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Cardiovascular deaths related to Carbon monoxide Exposure in Ahvaz, Iran

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ABSTRACT

Carbon monoxide is an odorless, colorless and toxic gas that emitted from combustion. Carbon monoxide can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain), tissues, fibrinolysis effects, abortion and death at extremely high levels. The aim of this study was to assess health-effects of carbon monoxide exposure in Ahvaz city. Data were collected through Ahvaz Meteorological Organization and Department of Environment. Raw data processing by Excel software includes (instruction set correction of averaging, coding and filtering) and after the impact of meteorological parameters was converted as input file to the Air Q model. Finally, health-effects of carbon monoxide exposure were calculated. The results showed that the concentration of carbon monoxide was 7.41 mg/m^3 in Ahvaz as annual average. Sum of total numbers of deaths attributed to carbon monoxide was 16 cases within a year. Approximately 4.3% of total Cardiovascular deaths happened when the carbon monoxide concentrations was more than 20 mg/m^3. This could be due to higher fuel consumption gasoline in vehicles, Oil industry, steel and Heavy industries in Ahwaz. Mortality and Morbidity risks were detected at current ambient concentrations of air pollutants.

Key Words: Carbon monoxide, Cardiovascular deaths, Mortality, Morbidity, Ahvaz.

INTRODUCTION

Epidemiological Researches of the air pollution has been asserted a consistent increased human health and the rate of death toll attributable to the air pollution. Several studies have demonstrated relation between on short and long term effects exposure to air pollutants with human health. The most important effects of air pollution include: increase rates hospital admissions, asthma attacks, cardiopulmonary disease, death and number of the years of life lost (1-16). United States National Ambient Air Quality Standards (NAAQS) lists air pollutants as Carbon monoxide, ozone, particulate matter, sulfhore dioxide, Nitrogen dioxide, and Lead (17). Carbon monoxide (CO) is a nearly ubiquitous product of incomplete combustion of carbon-containing fuels. Outdoor sources include motor vehicles; engines on motorboats, lawnmowers, chain saws, and other devices that require fossil fuel combustion; residential wood burning; improperly adjusted gas-burning and oil appliances; coal combustion; and tobacco smoking. In urban areas, the contributions of diesel and stationary source combustion are relatively small in relation to gasoline-powered engines. Carbon monoxide is an odorless, colorless, and tasteless gas that binds to hemoglobin with an affinity 250 times that of oxygen, thereby interfering with the systemic delivery of oxygen to tissues. In addition, binding of carbon monoxide to hemoglobin causes an all ostrich change in the conformation of the oxy hemoglobin complex that increases the oxygen affinity of the remaining binding sites and interferes with the release of O_2 at the tissue level. In addition, carbon monoxide binds to cytochrome oxidize, exacerbates cellular hypoxia, and binds to other extra vascular proteins that include myoglobin, cytochrome P-450, catalase, and peroxides (18-19). Exposure to carbon monoxide can reduce the oxygen-carrying capacity of the blood. People with several types of heart disease already have a reduced capacity for pumping oxygenated blood to the heart, which can cause them to experience myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina), when exercising or under increased stress. For these people, short-term carbon monoxide exposure further affects their body’s already compromised ability to respond to the increased oxygen demands of exercise or exertion (20). Dockery et al in cohort study has shown adverse health impact of long-term air pollution exposure in the Six US cities. This study demonstrated that chronic exposure to air pollutants is independently related to cardiovascular mortality (21). In similar work Mohammadi *et al.* studied the association between daily mortality and carbon monoxide levels in the Ahvaz in 2009 (22). Also Goudarzi *et al*. studied the association between daily mortality and carbon monoxide levels in the Tehran in 2009 (23). Zallaghi *et al*. studied the association between daily mortality and carbon monoxide levels in the Ahvaz, Bushehr and Kermanshah in 2010 (24). AirQ software was proved to be a valid and reliable tool to estimate the potential short-term effects of air pollution, predicts health endpoints attributed to criteria pollutants, and allows the examination of various scenarios in which emission rates of pollutants are varied (25). The purpose of this study was to assess the potential effects of carbon monoxide exposure on human health in Ahvaz city (located in south-western Iran) during year 2011.

