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HEALTH IMPACTS OF NO_2 IN MASHHAD, IRAN

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ABSTRACT

Introduction: Nitrogen dioxide (NO_2) is a by-product of high-temperature fossil fuel combustion. There is a strong correlation between elevated NO_2 concentration and increased mortality and morbidity. Air-Q 2.2.3 model developed by WHO was used for the first time in the present study to evaluate the human communities' health risk as a result of NO_2 exposure in Mashhad, in 2012.
Materials and methods: Air-Q 2.2.3 developed by WHO was used for the first time in this study to calculate the risk on human communities as a result of NO_2 exposure in Mashhad during 2012.
Results: The concentration-response coefficient was 1.14% (95% CI 0.62–1.67%) per 10 μg/m^3 increase in NO_2 concentration. The study also showed that nearly 3.2% of total cardiovascular deaths, heart attacks, and hospital admissions for chronic obstructive pulmonary were related to NO_2 exposure to concentrations beyond 30 μg/m^3.
Conclusions: The results showed that there is significant correlation between human mortality and air. This assessment estimates the public-health impacts of current patterns of air pollution. Although individual health risks of air pollution are relatively small the public-health consequences are considerable.. Our results, which have also been used for economic valuation, should guide decisions on the assessment of environmental health-policy options.

INTRODUCTION

Nitrogen dioxide (NO_2) is a by-product of high-temperature fossil fuel combustion. It is an ubiquitous pollutant in urban environments as well as indoor environments coming from combustion sources [1]. NO_2 also is an important marker of air quality. A recent review provided moderate evidence that long-term exposure to an annual mean concentration below 40 μg/m^3 of this pollutant was associated with adverse health effects such as respiratory symptoms/diseases, hospital admissions, mortality, and otitis media [2]. A cross-sectional SAPALDIA study in Switzerland confirmed the association of NO2 exposure and lung function decrements among adults [3]. Other studies also endorsed that the exposure to Nitrogen dioxide can aggravate chronic respiratory and cardiovascular diseases, alter host defenses, damage to the lung tissue, causing premature death, and possible contribution to cancer [4, 5]. Mashhad is the second biggest religious town around the world and the second most polluted city in Iran. Accelerated urban population growth

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and industrial activities and attraction of more than 14 million pilgrims and tourists each year (second largest holy city in the world), make the city a gripped by traffic dilemma regarding the transportation system, especially in the Central Business District (CBD)[6]. Moreover, there are many other pollutant sources like factories, compost plants and industries are in Mashhad suburbs which their location are not compatible with dominant winds direction. Air pollution in Mashhad is responsible for a number of negative health effects. It has been proved that air pollution can affect human health. These health effects include increased hospital admissions due to the exacerbation of cardiac and respiratory diseases, as well as increased mortality.

This study is the first attempts for applying the Air-Q 2.2.3 model and the approach proposed by the WHO to provide quantitative data on the impact of NO_2 exposure of people living in Mashhad, in 2012.

MATERIALS AND METHODS

Study area and sampling

The Holy City of Mashhad (Latitude 36°21'28" N, Longitude 59°33'20"E) is at an elevation of 985 m above sea level. Mashhad, the biggest religious city in Iran, is a populous city and located on a plain between Binalood and Hezar-Masjed heights; Furthermore, Mashhad has a temperate climate, and it has about 270-300 days of inversion in year. The city is home to more than 2.5 million people and also receives over 14 million pilgrims annually. Table 1 reports the main sources of air pollution in Mashhad. Based on statistics provided by environmental office of Khorasan Razavi province, motor vehicles traffic account for about 72 percent of urban air pollution situation in Mashhad. In this metropolis about 900 thousands motor-vehicles are in traffic. Moreover, there are many polluting units like factories, compost plants, etc. in Mashhad suburbs, which are not compatible with dominant winds.

According to many physicians, air pollution in Mashhad is the cause of many diseases such as gastrointestinal, heart, respiratory and vascular diseases. Environmental office of Khorasan Razavi province provides public health-based recommendations based on the air quality monitoring.

Table 1. The priorities of air pollutant sources of Mashhad

Source	Priority	Source	Priority	Source	Priority
Vehicles	1	Industries (inside the city)	1	Planes	3
Filling stations (inside the city)	1	Indoor	1	Filling stations (outside the city)	4
Commercial	1	Trains	2	Industries (outside the city)	4

Fig.1. Mashhad air pollution manitoring station sites

Air-Q 2.2.3 model inputs (WHO, 2010)

(The program needs the following data to run):
1. Introductory data.
2. Pollutant data, in the current study Nitrogen dioxide (NO_2) was the target pollutant).
3. Mashhad city coordinates
4. Exposed population data .
5. Air Quality data
6. The program calculates the Relative Risk (RR) manually using the following equation:

RR = exp [B (X - Xo)]
B = 0.0006 - 0.0010 (mean 0.0008)
X = annual mean concentration (μg/m^3)
Xo = threshold concentration (μg/m^3)

7. Health data such as: health end point (hospital admissions respiratory diseases), baseline incidence , relative risk (mean, lower and upper) from previous equation, scientific certainty of relative risk (choice unknown), calculate impact of concentrations > 10 μg/m^3, calculate impact estimates to estimate number of excess cases for mean, lower and upper relative risk.

