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# QUANTIFICATION OF HEALTH EFFECTS OF EXPOSURE TO AIR POLLUTION ($PM_{10}$) IN TABRIZ, IRAN

**GHOZIKALI M.G.**[1,2]
**BORGINI A.**[3]
**TITTARELLI A.**[3]
**AMRANE A.**[4]
**MOHAMMADYAN M.**[5]
**HEIBATI B.**[5,*]
**YETILMEZSOY K.**[6]

[1]*Tabriz Health Services Management Research Center*
*Department of Environmental Health Engineering*
*East Azerbaijan Province Health Center*
*Tabriz University of Medical Sciences, Tabriz, Iran*
[2]*Department of Environmental Health Engineering*
*School of Public Health and Center for Air Pollution Research (CAPR)*
*Institute for Environmental Research (IER)*
*Tehran University of Medical Sciences, Tehran, Iran*
[3]*Fondazione IRCCS Istituto Nazionale dei Tumori*
*Environmental Epidemiology and Cancer Registry Unit, Via Venezian 1, Milan, Italy*
[4]*Ecole Nationale Supérieure de Chimie de Rennes*
*Université de Rennes 1, CNRS, UMR 6226, Rennes, France*
[5]*Health Sciences Research Center, Student Research Committee*
*Mazandaran University of Medical Sciences, Sari, Iran*
[6]*Department of Environmental Engineering, Faculty of Civil Engineering*
*Yildiz Technical University, 34220, Davutpasa, Esenler, Istanbul, Turkey*

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*to whom all correspondence should be addressed:
e-mail: b.heibati@gmail.com

**ABSTRACT**

Epidemiological studies show that long-term exposure to PM is associated with an increased risk of cancer or cardiovascular and respiratory diseases. The main objective of the present study was the assessment of health outcomes related to $PM_{10}$ (particulate matter (PM) of aerodynamic diameter ≤ 10 µm) exposure in Tabriz, Iran. Related health impacts (relative risk and baselineincidence) due to exposure to $PM_{10}$ in the city of Tabriz were assessed by using the well-established AirQ2.2.3 model by the World Health Organization European Center for Environment Health. We estimated that out of 15,651 total deaths in the city, 7679 and 1020 people died due to cardiovascular and respiratory related deaths respectively. Among the 19,467 people admitted to hospital due to respiratory disease, 1114 diseases could be attributed to $PM_{10}$. According to this model, cases of natural mortality, cardiovascular deaths and respiratory mortality caused by $PM_{10}$ were about 832, 439, and 85, respectively.

**Keywords:** AirQ2.2.3 Model; Hospital Admissions; Mortality; $PM_{10}$; Respiratory Disease

## 1. Introduction

Multiple studies in recent years have shown that exposure to air pollution is associated with various human health adverse outcomes (Boldo *et al.*, 2006; Downs *et al.*, 2007; Tominz *et al.*, 2004), such as cancer or cardiovascular and respiratory diseases. Epidemiological studies for more than a decade in Europe and around the world, show increasing mortality and morbidity and diseases related to air pollution (Han and Naeher, 2006; Mao *et al.*,2005). Today, modern industries are the main cause of the release of gases and particles contributing to high levels to air pollution (Riga-Karandinos and Saitanis, 2005). Annually, an estimated million people lose their lives due to respiratory diseases and other diseases caused by exposure to air pollution in urban areas (Defense, 1996; Laden *et al.*,2006). The impact of health problems related to air pollution in terms of costs are not often taken into account, namely costs impact on health care, absence from work and job loss, such as most cases of permanent disability and death (Defense, 1996; Laden *et al.*, 2006). Some studies have shown that $PM_{10}$ concentration levels above 20 µg $m^{-3}$ have a significant impact on mortality (Jerrett *et al.*, 2005a; Jerrett *et al.*, 2005b). Therefore, the European governments, World Health Organization (WHO) and other groups and associations have been using corresponding data try to propose framing policies and environmental policies. This include for example, quantitative estimates of the effects of air pollution on public health (Jerrett *et al.*, 2005; Kim *et al.*, 2004; Naddafi *et al.*, 2012; Nafstad *et al.*, 2004). Air pollutants are not only gaseous compounds, since there is a large number of chemicals and particles suspended in air. Suspended particles present in the atmosphere are considered as one of the most serious environmental matter in developing countries.

Total suspended particles (TSP) released by various sources include $PM_{10}$, $PM_{2.5}$, $PM_{0.1}$, metal combinations, inorganic compounds, pollen grains, microorganisms, and particles of soot caused by industrial processes. According to some reports, for every increase of 10 µg $m^{-3}$ particles suspended in air, the mortality rate increases from 1 to 3% (Finkelstein *et al.*, 2004; Hoek *et al.*, 2001; Kappos *et al.*, 2004; Katsouyanni *et al.*, 2001; Tertre *et al.*, 2002). $PM_{10}$ is the most commonly measured and available pollutant across air quality monitoring stations around the world. $PM_{10}$ is commonly used in many epidemiological studies reported worldwide. Quantification of the effects of air pollution on public health can provide important information for public health officials and decision makers (Gauderman *et al.*, 2007; Kappos *et al.*, 2004; Levy*et al.*, 2000; Miller *et al.*, 2007).

