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# EVALUATION OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE (COPD) ATTRIBUTED TO $O_3$ AND $NO_2$ IN SIX METROPOLITANS OF IRAN BY USING AIRQ MODEL

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**ABSTRACT:**

**Introduction:** Air pollution in metropolitans is an important problem and health concern. Air pollution increases respiratory diseases, significantly. We evaluated the relation between COPD and criteria air pollutants in six major cities of Iran including Tehran, Mashhad, Tabriz, Isfahan, Shiraz and Arak by AirQ model, developed by World Health Organization.

**Materials and methods:** At first, hourly data of pollutants collected from the Department of Environment of cities and validated according to WHO guidelines. Quantification of the number of cases COPD were performed by using statistical analysis and the World Health Organization model.

**Results:** Results showed total cumulative numbers of hospital admission cases due to COPD (HA-COPD) estimated in the present study were 372, 102, 130, 96, 55 and 29 cases in Tehran, Mashhad, Isfahan, Shiraz, Tabriz and Arak, respectively. According to obtained results, among seven metropolises, the highest and lowest COPD rate dedicated to Tehran and Arak, respectively.

**Conclusions:** Air pollution is considered as a major threat to public health in major cities of Iran. This study proved association between short-term exposure to $O_3$ and $NO_2$ and hospital admission for respiratory diseases. Therefore, policy makers and authorities should use appropriate actions and attempts based on scientific evidence in order to reduce pollutants, control air pollution and diminish their harmful effects on health of residents.

## INTRODUCTION

Air pollution is one of the most important environmental health issues. Researches over the last years have determined that there is a relationship between air pollution and health of people [1-12]. The gaseous pollutants such as ozone $O_3$ and nitrogen dioxide $NO_2$ are highly reactive oxidants and can cause chronic obstructive pulmonary disease at high concentrations. Ozone is a pollutant that can cause respiratory and cardiovascu-

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lar diseases, eye burning sensation and failure of immune defense against infectious diseases. The ozone is able to penetrate into every pore of the lung tissue depends on the primary concentration. A small increase in ozone concentration affects bronchioles slightly, but its main effect is on the lower parts of lung such as alveolar system [13]. According to some studies on human and animals, exposure to ozone led to some pulmonary disorders and complications [14-16]. The impacts of ozone include: histological changes in bronchiolar epithelium, changes in lungs function, changes in the lungs protein structure volume [17-19]. Nitrogen dioxide ($NO_2$) is a by-product of high-temperature fossil fuel combustion. It is a common pollutant in urban environments and comes from combustion sources into indoor environments [20]. $NO_2$ also is an important marker of air quality.

Based on moderate evidence in a recent review, long-term exposure to an annual mean concentration below 40 $\mu g/m^3$ of this pollutant was associated with adverse health effects such as respiratory symptoms/ diseases, hospital admissions and mortality [21]. Human activities represent the main sources of $NO_2$, from automobile exhaust emissions to stationary sources such as fossil fuels, power plants, industrial boilers, waste incinerators and heating household appliances; but the main source of nitrogen dioxide in urban area is the gas emitted by the public transportations. $NO_2$ concentration varies from morning to night. The main sources of $NO_2$ in indoor environment are the natural gas cookers and the smoke produced by cigarettes. Acute short-term (1h) effects and low concentrations have been observed in animals [22-24]. Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory airway disease that is described by hyper secretion, cough and inflammatory cell influx, and persistent airflow limitation [25, 26]. According to WHO, COPD, it was estimated to be the 12$^{th}$ cause of disability and the six$^{th}$ cause of mortality in 1990, and it is also estimated to be the 5$^{th}$ cause of disability and the third cause of mortality by 2020. According to prediction and estimation of World Health Organization, about 80 million people have gotten moderate to severe COPD and 3 million people of them died of COPD in 2005, which were correspondence of almost 5 % of all deaths globally. Total deaths due to COPD are projected to increase by more than 30 % in the next 10 years [27]. By the year 2020, it has been estimated that COPD will rank 5$^{th}$ among the conditions with a high burden to society [28]. A large number of research showed that acute and chronic morbidity such as COPD are due to gaseous air pollutants. In a study performed in Shiraz, there was significant relationship between sulfur dioxide pollutant and hospitalizations due to respiratory diseases in elderly group and COPDs ($P < 0.001$) [29]. Also in a study performed in 2009 showed how an increase of 18.4 ppb level of $O_3$ concentration was associated with an increase of emergency room visits for COPD 3.7% (95% CI: 0.5% to7.9%) [30]. Air pollution and its concern are increasing particularly in developing countries. Individuals in megacities encounter air pollution problem every day. In this research, cities in Iran with a population over 480,000 inhabitants in different provinces were investigated. Metropolises of Tehran, Mashhad, Tabriz, Isfahan, Shiraz and Arak were six major cities in Iran. These six cities were host for 26.6 % of the population of Iran country. These megacities of Iran suffered by increasing air pollution levels because of industrial activities, urbanization, heavy traffic and high population density. In this study it was surveyed the evaluation of excess hospitalization cases due to chronic obstructive pulmonary disease (COPD) attributed to atmospheric $O_3$ and $NO_2$ during 2011-2012 in six major cities of Iran.

