autophagy, necrosis, apoptosis, pyroptosis, and ferroptosis are the most well-known side effects of PM\textsubscript{2.5} [51]. In our study, the average number of IHD was 27.92 cases. After the number of deaths, particles’ effect on IHD was greater than the other diseases, such as COPD, LC, and BS. In this paper, the average number of IHD was 27.92 cases, as shown in Figure 4.

**The estimate of the BS incidence related to PM\textsubscript{2.5} concentration**

Cerebrovascular events and short-term exposure to PM have a relationship. PM size fraction (PM\textsubscript{2.5}, PM\textsubscript{10}, PM\textsubscript{2.5-10}) and their effects on cerebrovascular diseases in meta-analyses have been evaluated. The evidence of this study showed an association between PM size and mortality and hospital admission [52]. About 10 μg/m\textsuperscript{3} increase of PM\textsubscript{2.5} is associated with 1.130 rise of risk ratio in stroke incidence [53]. The main mechanism of the PM\textsubscript{2.5} effect on causing a stroke is not clear; inflammation and thrombosis are proposed for this relationship [54, 55]. BS has the lower level of the leading group of diseases classified as PM\textsubscript{2.5} in this AirQ+ software (Figure 4).

**4. Conclusion**

In natural pollutants, PM\textsubscript{2.5} has primary side effects on human respiratory and cardiovascular systems. In this study, the estimated relationship between PM\textsubscript{2.5} as the main natural pollutant and four main diseases and mortality rate using software was considered for a long time. AirQ+ software model has an opportunity to evaluate the health impact assessment of ambient PM\textsubscript{2.5} on human health. Natural sources of PM\textsubscript{2.5} are a major environmental pollutant in the city of Sanandaj.

There is a statistical relationship between PM\textsubscript{2.5}, heart, and lung diseases. Thus, an increase in PM\textsubscript{2.5} concentration could increase the rate of mortality, COPD, LC, IHD, and BS estimated with the AirQ+ software.

**Ethical Considerations**

**Compliance with ethical guidelines**

Institutional Review Board and Ethics Committee of Kurdistan University of Medical Sciences (Ethics Code: IR.MUK.REC.1399.207) approved the study.

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**Authors’ contributions**

All authors equally contributed to preparing this article.

**Conflict of interest**

The authors declared no conflict of interest.

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