Tabriz with a population of over one and half a million people, is one of most populated city in Iran such as Tehran, Mashhad, and Isfahan. It is also a major Iranian heavy industrial and manufacturing center. Due to the emergence of vehicular traffic, and modern industries such as the thermal power plant, petrochemical complex, and the oil refinery in the west of the city, air pollution levels have increased continuously, since the second half of the twentieth century (Badescu and Cathcart, 2011). An immediate environmental disaster is looming on Tabriz due to the rapid shrinkage of Uremia Lake. The lake has been facing a grave crisis since the late twentieth century. Reduction of water depth, increasing water salinity to saturation level, and appearance of huge salt fields around the lake is alarming indications of gradual total desiccation of the unique ecosystem, which has occurred due to global warming and ever increasing demand for the fresh water sources in the basin. It is feared that in the foreseeable future low-lying clouds of airborne salt and minerals will hover over large areas around the lake including Tabriz and pose serious health hazards (Badescu and Cathcart, 2011).

The main objective of the present study was the assessment of health outcomes due to $PM_{10}$ in Tabriz air. Though the approach used is theoretical and provides an estimation of the real risk for the population observed, its easiness of application and the use of risks derived from important epidemiological studies (particularly, very large cohorts in United States) could give quick, useful and suitable assessment on health effects due to air pollution exposure also in regions where no traditional epidemiological studies were conducted since nowadays.

## 2. Materials and methods

### *2.1. Study area*

This study was conducted in Tabriz, a city of 1,545,491 residents (Figure 1). Tabriz is located in northwest of Iran in the East Azerbaijan province between the Eynali and Sahand mountains in a fertile area on the shore of the Aji and Ghuri Rivers (Badescu and Cathcart, 2011). Tabriz has a semi-arid climate with regular seasons. The annual precipitation is around 380 millimeters (15 in), a good deal of which falls as snow during the winter months and rain in spring and autumn. The average annual temperature is about 12 °C. There are hundreds of industrial complexes in the Tabriz industrial area. Modern industries in this city include the manufacturing of machinery, vehicles, chemicals and petrochemical materials, refinery, cement, electrical and electronic equipment, home appliances, textiles and leather, nutrition and dairy factories and woodcraft (Badescu and Cathcart, 2011).