MATERIALS AND METHODS

In this retrospective study, was used to assess the potential effects of carbon monoxide exposure on human health in Ahvaz city (located in south-western Iran) during year 2011. Data were collected through Ahvaz Meteorological Organization and Department of Environment. These data were on volumetric base. Health effects are being related to the mass of pollutants inhaled and this is why the AirQ model was on gravimetric basis. So, there was a paradox between AirQ model and ADoE data. Conversion between volumetric and gravimetric units was implemented for solving this problem (1). The most important part of analysis is data processing that encompasses modification of temperature and pressure, primary processing (the deletion, spreadsheet and synchronization), secondary processing (writing code and condition correction), formulation and filtering. We calculated cardiovascular deaths related to carbon monoxide by AirQ2.2.3 based on the utilizing relative risk, attributable proportion and baseline incidence from WHO data (1). This model is a valid and reliable WHO-proved tool to estimate the potential short term effects of air pollution. This model includes four screen inputs (Supplier, AQ data, Location, Parameter) and two output screens (Table and Graph) (2). For estimated of health impact attributable to the exposure of air pollution on the target population using AirQ model, that estimate the this impacts to specific air pollutants on a resident population in a certain area and period.

Description of Study Area

Ahvaz city, with a population of 1 million approximately, with an area of 8152 square kilometers, the capital city of Khuzestan Province is located between 48 degree to 49°29′ east of Greenwich meridian and between 31 degrees and 45 minutes to the north of the equator (2). From past to now, Ahvaz has been well known due to industries as well as environmental pollution. In the last decade, an anthropogenic source of air pollution (dust storm) has joined to other environmental problems (26). Physical, chemical and biological characteristics of dust storm and also identification of Hazardous Air Pollutants (HAPs) such as BTEX have been well documented (26-29). Social impacts of dust storm on Ahvaz citizens was also evaluated (30). Furthermore, health effect of air pollution in terms of nitrogen dioxide , ozone and particulate matter in most of megacities particularly Ahvaz was reported. So, we decided to assess health effects of carbon monoxide which has not studied yet (1, 2, 25, and 26). To perform this study data was taken from Ahvaz Department of Environment (ADoE). Stations were Naderi, Behdasht ghadim, Havashenasi, and Mohitzist.

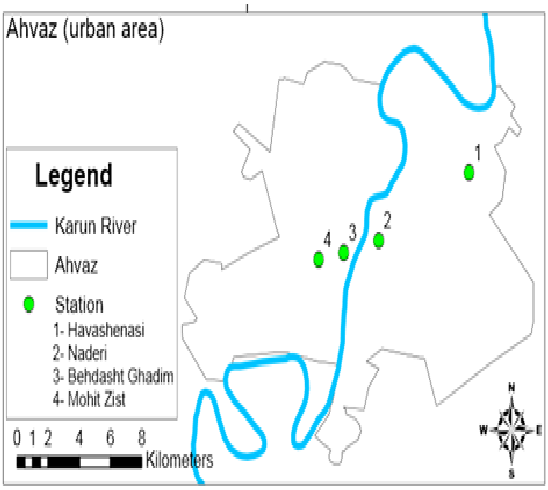

Fig 1: Location of the study area and sampling station in the Khuzestan Province (Ahvaz city), in the south west of Iran (31).

Data Analysis

AirQ model is based on statistical equations and epidemiological indices that were calculated using the following formulas:

$$\mathbf{AP = SUM\ \{[RR(c)-1] \times p(c)\}\ /SUM\ [RR(c) \times p(c)]}$$

Where p is the proportion of the population exposed, and RR is the relative risk of disease (risk in exposed/risk in non exposed, or R1/Ro)*.

Relative risk (RR) is the risk of an event (or of developing a disease) relative to exposure. It is calculated by dividing the incidence rate among those exposed to the factor by the incidence rate among those not exposed to the factor (32).