## MATERIALS AND METHODS

This study was a descriptive–analytic and we used the approach proposed by the World Health Organization (WHO). Evaluation of chronic obstructive pulmonary disease (COPD) attributed to atmospheric $O_3$ and $NO_2$, in six major cities of

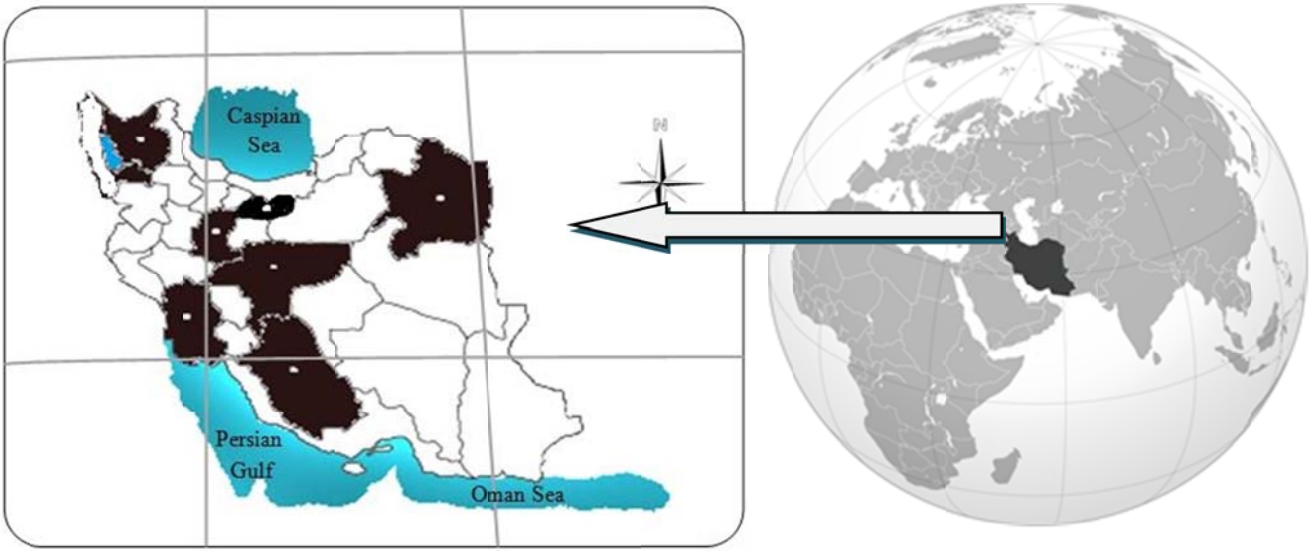


Fig.1. Map of Iran in the world and location of studied metropolises

Iran was assessed by AirQ 2.2.3 [24], and it was shown in Fig.1.

At first, hourly data of pollutants collected from permanent monitoring station of Department of Environment in six studied cities during 2011-2012. These data were on volumetric base. Statistical Centre of Iran (SCI) adopted population of studied cities from the recent census report in 2011. According to the criteria for air quality health impact assessment, monitoring stations with valid data identified and investigated.