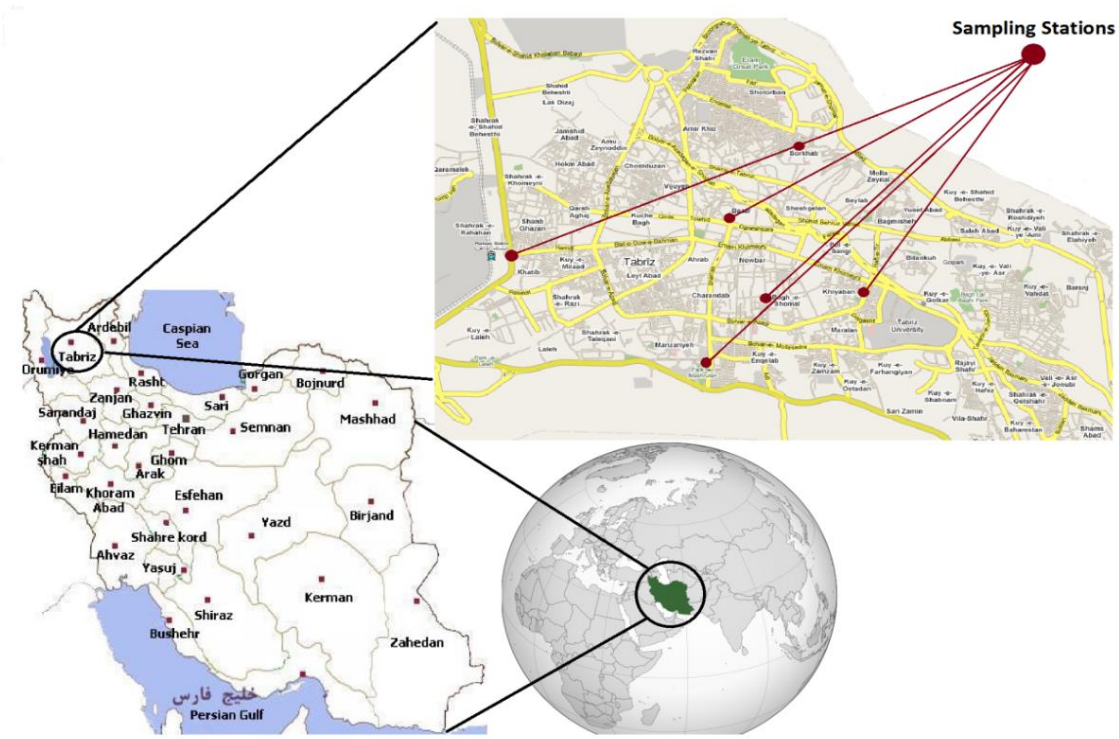


**Figure 1.** Map of the study area and locations of monitoring stations

### *2.2. AirQ 2.2.3 software*

We conducted a cross-sectional study, in which we used the AirQ software Ver.2.2.3 developed by the WHO European Centre for Environment Health, Bilthoven Division (WHO, 2015). This model was used to estimate the impacts of exposure to specific ambient air pollutants ($PM_{10}$ effects in this study) on the health of people living in a certain period and area. Several researchers have shown that this software can be used to estimate the impact of exposure to atmospheric pollutants on health outcomes (Fattore *et al.*, 2011; Naddafi *et al.*, 2012). The AirQ2.2.3 software consists of two quantification modulus and lifetime tables. This program is used to estimate the effect of exposure to specific atmospheric pollutants on the health of people living in a given period and area. In this study, the mortality and morbidity rates (health end point) associated with the $PM_{10}$ concentrations were estimated by this model.In other words,daily concentrations of particulate matter of aerodynamic diameter ≤ 10 μm ($PM_{10}$) were used to assess human exposure and health effects in terms of attributable proportion of the health outcome, annual number of excess cases of mortality for all causes, and cardiovascular and respiratory diseases. Quantification of the health impact (selected outcome) for the exposure to the air pollutant is based on the population attributable risk proportion concept.

*2.3. Statistical analysis*

In statistics and epidemiology, RR (relative risk) is the ratio of the probability of an event occurring in an exposed group to the probability of the event occurring in a comparison, non-exposed group. A RR of 1 means there is no difference in risk between the two groups. An RR of < 1 means the event is less likely to occur in the experimental group than in the control group and an RR of > 1 means the event is more likely to occur in the experimental group than in the control group (Sistrom *et al.*, 2004). AR (attributable risk) is the amount of disease that can be attributed to a certain exposure. In epidemiology, attributable risk is the difference in rate of a condition between an exposed population and an unexposed population (Benichou, 2001).

For the present case, we implementedquantification modulus, andused amounts of the attributable proportion (AP), the relative risk (RR), and the based incidence (BI) for each health consequences according to the defaults reported by WHO (2015). These default values were utilized in order to calculate/estimate the attributable proportion of the health outcome and the estimated number of excess cases using the AirQ2.2.3 software.

The epidemiological indices considered in this work were explored based on three index estimates for each health outcome; lower, central and upper. Lower, central and upper index estimate showed number of each health endpoint (number of cases) in three modes in 5, 50, and 95% RR, respectively. In other words, upper index estimate illustrate number of cases in 95% RR (overestimate), lower index estimate showing number of cases in 5% RR (underestimate) and central index estimate corresponds to the central RR.

In this study, the following values of RR were considered for the present health endpoints (given in the respective order of the index estimates: lower, central, upper): (a) RR for the total mortality = 1.0062, 1.0074, 1.0086, (b) RR for the cardiovascular mortality = 1.005, 1.008, 1.018, (c) RR for the respiratory mortality = 1.0080, 1.0120, 1.0370, (d) RR for the hospital admissions (HA) cardiovascular disease = 1.0060, 1.0090, 1.0130, and (e) RR for the HA respiratory disease = 1.0048, 1.0080, 1.0112. Moreover, for these health endpoints, the default values of BI were as follows: (a) BI for the total mortality = 1013 per $10^5$ people, (b) BI for the cardiovascular mortality = 497 per $10^5$ people, (c) BI for the respiratory mortality = 66 per $10^5$ people, (d) BI for the HA cardiovascular disease = 436 per $10^5$ people, and (e) BI for the HA respiratory disease = 1260 per $10^5$ people.

The assessment is set up on attributable proportion (AP), defined as the fraction of the health outcome in a certain population attributable to certain atmospheric pollutant's exposure, assuming a proven causal relation between exposure and health outcome and no major confounding effects in that association. The AP can be easily calculated by the following general formula (Fattore *et al.*, 2011):

$$\mathrm{AP} = \frac{\sum[(\mathrm{RR(c)} - 1) \times \mathrm{p(c)}]}{\sum[\mathrm{RR(c)} \times \mathrm{p(c)}]} \tag{1}$$

where AP is the attributable proportion of the health outcome, RR is the relative risk for a given health outcome, in category “c” of exposure, obtained from the exposure–response functions derived from epidemiological studies and p(c) is the proportion of the population in category “c” of exposure. In this study, demographic data of the total population stratified by age was obtained from Statistical Centre of Iran (SCI) and AP is calculated for every 100,000 people based on the statistical model and out of the defined state attributed to PM exposure. If the baseline frequency of the health outcome in the population under investigation is known, the rate attributable to the exposure can be calculated as

