RESEARCH ARTICLE

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Association of Health Effects of Air Pollution on Chronic Obstructive Pulmonary Disease (COPD)

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Background & Aims of the Study: Lung is directly exposed to surrounding air and existing pollutants to perform its natural task. In this paper, COPD cases attributed to NO_2, O_3, and SO_2 were studied based on assessed data in Ahvaz city of Iran during 2014-2015.

Materials and Methods: Data were processed by Excel through steps including temperature and pressure correction, programming, processing (average) and filtering.

Results: The results indicated that number of COPD cases was estimated to 15 members in accordance with the central relative risk, so, each 10µg increase in NO_2 concentration would lead to 0.38% increase in COPD risk. Each 10µg/m^3 increase in Ozone concentration causes 0.58% increase in disease attributed to this pollutant. Number of cumulative cases of this disease has been equal to 35 members during 2014-2015. Estimated cumulative number of obstructive pulmonary caused by sulfur dioxide has been estimated to 20 members during 2014-2015. Obviously, each 10µg/m^3 increase in SO_2 concentration would lead to 0.44% increase in risk of the considered disease.

Conclusion: In conclusion, O_3 as a pollutant has the most effect on COPD compared to the other two pollutants in Ahvaz city of Iran during 2014-2015. This might be because of more days with high concentration of this pollutant compared to other two pollutants in Ahvaz. If emission of this pollutant is not prevented, number of people who are suffering from COPD will increase to 55 members in 2016 and it will be reduced to 13 members in case of control.

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Background

National Ambient Air Quality Standard (NAAQS) has introduced criteria pollutants of air including CO, NO_2, SO_2, PM_{10}, $PM_{2.5}$, O_3, and Lead (1-7). Each person breathes 10m3 air averagely per day; hence, it is required to investigate its effect on human who are exposing to it (8-14). The air is one of the important physiological needs of human and

other creatures; so, life without air is unimaginable (2,15-17). According to the report of World Health Organization in 2002, 3 million persons die per day due to air pollution, 300000 members out of them die in open urban spaces and the remained occurs in closed spaces. In fact, lung is directly exposed to the air and existing pollutants of it (1,3,18,19). Epidemiological studies conducted in last decade showed that the mortality rate associated with air pollution is increased. The considerable point is that at the occurrence time of dust phenomenon, cardiac diseases and pulmonary diseases have been increased by 12% and 14%, respectively (1,3,11,15,18,19). Hence, determining the effects of air pollution on general health has become a debatable issue. Population of Ahvaz is equal to one million people and is located in west-south part of Iran. Although, Ahvaz has been always exposed to air pollution caused by industry and transportation, the pollution raised from dust-storm has attracted attention of politicians and scientists; therefore, researches in this field are necessary (1,2,18,20,21). Among human-made air pollutants, SO_2 has been more considered in studies. More than 80% of SO_2 is emitted to atmosphere due to the fossil fuel consumption by people, while the share of power plant in this amount is about 85% and only 2% of it is the share of cars (22). SO_2 is treated as the major pollutant in many megacities. The amount of sulfur varies in fuels and petroleum products. The health effects of it include obstructed airways, bronchospasm, eye and respiratory tract irritation, reduced lung function and breathlessness, reduced depth of breathing, decreased lung immune system, cardiovascular and respiratory complications. Exposing to the concentrations of 1-5 ppm during 10 minutes causes breathlessness in some asthmatics. In concentrations of 0.5-1 ppm, the person suffers from wheezing and difficulty in breathing within 10 minutes. There was not any pulmonary symptom when the person was exposed to 0.3 ppm concentration for 120 minutes (18). The directive amount of SO_2, entitled 24-hourly (daily) average, is presented by WHO equal to 20µg/m^3 (8,18). Ozone is a powerful oxidizer as the secondary pollutant form which is affected by sunlight on nitrogen dioxide and oxygen molecules production of radicals in the troposphere (2,13). Formation formula of ozone at the earth level (the lower layer of the troposphere) is as follows:

VOC + NO_x+ Heat + Sunlight => Ozone

Maximum concentrations of ozone occur at noon and it is totally a summer pollutant (2,23,24). Maximum concentrations of ozone on the ground surface rarely continue for 2-3 hours. Ozone enters into body through breathing and there is not any other way for this pollutant entering to body. About 40% of ozone is absorbed in nose and throat and 60% of it reaches to depth of lung (2,13).

Ozone enters into the body through two mechanisms:

A) Oxidizing sulfhydryl, amino acids, enzymes, coenzymes, proteins and peptides

B) Oxidizing poly-unsaturated fatty acids to fatty acid peroxides.