RR = Incidence in the exposed / Incidence in the non exposed

Attributable proportion was multiplied at baseline incidence and divided to 10^5. Obtained value should be multiplied at population (10^6). The results will be the excess cases of deaths and diseases associated with given pollutant (carbon monoxide). The primary standard of carbon monoxide according to National Ambient Air Quality Standard (NAAQS) 8-hour is 9 ppm (10.31 mg/m^3) (17, 1).

RESULTS AND DISCUSSION

The table 1 shows that annual average, summer average, winter average and 98 percentile of carbon monoxide concentration in Ahvaz. The Naderi and Havashenasi had the highest and the lowest carbon monoxide concentrations during 2011, respectively.

Table 1: Highest and lowest concentrations of Carbon monoxide (mg/m^3) corresponding to stations

Stations / Parameter	Average Ahvaz	lowest stations (Havasheni)	highest stations (Naderi)
Annual mean 24-hour	7.418	6.123	8.512
Summer mean 24-hour	8.021	5.763	9.823
Winter mean 24-hour	5.942	5.012	6.892
Percentile 98	24.326	18.143	38.23

Figure 2 show that summer 24-hour average of carbon monoxide in Ahvaz in 2011 was higher than NAAQS standards. In view of carbon monoxide concentrations, show that summer 24-hour average was the highest concentrations during this year respectively.

Relative risk and estimated Attributable Proportion percentage for cardiovascular deaths were estimated in table 2. According to model's default, the baseline incidence (BI) of this health endpoint for carbon monoxide was 497 per 105 so the number of estimated number of excess cases were estimated 16 at centerline of relative risk (RR=1.007 and AP=4. 1569%).

Cumulative cases of cardiovascular deaths related to carbon monoxide pollutant in people over 65 years has illustrated in Figure 3. This Figure shows three ranges of relative risk (down, mean, up). 16 persons were estimated as total cumulative number of cardiovascular death within people over 65 years in one year of exposure. 72% of these cases have occurred in days with carbon monoxide levels not exceeding 10mg/m^3. Also, Show that despite the relative risk of health effects of carbon monoxide concentrations below 2 mg/m^3due to lack of contact with the population concentration is zero In other words, no one day in 2011 has been reaches the carbon monoxide concentration below 2 mg/m^3. In this study, we estimate cardiovascular deaths were associated with short and long term fluctuations in concentrations of carbon monoxide pollutant in people over 65 years, using AirQ model in Ahvaz, Iran. Sum of Cardiovascular mortality attributed to carbon monoxide in Ahvaz was 16 cases in 2011. Results show that approximately Ahvaz with 4 percent is one of the most polluted cities. The higher percentage of these deaths perhaps could be the result of higher average carbon monoxide or because of sustained high concentration days in Ahvaz.

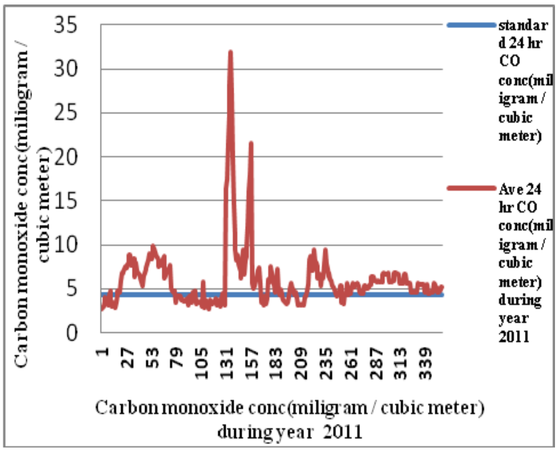

Fig 2: relationship between standard 24-hr average Carbon monoxide concentrations and 24-hr average Carbon monoxide concentrations in Ahvaz during year 2011

Table 2: Estimated relative risk indicators and the component attributable to Carbon monoxide in people over 65 years cases attributable to cardiovascular deaths (BI= 497)