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

where IE is the rate of the health outcome attributable to the exposure and I is the baseline frequency of the health outcome in the population under investigation. Finally, knowing the size of the population, the number of cases attributable to the exposure can be estimated as follows (Fattore *et al.*, 2011):

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

where NE is the number of cases attributed to the exposure, and N is the size of the population investigated. RR gives the increase in the probability of the adverse effect associated with a given change in the exposure levels, and comes from time-series studies where day-to-day changes in air pollutants over long periods were related to daily mortality, HA, and other public health indicators.

*2.4. Exposure assessment*

$PM_{10}$ concentrations in Tabriz were measured by the Eastern Azerbaijan's Department of Environment (EA-DoE), using fix stations in six areas during 365 days in 2011. Hourly $PM_{10}$ data obtained from EA-DoE and 24-hour means were calculated using Microsoft Excel®. We performed all data processing including coding, averaging, and filtering as commonly done in previous published studies (Ghanbari *et al.*, 2014; Ghanbari *et al.*, 2015). The EA-DoE network included six monitored stations (Figure 1): (1) Abrasan (residential-commercial area in the eastern of the city), (2) Baqshomal (residential-commercial area in the city center), (3) Health center (residential area in the northern of the city), (4) Hakim Nezami (residential area in the southern of the city), (5) Rah Ahan (commercial industrial area in the western of the city), and (6) Raste Kouche (commercial area in the city center). The parameters (annual and seasonal average, maximum and annual 98th percentiles) required for the use of the AirQ2.2.3 model were obtained, and concentrations were divided into 10 μg $m^{-3}$ categories, and the corresponding to equivalent exposure categories. $PM_{10}$ data were expressed as daily average concentrations. The AirQ2.2.3 model assumes that concentrations measured are representative of the average exposure of the people (Ghanbari *et al.,* 2015).

## 3. Results and Discussion

According to the latest census report by Statistical Centre of Iran (SCI) in 2010, the population in Tabriz city is 1,545,491 people (Ghanbari *et al.*, 2014).In addition, the air pollution in Tabriz is mostly under the influence of atmospheric thermal inversion in cold season and moreover recently the Middle East dust storm (originating from Iran) in the warm season exacerbated the air pollution in this area (Sanobari *et al.*,2007).

In Tabriz city during 2011, 15,651 people have lost their lives due to natural death (all causes without accidents), of whom 7679 died of cardiovascular causes (ICD-9 Code 410-436) and 1020 people died of respiratory causes (ICD-9 Code 460-519). Also 19,467 people were admitted to hospitals due to respiratory disease(hospital admissions for respiratory diseases), including 1114 diseases which can be attributed to $PM_{10}$.

We estimated through the use of the AirQ2.2.3 model that natural mortality, cardiovascular and respiratory mortality due to $PM_{10}$ accounted for 832, 439 and 85 deaths respectively, in central RR and AP. In other words, 1356 Tabriz citizens have lost their lives due to exposure to $PM_{10}$ in 2011. Approximately, 55% of cases occurred during days showing $PM_{10}$ concentration lower than 100 μg $m^{-3}$. Maximum exposure to $PM_{10}$ was in the range 60-70 μg $m^{-3}$observed during 53 days during the considered year of monitoring. Table 1 presented the highest and lowest concentrations of $PM_{10}$ (μg $m^{-3}$) and average of all sampling sites (Tabriz city). The annual average, summer average, winter average and 98 percentile of $PM_{10}$ concentrations are collected in Table 1.

**Table 1.** Highest and lowest concentrations of $PM_{10}$ (µg $m^{-3}$) corresponding to stations for use in the AirQ2.2.3 model

| Parameter | Rah Ahan (maximum) | Baqshomal (minimum) | Tabriz |
|---|---|---|---|
| Average annual | 90 | 79 | 85 |
| Average summer | 47 | 54 | 51 |
| Average winter | 58 | 78 | 84 |
| 98% annual | 258 | 276 | 268 |
| Maximum annual | 480 | 451 | 440 |
| Maximum summer | 480 | 451 | 440 |
| Maximum winter | 330 | 396 | 386 |
| SD (annual) | 62 | 59 | 55 |
| Median( annual) | 75 | 66 | 73 |
| Mode (annual) | 168 | 49 | 75 |
| Quartile 25% | 55 | 48 | 53 |
| Quartile 50% | 75 | 66 | 73 |
| Quartile 75% | 101 | 89 | 96 |

SD:Standard Deviation.

Table 2 shows the values of RR used in the present assessment together with total mortality, cardiovascular mortality, respiratory mortality, and some other health effects.