AirQ has been designed on gravimetric base, so we obtained data of pressure and temperature from Iran Meteorological Organization and used following equation to convert ppb unit (DOE data) to µg/m$^3$ unit (model required):

$$\frac{\mu g}{m^3} = \frac{P\ (mmHg) \times MW \times ppm}{62.4\ \times T\ (°K)} \times 1000$$

Where:

*WM* : molecular weight of pollutant,
T : temperature as Kelvin degree
P: pressure

For health impact assessment, quantification of exposure to annual mean, winter and summer mean, annual 98 percentile, annual maximum and winter and summer maximum were calculated in all cities and their stations. All of these parameters were corrected and processed for all pollutants by Excel [24, 25]. Hospital admission due to chronic obstructive pulmonary disease (COPD) attributed to $O_3$ and $NO_2$, was assessed by AirQ 2.2.3. AirQ model was used to estimate the impacts of exposure to specific air pollutants on health of people living in a certain period and area. The assessment was based on the attributable proportion (AP), defined as the fraction of health outcome in a certain attributable population exposed to a given atmospheric pollutant. The AP calculated by following equation:

AP= SUM {[RR(c)-1] ×P(c)} /SUM [RR(c) × P(c)]

Where,

P(c) : population of city

RR : relative risk of health endpoints in category "c" of exposure that obtains from epidemiological study and exposure-response functions. Relative Risk (RR) was defined as a ratio of the probability of an event for exposed and non-exposed people. Rate of the health outcome attributed to the exposure (IE), calculated as:

IE=I×AP

Where,

I : the baseline frequency of the health outcome in the population under investigation (survey). Number of cases attributed to the exposure of pollutant (NE) with knowing size of population (N) calculated as : NE=IE×N

Baseline incidence (BI) multiplied at population size and attributable proportion (AP) then divided to $10^5$ to obtain number of excess cases:

$$\left(\frac{\text{Baseline incidence}\times \text{Population}}{10^5}\right) \times \text{Attributable proportion} = \text{No. of excess cases}$$ [31]

Finally, after importing prepared data to AirQ 2.2.3, results presented the excess cases of hospital admission due to chronic obstructive pulmonary disease (COPD) attributed to ozone ($O_3$) and nitrogen dioxide ($NO_2$) pollutant in six Metropolises

## RESULTS AND DISCUSSION

In recent decades, air pollution in Iran considered as a serious threat to health and environment. In this study, we estimated hospital admissions due to chronic obstructive pulmonary disease (COPD) attributed to expose with $O_3$ and $NO_2$ pollutants during 2011 to 2012 in six metropolises of Iran. The annual average, summer average, winter average, and 98 percentile of $O_3$ and $NO_2$ concentrations were shown in Table 1. As can be seen in Table 1, among six studied cities for nitrogen dioxide, highest annual concentration (μg/m$^3$) was reported in Tehran and Isfahan, with mean value of 80 and 128 μg/m$^3$, respectively. WHO Guideline [32] set and determined 40 μg/m$^3$ for annual mean of $NO_2$, that according to these standards, all of the studied cities exceeded from national standard. In Tehran, Mashhad, Isfahan, Shiraz, Tabriz and Arak, annual mean concentrations of $NO_2$ were 2, 1.85, 3.2, 1.42, 1.3 and 2.22 times higher than standards, respectively. Since the number of excess HA-COPD for Tehran was so much higher than other cities, we preferred to show this city in a different scale (Fig.2). The percentage of time on which people in Tehran are exposed to different concentrations of pollutants during 2011 to 2012 was shown in Fig.2. The highest number of days of exposure to $NO_2$ in 2011 and 2012 observed in concentration range of 70–79 and 80–89 μg/m$^3$, which were higher than NAAQSs, published standards for annual mean. In addition, the highest numbers of days of exposure to $O_3$ concentrations were in the concentration range of 40–49 and 50–59 μg/m$^3$ in 21 March 2011 to 20 March 2012. Baseline incidence (BI) and relative risks with 95% confidence intervals (95% CI) that used for the health effect estimation in present study were shown in Table 2. To make sure of accuracy and precision, the obtained BI and RR in this study were compared to other studies in Iran [33, 34] and statistics of World Bank [35] and World health 2013 [36]. Because Iranian population is generally younger than of European countries, thus baseline for total mortality and morbidity should be lower. The average BI was about 101.4 per 1000 people for Iran.