Air-Q 2.2.3 model outputs

Air-Q 2.2.3 model estimates the pollutant health impacts such as: estimate number of cases per 100000/year for each concentration range, relative risk and hospital admissions.

RESULTS AND DISCUSSION

Exposure levels

The primary standard for NO_2 published by National Ambient Air Quality Standards was 100 μg/ m^3. The current WHO air quality guideline recommended a 1-hour and annual average level of 200 μg/m^3 and 40 μg/m^3 for NO_2 exposure respectively [7]. Table 2 shows the descriptive statistical analysis of NO_2 concentrations during the period of study. The table clearly indicates that the concentrations of NO_2 varied across seasons. The maximum concentration of NO_2 was 183 μg/m^3 at Daneshgah site during winter, while the minimum value was 18 μg/m^3 at Lashgar site during summer. The higher concentration of NO_2 during winter than summer may be attributed to considerably less mixing in the lower air boundary during winter and also the photochemical activities by which NO_2 and hydroxyl (OH) radicals react to form nitric acid (HNO_3). The low levels of NO_2 in Monsoon and summer may be due to the higher air turbulence and degradation of nitrite in the presence of intense sunlight [8, 9]. In general, several factors are likely contribute to NO_2 seasonal variations including traffic density, proximity to other sources of emissions and meteorological conditions such as temperature, relative humidity and duration of sunshine. The Table 2 also shows that annual, summer and winter average values of NO_2 were 53, 67 and 99 μg/ m^3 respectively.

Table 2. Seasonal and annual mean concentrations (μg/m^3) during study period

Parameter	Daneshgah (max)	Lashgar (min)	Mashhad
Maximum			
Winter	183	110	117
Summer	94	77	101
Annual	183	110	117
Minimum			
Winter	48	25	38
Summer	28	18	27
Annual	34	23	31
Mean			
Winter	113	59	99
Summer	69	36	67
Annual	88	48	53

Air pollution measurement through 12 measurement stations which are observing and registering Mashhad air pollution status shows that air pollution is more critical in Daneshgah, Qale-sakhteman, Panjrah and Sajad regions (Fig.2).

Health impacts

AirQ2.2.3 integrated the data on pollutant concentration-response functions with data on population exposure to calculate the extent of respiratory health effects expected from exposure to NO_2. Several studies have examined the association between NO_2 and respiratory hospital admissions. The statistically significant correlation between NO_2 exposure and mortality rate observed in different studies in China, Europe [10] and Canada [10] suggests that the role of exposure to ambient NO_2 should be further investigated.

The baseline hospitalization rates were determined separately for cardio- vascular, COPD and respiratory admissions per 100 000 people using the same principles. It indicated that the health risk related to NO_2 increased by increasing NO_2 concentration. Regarding morbidity rates, short-term exposure to NO_2 is estimated to cause 54 (95% CI 43–104) respiratory hospitalizations per year in Mashhad. Cumulative number of hospital admission for COPD was 14 persons. COPD is one of the leading causes of morbidity and mortality in the industrialized and developing countries. According to WHO, COPD was estimated to be the 12th cause of disability and the sixth cause of mortality in 1990, and it is also estimated to be the 5th cause of disability and the third cause of mortality by 2020[11]. The total cumulative number of cardiovascular death, which attributed to exposure with NO_2 during one year of monitoring was 23 persons. 70% of these cases have been observed in days with NO_2 levels not exceeding 100μg/m^3.