**Table 2.** Estimated attributable proportion (AP) expressed as percentage and number of excess cases in a year due to short-term exposure to $PM_{10}$

| Health endpoint | Index estimate | RR | Estimated AP (%) | Estimated number of excess cases (people) |
|---|---|---|---|---|
| Total mortality (BI=1013 per $10^5$ people ) | Lower | 1.0062 | 4.49 | 703 |
| | Central | 1.0074 | 5.32 | 832 |
| | Upper | 1.0086 | 6.13 | 959 |
| Cardiovascular mortality (BI=497 per $10^5$ people) | Lower | 1.0050 | 3.66 | 281 |
| | Central | 1.0080 | 5.72 | 439 |
| | Upper | 1.0180 | 12.02 | 923 |
| Respiratory mortality (BI=66 per $10^5$ people) | Lower | 1.0080 | 5.72 | 58 |
| | Central | 1.0120 | 8.35 | 85 |
| | Upper | 1.0370 | 21.92 | 224 |
| HA cardiovascular disease (BI=436 per $10^5$ people) | Lower | 1.0060 | 4.35 | 293 |
| | Central | 1.0090 | 6.39 | 431 |
| | Upper | 1.0130 | 8.98 | 605 |
| HA respiratory disease (BI=1260 per $10^5$ people) | Lower | 1.0048 | 3.51 | 684 |
| | Central | 1.0080 | 5.72 | 1114 |
| | Upper | 1.0112 | 7.83 | 1525 |

BI: Based Incidence; HA: Hospital Admissions; RR: Relative Risk; AP: Attributable Proportion.

Epidemiological indicators such as RR and AP are shown in this Table. In fact, these indicators were epidemiological indices and their values depend on the selected health outcomes. The RR size and the AP of the total number of deaths attributable to $PM_{10}$ can be estimated to be 1.0074 and 5.32%, respectively, using the central limit. The number of deaths due to cardiovascular disease and the number of deaths due to respiratory associated with exposure to $PM_{10}$ in the air of Tabriz was 439 and 85 people, respectively. Table 2 also shows, considering the relative central risk, that the AP yield related to respiratory complications caused by $PM_{10}$ was 5.72%; while the proportion of AP to the conditions of lower limit and upper limit were 3.51 and 7.83%, respectively. For a population of one and half millions people and BI = 497 per one hundred thousand people each year, 7679 cardiovascular mortality cases can be expected annually, out of this number, 439 cases can be attributed to $PM_{10}$ concentrations above 10 µg $m^{-3}$.

Table 3 also shows, 55% of acute cardiovascular mortality cases occurred during days showing pollution not exceeding 100 µg $m^{-3}$, 77.8% of cardiovascular mortalities occurred in days with pollutant not exceeding 150 µg $m^{-3}$. For respiratory mortality considered baseline incidence, namely 66 per $10^5$ people (BI = 66), 1020 cases can be expected annually, and out of this number 85 cases can be attributed to $PM_{10}$ concentrations above 10 µg $m^{-3}$. 44.3% of respiratory mortality cases occurred during days showing $PM_{10}$ concentrations lower than 90 µg $m^{-3}$. In addition, 87% of respiratory mortalities occurred during days showing pollution not exceeding 200 µg $m^{-3}$.

**Table 3.** Estimated number of excess cases (cardiovascular and respiratory mortality) in three RR (overestimate, central and underestimate) in a year due to short-term exposure to $PM_{10}$

| Concentration (µg $m^{-3}$) | Estimated number of excess cases (Cardiovascular mortality) | | | Estimated number of excess cases (Respiratory mortality) | | |
|---|---|---|---|---|---|---|
| | RR = 1.0180 | RR = 1.0080 | RR = 1.0050 | RR = 1.0037 | RR = 1.0012 | RR = 1.0080 |
| < 10 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10-19 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20-29 | 6 | 3.1 | 2 | 2 | 0.6 | 0 |
| 30-39 | 26 | 12.6 | 8 | 7 | 2.4 | 1 |
| 40-49 | 68 | 32.6 | 21 | 17 | 6.3 | 4 |
| 50-59 | 131 | 62.6 | 40 | 32 | 12.1 | 8 |
| 60-69 | 229 | 108.8 | 70 | 56 | 21.1 | 14 |
| 70-79 | 326 | 155.3 | 100 | 80 | 30.1 | 20 |
| 80-89 | 408 | 194.5 | 125 | 100 | 37.7 | 25 |
| 90-99 | 508 | 241.7 | 155 | 124 | 46.8 | 31 |
| 100-109 | 565 | 268.9 | 172 | 138 | 52.1 | 35 |
| 110-119 | 607 | 288.9 | 185 | 148 | 56 | 38 |
| 120-129 | 641 | 305.3 | 195 | 156 | 59.2 | 40 |
| 130-139 | 695 | 331.1 | 211 | 169 | 64.2 | 43 |
| 140-149 | 718 | 341.8 | 218 | 174 | 66.3 | 44 |
| 150-159 | 742 | 353.3 | 225 | 180 | 68.5 | 46 |
| 160-169 | 768 | 365.6 | 233 | 186 | 70.9 | 48 |
| 170-179 | 773 | 368.2 | 235 | 187 | 71.4 | 48 |
| 180-189 | 785 | 373.7 | 239 | 190 | 72.5 | 49 |
| 190-199 | 803 | 382.5 | 245 | 194 | 74.2 | 50 |
| 200-249 | 827 | 393.7 | 252 | 200 | 76.4 | 52 |
| 250-299 | 836 | 398.3 | 255 | 203 | 77.3 | 53 |
| 300-349 | 870 | 414.2 | 265 | 211 | 80.4 | 55 |
| 350-399 | 908 | 432.5 | 277 | 220 | 83.8 | 57 |
| ≥ 400 | 923 | 439.4 | 281 | 224 | 85.1 | 58 |