Number of excess cases of hospital admission COPD due to short-term exposure above 10μg/m$^3$ for $O_3$ and $NO_2$ in six cities was estimated and shown in Table 3. Results showed total cumulative number of cases due to HA-COPD estimated in the present study for $O_3$ and $NO_2$ in six cities were 493 and 281 cases in central RR in a year, respectively. As seen in Table 4, Fig.2 and 3 with regard to AP and exposed population, maximum number of hospital admission due to COPD for $NO_2$ among investigated cities belonged to Tehran with 281 cases. Also maximum number of excess hospital admission due to COPD for $O_3$ among investigated cities belonged to Tehran with 209 cases. Results the study conducted in Tehran [34] showed number of excess cases attributed to $NO_2$, $SO_2$, and $O_3$ in percentage of attributable proportion (AP) 2.79, 3.38 and 4.80, were 247, 298 and 424 cases respectively. In our study attributable proportion and number of COPD in Tabriz due to $O_3$ and $NO_2$ exposure was 1.9%, 1.07%, 29 and 16 cases, respectively. In

a study, quantification of health effect of COPD from exposure to $NO_2$, $SO_2$, and $O_3$ in Tabriz was investigated [37] and results of this study showed that attributable proportion, and number of persons suffering from COPD due to $O_3$ and $NO_2$ exposure (BI=101.4 per$10^5$ persons) were 2.9%, 0.89%, 0.41%, 44, 13 and 6 cases, respectively. The results of studies in both Tabriz and Tehran (as this study) are slightly close together. The results of another study in Europe, the APHEA project (a meta centric and multi-pollutant study) evaluated air pollution (multi-pollutant) and its short-term effects such as HACOPD. The RR for a 50 μg/$m^3$ increase in daily mean level of pollutant was 1.02 (95%CI1.00–1.05) for $NO_2$ and 1.04 (95% CI1.02– 1.07) [34]. Based on Study in six Iranian major cities, total cumulative numbers of hospital admissions due to COPD (HA-COPD) were estimated, which were 243 in central relative risk in a year [9]. Other studies have been conducted in US cities, [2006] [38] European cities, (1997) [39] Milan (Italy) (2011) [31] and Hong Kong (China) [40]. On health effects of atmospheric pollution, as this study has confirmed, they found association between gausses pollutants ($O_3$ and $NO_2$) and HA COPD, as well. Totally, researches carried out in this issue showed convincing evidences from role of pollutants in the incidence of cardiovascular disease, especially COPD. In fact, various factors, such as smoking, occupational exposures, inappropriate diet, indoor air pollution, exposure to $O_3$ and $NO_2$ can influence incidence of COPDs, especially in elderly people, but exposure to air pollutants can exacerbate these diseases as predisposing factors [29].