Indicator / Estimate	RR (Medium)	Estimated AP (%)	Estimated number of excess cases (persons)
Down	1.002	1. 289	6.1
Mean	1.007	4. 1569	15.2
Up	1.012	7. 0196	23.4

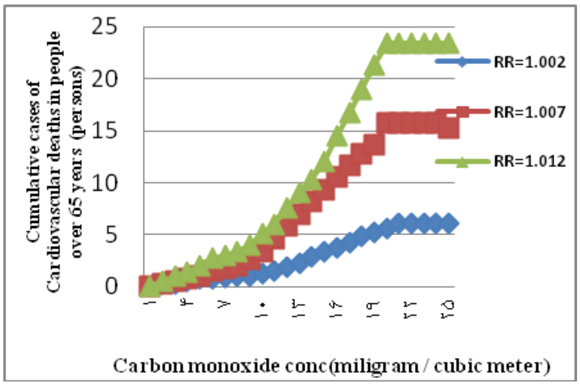

Fig 3: relationship between cumulative of Cardiovascular deaths related to Carbon monoxide pollutant in people over 65 years

Table 1 shows that the maximum 24-hour average of summer and winter of Naderi and Havashenasi were the highest and the lowest stations during this year respectively. Relative risk, the percentage, attributable ratio and the cardiovascular deaths attributed to the carbon monoxide is estimated in Table 2. According to table 2, the relative risk (RR) of cardiovascular deaths has increased 0.42 percent in lieu to each 1 mg increase of the carbon monoxide concentration. (0.22 percent per CI= 0.0/5 and 0.94 percent per CI= 0.95). Figures 2 to 3 have illustrated carbon monoxide concentrations versus related health endpoint and average concentrations in during years. Other researcher showed the association of daily mortality and morbidity with short-term variations in the ambient concentrations of air pollutants (33-34). Which are in similar work. Gudarzi *et al*. in 2009 estimate the carbon monoxide hygienic effects in Tehran (capital of Iran). Based on their results, almost 3.4% of all cases of whole cardiovascular deaths are attributed to carbon monoxide in people over 65 years (1). In another study, Mohamadi *et al*. in 2009 calculated health affects air pollutants in Ahvaz. Based on their results, approximately 3 percent of total cardiovascular deaths related to carbon monoxide in people over 65 years (2). Zalaghi *et al*. in 2010 Survey of health effects of air pollution Ahvaz, Bushehr and Kermanshah. Based on their results, approximately 3.5 percent in Ahvaz, 2.7 percent in Kermanshah and 0.4 percent of total cardiovascular deaths attributed to carbon monoxide in people over 65 years (24). Prescott *et al.* found effects of air pollution on cardiovascular and respiratory cause's mortality between the two age groups (fewer 65 yrs, over 65 yrs), daily all-cause mortality and respiratory mortality had statistically significant association with carbon monoxide (35). Bunnell & Horvath have shown that at COHb levels of7% and 10% related to carbon monoxide visual tracking performance can be significantly improved in resting conditions, but in contrast it is significantly impaired if the subjects engage in heavy exercise (36). According to one study there has been a 35% excess risk of death from arteriosclerotic heart disease among smoking and nonsmoking tunnel officers exposed to carbon monoxide, in which the long-term mean COHb levels were generally less than 5% (37).

CONCLUSSION

Based on the results of this study, 4% of all cardiovascular deaths were attributed to respiratory carbon monoxide in people over 65 years. Larger relative risks for air pollution were mostly found in the elderly except for carbon monoxide and for death-cause Cardiovascular which showed larger relative risk in people over 65 years. High percentage of the observed health endpoints was associated with high concentration of measured carbon monoxide, and as it was mentioned previously, carbon monoxide concentration was higher than NAAQS guidelines' values. In order to verify and compare the results with the actual results were referred to the registration center for disease But unfortunately because of lack and was not database quantities we used values of parameters required calculated by the from WHO (in Middle East). Although the results of this study are in line with results of other researches around the world, since the geographic, demographic, and climate characteristics are different, there is still high need to further studies to specify local RR and BI.

CONFLICT OF INTERSTS

Authors have no conflict of interests.

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