The people exposure days percent with certain $PM_{10}$ concentrations in the population observed is shown in Table 4. It is observed from Table 4 that people exposure day percent are high in concentration intervals of 60-70 µg $m^{-3}$, and it is allocated the greatest health endpoints.

For hospital admission cardiovascular disease considered baseline incidence of 436 per $10^5$ people (BI = 436), about 6736 cases can be expected annually; and out of this number, 431 cases can be attributed to $PM_{10}$ concentrations above 10 μg $m^{-3}$. 61.2% of hospital admission cardiovascular diseases occurred during days where $PM_{10}$ concentrations not exceeding 110 μg $m^{-3}$. For hospital admission respiratory disease considered baseline incidence of 1260 per $10^5$ people (BI = 1260), about 19,467 ceases can be expected annually; and out of this number, 1114 cases can be attributed to $PM_{10}$ concentrations above 10 μg $m^{-3}$. 80.4% of hospital admission respiratory diseases occurred during days showing $PM_{10}$ concentration not exceeding 150 μg $m^{-3}$. About 55% attributable deaths occurred during days where $PM_{10}$ concentrations did not exceed 100 μg $m^{-3}$. The mortality rate increase caused by increasing $PM_{10}$ concentrations from 90 to 100 μg $m^{-3}$ was approximately 11%. Considering the underestimate (RR = 1.0062) and overestimate relative risk (RR = 1.0086), cumulative of total mortality attributed to $PM_{10}$ exposure was 703 and 959 people, respectively. Charts drawing based on the cumulative number of each health endpoint showed number of cases in three modes, 5, 50 and 95% RR. Figures 2 and 3 demonstrate the cumulative number of the cases for a hygienic consequence affected by the respective pollutant concentration from a quantification point of view; the figures illustrate number of cases in the upper, central and lower domains of the RR, showing therefore three curves for every figure. The mid curve corresponds to the central RR, the lower curve corresponds to a RR of 5% (underestimate) and the upper curve corresponds to a 95% RR (overestimate).

**Table 4.** Estimated people exposure days expressed as percentage and concentration intervals $PM_{10}$

| **Concentration intervals $PM_{10}$ (μg $m^{-3}$)** | **People exposure days (%)** |
|---|---|
| < 10 | 0 |
| 10-19 | 0 |
| 20-29 | 3.56 |
| 30-39 | 6.57 |
| 40-49 | 9.86 |
| 50-59 | 11.51 |
| 60-69 | 14.52 |
| 70-79 | 12.33 |
| 80-89 | 9.04 |
| 90-99 | 9.59 |
| 100-109 | 4.93 |
| 110-119 | 3.29 |
| 120-129 | 2.47 |
| 130-139 | 3.56 |
| 140-149 | 1.37 |
| 150-159 | 1.37 |
| 160-169 | 1.37 |
| 170-179 | 0.27 |
| 180-189 | 0.55 |
| 190-199 | 0.82 |
| 200-249 | 0.82 |
| 250-299 | 0.27 |
| 300-349 | 0.82 |
| 350-399 | 0.82 |
| $\geq$ 400 | 0.27 |

Figure 2 shows the presence of an increasing risk of mortality associated to an increase of exposure to $PM_{10}$ concentrations in the population observed. This risk is significant considering total mortality (first box of the figure), and also analysing separetely cardiovascular mortality (second box) and respiratory mortality (third box), with a risk lightly higher for the last group (RR = 1.0120, while RR = 1.0080 for cardiovascular mortality). Similar risk figures appeared for hospital admissions (see Figure 3, where the the two groups of pathologies were considered separetely): RR = 1.0090 for cardiovascular diseases, RR = 1.008 for respiratory diseases. For all the health outcomes considered, the risk seems quiete negligible for lower levels of exposure ($PM_{10}$ < 40 μg $m^{-3}$), while the risk continue its increasing to the highest levels of exposure.