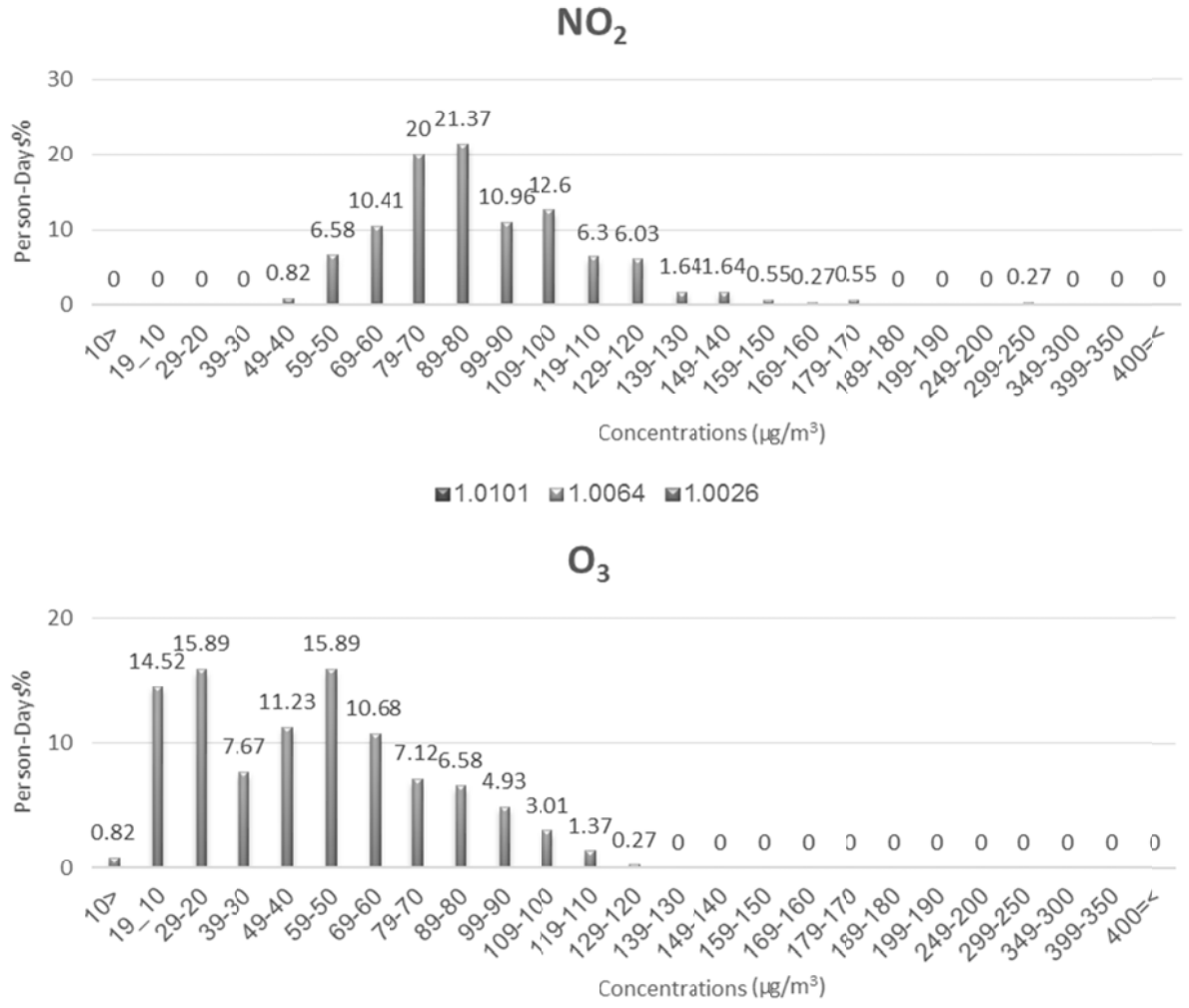


Fig.2. Percentage of days that people in Tehran were exposed to different concentrations of pollutants.