In a study performed in 17 cities in China,

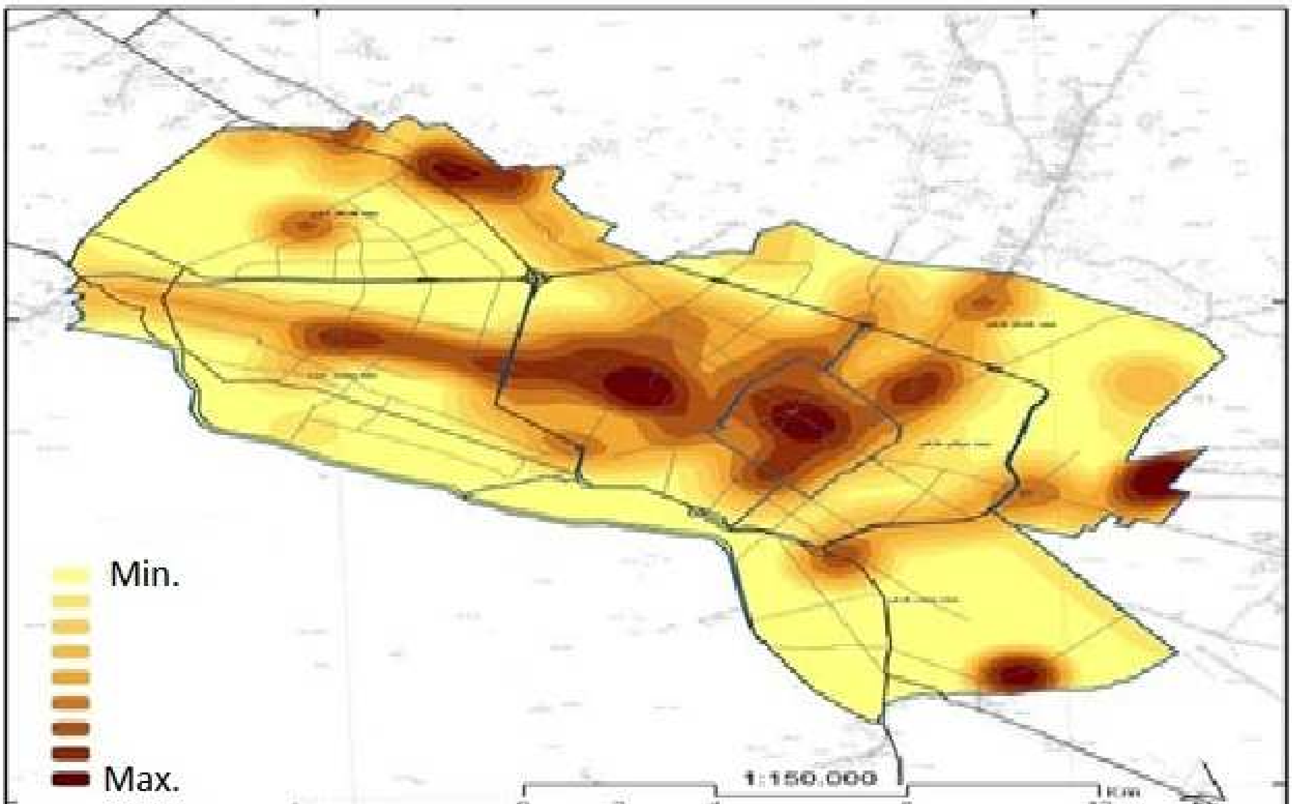

Fig.2. Distributions of air pollution in Mashhad zones

cardiovascular and respiratory diseases accounted for 44% and 14% of total non-accidental deaths respectively. The mean daily concentrations of NO_2 in the study ranged from 23 µg/m^3(Taiyuan) to 67 µg/m3(Shanghai) [12] . In 2008, Goodarzi et al. used the Air Q model to estimate the health effects of NO_2 in Tehran. According to their study, nearly 3.4% of total cardiovascular deaths, heart attacks, and the hospital admission for chronic obstructive pulmonary were related to exposure to NO_2 concentrations beyond 60 µg/ m^3. The AirQ2.2.3 model was used in both studies. The comparison between the results of these studies shows that near the 3.2% of all cardiovascular deaths, heart attacks, and the hospital admission for chronic obstructive pulmonary in Mashhad were related to exposure to NO_2 in concentrations more than 30 µg/m^3.

This study showed that the concentration-response coefficient was 1.14% (95% CI 0.62–1.67%) per 10 µg/m^3 increasing in NO_2 concentration. The health impact assessment using concentration–response functions provides general information about the pollutants level and their potential adverse impact, however this approaches come with several uncertainties, which need to be considered before making any conclusion. Some of the uncertainties are [13]: (a) It is not possible to accurately determine population exposure to ambient air pollutants because of the limited knowledge of public time-activity patterns. (b) There are many epidemiological studies characterizing concentration-response functions, including the one used in this study are affected with confounding factors and statistical uncertainties. However, quantifying the health effects of ambient air pollution is related to the issue of whether or not there is a threshold values for ambient air pollutant health effects. Many epidemiological studies are now demonstrating adverse health effects at levels of air pollutants well below air quality standards. It also should be taken into account that health impacts are affected by local meteorological conditions; therefore, concentrations-response functions developed in one part of the world may not be applicable in the other.

CONCLUSIONS

This study is the first attempt to apply the AirQ2.2.3 to provide quantitative data on the impact of NO_2 exposure on public health in Mashhad City, during a one year period (March 2012 to Feb 2013). The concentration-response coefficient was 1.14% (95% CI 0.62–1.67%) per 10 µg/m^3 increase in NO_2. Finally, in evaluating any policy that would reduce air pollution, it is useful to compare the policy's costs to the benefits achieved in monetary units.

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COMPETING INTERESTS

The authors declare no competing interests.

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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 the authors.

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