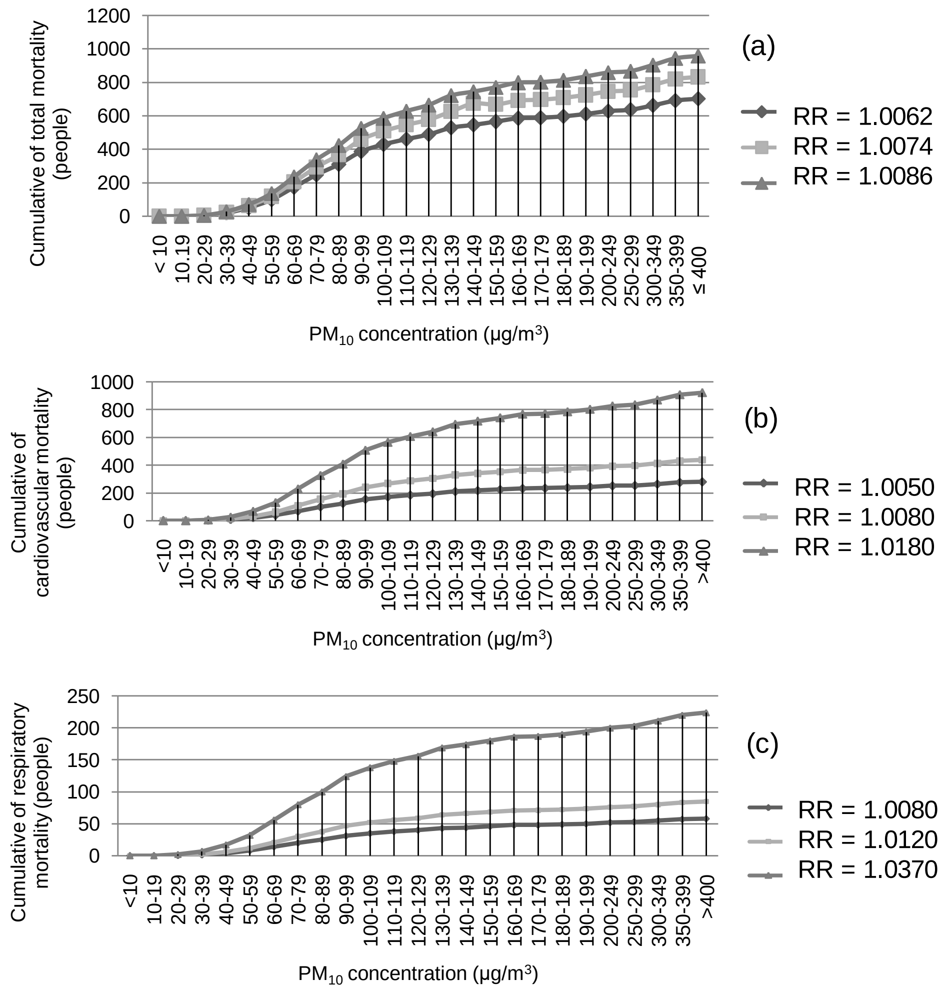


**Figure 2.** Cumulative numberof deaths due to $PM_{10}$ at various concentration intervals: (a) total mortality, (b) cardiovascular mortality, and (c) respiratory mortality

We assessed the impact on mortality of atmospheric pollution in Tabriz, Iran in 2011 using methodology developed by the WHO (2015). In Tabriz, with a total population of 1,545,491 people, total natural mortality (non- accidental mortality) is 15,651 people annually; and out of this number, the mortality of 832 people can be attributed to $PM_{10}$ concentrations above 10 μg $m^{-3}$. Therefore, based on this model, mortality of exposure to $PM_{10}$ in Tabriz was approximately 5.32% of all health endpoints (deaths), that to compare with results of Tehran (3.40%) (Goudarzi *et al.*, 2009). Also, we estimated that among the 19,467 people admitted to hospitals due to respiratory disease, 1114 diseases could be attributed to $PM_{10}$. We also estimated that 1356 citizens in Tabriz may have lost their lives due to exposure to $PM_{10}$ in 2011.

According to the results of the present study, more than 17% of all natural deaths attributabled to $PM_{10}$ with higher concentration of 10 μg $m^{-3}$, that this result is approximately consistent with the study conducted in Tehran (Hosseinpoor *et al.*, 2005). Naddafi *et al.*, (2009) concluded in their survey that the control of airborne particulate matter is essential due to high levels of TSP in the central city of Yazd, Iran (Naddafi *et al.,* 2009). Studies conducted in other countries are indicative of the fact that health effects associated with short-term exposure $PM_{10}$ in various cities of developed and developing countries are similar and for 10 μg $m^{-3}$ increase of the $PM_{10}$ concentration the risk of death increased by 0.50%.This problem can cause a lot of concern, and hence quick action is required to reduce air pollution (Goudarzi *et al.,* 2009).