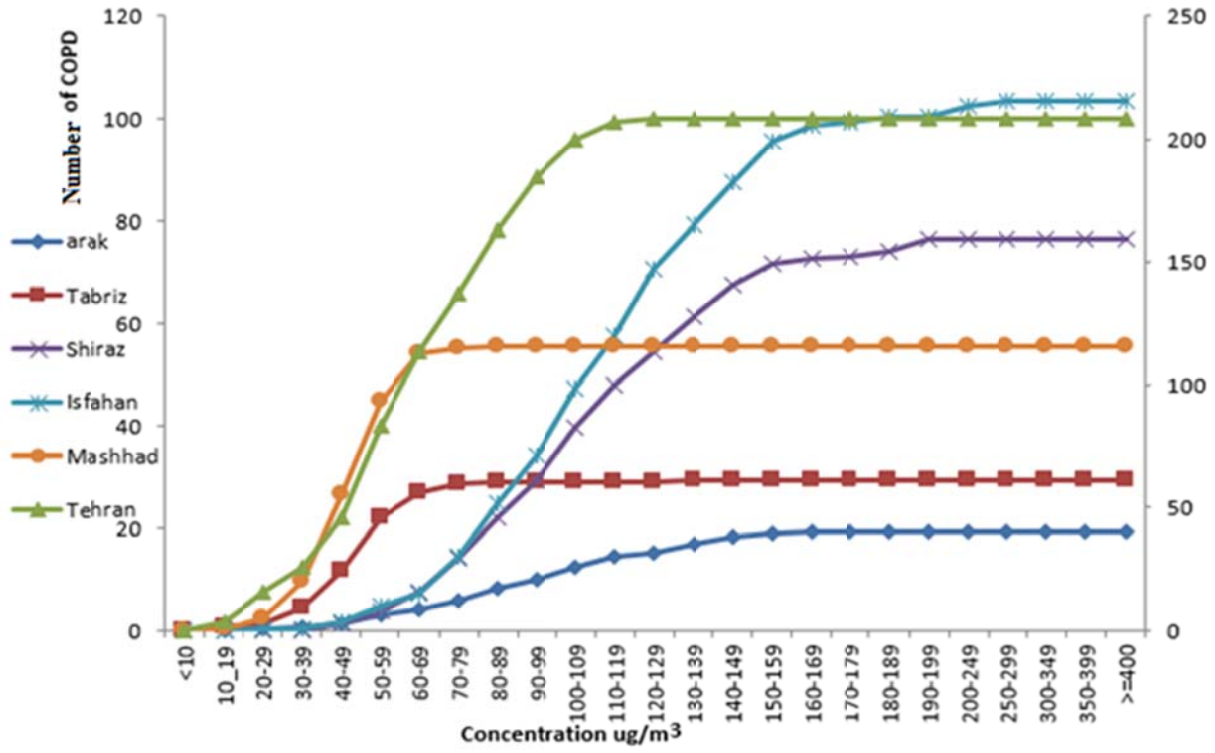


Fig.3. Estimation of $O_3$ attributed COPD versus concentration interval by AirQ in six city of Iran

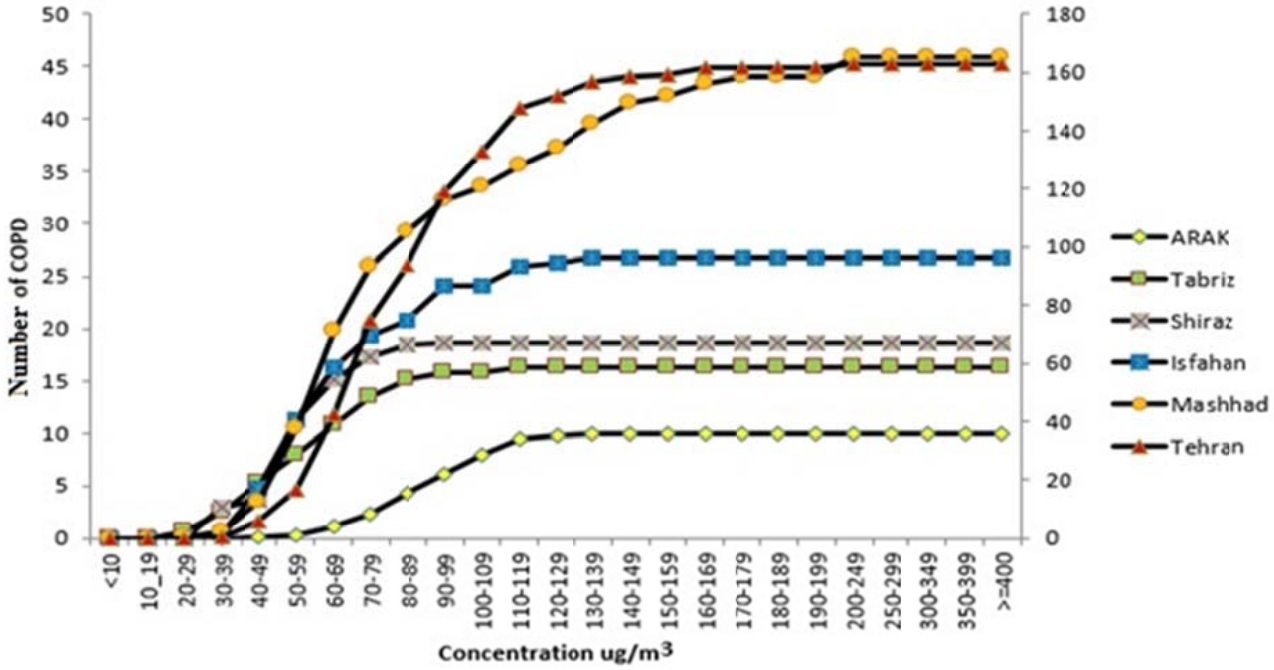


Fig.4. Estimation of $NO_2$ attributed COPD versus concentration interval by AirQ in six city of Iran