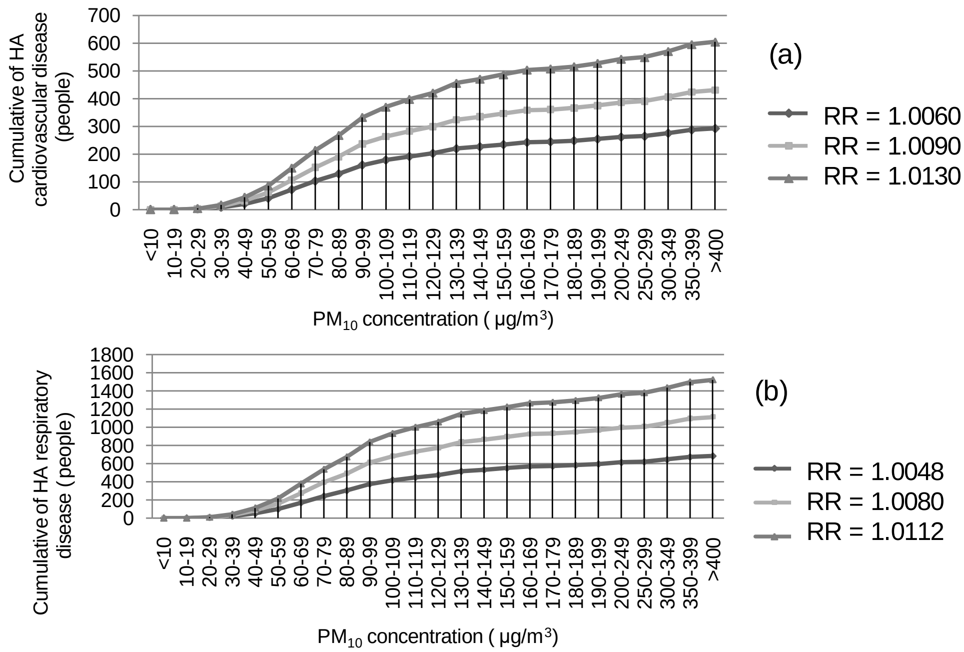


**Figure 3:** Cumulative number of outpatient visit and hospital admission due to $PM_{10}$ at various concentration intervals: (a) cardiovascular diseases, and (b) respiratory diseases

The AirQ2.2.3 software provided by the WHO (2015) for the quantification of data related on the health of people exposed to air pollutants in a specific area has been used and defined, showing that for similar studies the respective results appeared close to each other. The determination of health effects for the metropolis of Tabriz, the need for alternative thinking and effective action of local authorities and the related country decision on the issue of reducing air pollution load is therefore a huge policy. Including measures such as urban traffic control and reduce emissions related to transportation and energy production in cities, modification of municipal infrastructure and development of public transportation, reduction of production green house gases, reduction of pollutants discharge from factories by applying different strategies in urban areas, reduction of air pollution and health effects could have a significant effect on the reduction of air pollution and its adverse effects on citizens health.

### *3.1. Limitations*

It should be noted that the study described herein has some limitations. One of the limitations of this approach is that the health impact focuses on individual compounds without considering the simultaneous exposure to several ones, which is what actually occurs. The health effects of atmospheric pollution are indeed the consequence of interactions between different air contaminants, and between these ones and other compounds of natural origin. Generally, in quantitative assessments of health effects, the interactions between different contaminants are not investigated as it would require a good knowledge of the mechanisms of toxicity for the different compounds, which is rarely available. A further limitation is due to the RR estimates derived in studies of different populations in comparison to that under investigation. Furthermore, this model does not consider intra-individual differences due to different behaviors inside the population considered (i.e., active or passive smoking, mobility during the day, proximity to major roads, etc.). That's because the approach is ecological and not epidemiological., Finally, another limitation related to the exposure assessment is that the approach assumes that concentrations measured in specific sampling points are representative of the average exposure suffered from people living in Tabriz.

## 4. Conclusions

In consideration of the foregoing facts, better quantification studies are recommended, and the following actions should be performed in order to reduce health effects caused by air pollution:

- Restricting the use of petroleum, coal and fossil fuels; measures are necessary to reduce the high urban traffic including the raise of the level of urban public transport systems and correct traffic management; and effective strategies to improve the quality of industrial productions should be implemented.
- Because prerequisite quantification is the calculation of load diseases attributable to air pollution and estimation of the health effects of air pollutants, epidemiological indicators are needed based on expert calculations.
- The use of this model or other models is recommended to investigate and evaluate the effects of air pollution on health of people in other metropolitan country, and comparisons should be made.

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**Declaration of conflicting interests**

The authors do not have any potential conflicts of interest to declare.

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