Table 1. Summary of required statistical parameters $O_3$ and $NO_2$ (μg/m$^3$) by means of the model

| City | Pollutant | Tehran | Mashahd | Tabriz | Isfahan | Arak | Shiraz |
|---|---|---|---|---|---|---|---|
| Average annual | $NO_2$ | 80 | 74 | 52 | 128 | 89 | 57 |
| | $O_3$ | 50 | 46 | 43 | 46 | 81 | 99 |
| Average summer | $NO_2$ | 70 | 60 | 46 | 85 | 88 | 61 |
| | $O_3$ | 70 | 51 | 55 | 43 | 91 | 120 |
| Average winter | $NO_2$ | 90 | 89 | 58 | 172 | 90 | 53 |
| | $O_3$ | 30 | 40 | 31 | 48 | 68 | 79 |
| 98 percentiles annual | $NO_2$ | 135 | 164 | 95 | 232 | 123 | 84 |
| | $O_3$ | 107 | 69 | 72 | 96 | 150 | 173 |

Table 2. Baseline incidence and relative risks for HA- COPD of $O_3$ and $NO_2$ in this study

| Pollutant | Baseline incidence | RR (95% CI) per 10 μg/m$^3$ |
|---|---|---|
| $NO_2$ | 101.4 | 1.0026 (1.0006-1.0044) |
| $O_3$ | | 1.0058 (1.0022-1.0094) |

Table 3. Hospital admission due to chronic obstructive pulmonary disease (COPD)

| Health end point (hospitalization) | Year | Pollutant | AP (attributable proportion) | No. of excess cases (uncertainty range) |
|---|---|---|---|---|
| Hospital admission due to chronic obstructive pulmonary (HA- COPD ) | Tehran | $NO_2$ | 1.78 (0.41-2.98) | 163 (38-272) |
| | | $O_3$ | 2.28 (0.88-3.65) | 209 (80-334) |
| | Mashahd | $NO_2$ | 1.64 (0.38-2.75) | 46 (11-77) |
| | | $O_3$ | 2.02 (0.77-3.24) | 56 (22-90) |
| | Tabriz | $NO_2$ | 1.07 (0.25-1.8) | 16 (4-27) |
| | | $O_3$ | 1.92 (0.74-3.08) | 29 (11-47) |
| | Isfahan | $NO_2$ | 1.33 (0.31-2.23) | 27 (6-45) |
| | | $O_3$ | 5.13 (2.01-8.06) | 103 (40-162) |
| | Arak | $NO_2$ | 2.01 (0.47-3.35) | 10 (2-16) |
| | | $O_3$ | 3.95 (1.53-6.26) | 19 (8-31) |
| | Shiraz | $NO_2$ | 1.19 (0.27-1.99) | 19 (4-31) |
| | | $O_3$ | 4. 9 (1.91-7.7) | 77 (30-120) |

## CONCLUSIONS

This study was the first research to health impacts assessment of air pollution in Tehran. COPD is one the major causes of mortality and disability in Iran. Nitrogen dioxide and ozone have a significant impact on COPD hospitalization. This study applied the AirQ for assess the impact of atmospheric pollution on health of people. As presented in this study, air quality affects daily hospital admissions dramatically. Quantifying the health impacts associated with exposure to air pollutants can be an important guide for legislator. Therefore, authorities must use the proper measures such as, restriction of use of fossil resources, improving public transportation systems, traffic management quality of the auto industry productions, etc., to control air pollutions and reduce the health effects on health.

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## COMPETING INTERESTS

All authors declare that they have no actual or potential competing financial interest.

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## ETHICAL CONSIDERATIONS

Ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/ or submission, redundancy, etc.) have been completely observed by authors.

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