The directive amount of air quality for 8-hours average of ozone is defined which is estimated to 100µg/m3 (13,24,25). Among 7 different oxides of nitrogen, NO and NO_2 have considerable effects on human and N_2O, as the greenhouse gas, is important in earth warming (8,15,26). This gas is produced by human resources such as automobile exhaustion and some other resources such as fossil fuels, power plants, industrial steam boilers, incinerators and heating appliances (27). The major source of NO_2 in urban areas is transportation. Concentration of NO_2 varies from morning to night. The directive amount of air quality for NO_2 is determined equal to 40µg/m^3 as the annual average. In particular, NO_2 harms lungs and causes respiratory diseases, irritation in lungs and reduction in immune system of respiratory against flu (28,29). Conducted studies on animals indicated that high concentrations of NO_2 seriously harms lung

tissue cells and is considered as a toxic gas with considerable health effects within short-term concentrations over 200µg/m^3 (8,22). Annual exposure to NO_2 increases the bronchitis symptoms in children with asthma and reduces pulmonary function of children. Some effects are as follows:

A-increase in meta-hemoglobin
B-preventing enzyme activity
C-Respiratory tract effects
D-general pathologic effects
E- Systematic effects.

Aims of the study:

The purpose of this study was the estimation of the health effects of air pollution on Chronic Obstructive Pulmonary Disease (COPD) in Ahvaz City (during 2014-2015).

Materials & Methods

Materials

The present research has been conducted to quantify and compare the effects of air pollutants (NO_2, SO_2, O_3) on COPD in Ahvaz city based on the model; using some information which are derived from Environment Protection Organization during 2014-2015. In this regard, the required raw data collected from Environment and Meteorological Organization; then, the data were processed through EXCEL and entered into AIR Q model by EXCEL. This model is a valid and reliable model which was introduced by World Health Organization in order to estimate short-term effects of air pollutants.

Data Collection

Information which is related to the concentration of three pollutants of NO_2, SO_2, and O_3 during 2014-2015 was taken from Environment Organization of Ahvaz in form of Excel file. Since, all stations for pollution assessment had no temperature sensor, the daily temperature and pressure information was collected from Ahvaz Meteorological Organization during 2014-2015.

Implementation steps

1- Providing input-file of model, using raw data.

To prepare this file, following steps were done, respectively:

1-1-Tempratue and Pressure correction and unit compliance with the model

1-2- Primary processing

This stage consists of removal, sheet classification of pollutants and time integration for average estimation.

1-3-Secondary processing

This stage consists of three parts including coding, calculating mean and condition modification.

1-4-Primary filtering

1-5-Secondary filtering

1-6-Quantification

To quantify air pollutants, Air Q software was employed. This software was presented by European Office of Environment and WHO in 2014 which is applied to quantify health effects of air pollution. This software consists of two quantification models and age tables. Quantification model is used in this paper.

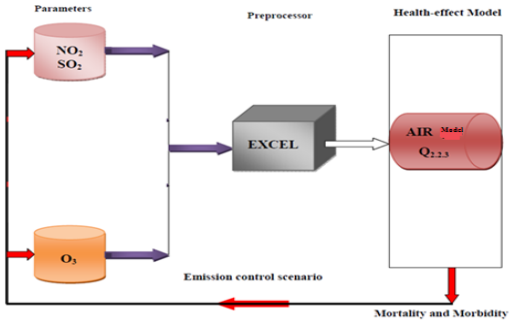

Figure 1) Research Schema

Characteristics of study area (Ahvaz City)

Ahvaz city with an area of 8152 square kilometers is located between 48 degrees to 49 degrees, 29 minutes east longitude of the Greenwich meridian and 30 degrees, 45 minutes to 32 degrees north latitude from the equator and center of Khuzestan province with a height of 18 meters above sea level (2,4,8,13). It has a warm and semi-humid climate. It has rainfall in winter while there is no rain in five

hot months of the year or it is low. Annual average of rainfall in this city is about 25ml and its maximum level is during December to February. Relative humidity of this area is approximately equal to 41.5% (2,4,8,13).

Results

The data file of air quality is created for each pollutant after processing of raw data. The following tables are related to indexes including Baseline Incidence, Relative Risk and Attributable Proportion (epidemiologic indexes) regarding selected health effect (COPD). After screening indexes in which, baseline incidence, relative risks and attributed proportion indexes are estimated, number of cases or cumulative numbers of one implication can be seen in table. Tables associated with COPD for three pollutants are indicated based on the tables of model. According to table 1, in terms of maximum seasons, summer and winter, all Meteorology stations and general office have had the highest and lowest concentrations during 2014-2015, respectively.

According to table 2, number of cases at central cumulative level estimated to 15 members.

According to table 3, in terms of one-hour average of seasons of summer and winter and the entire year as well as Meteorology station of Naderi office have had the highest and lowest concentrations during 2014-2015, respectively.

Table 1) NO_2 concentrations based on microgram per cubic meter to be used in model (Ahvaz- 2014-2015)

	station		
	Meteorology (maximum)	**Office (minimum)**	**Ahvaz**
annual average	74.46	31.59	51.53
summer average	55.12	19.78	37.29
winter average	94.56	43.85	66.32
98 percentile (annual)	316.97	134.67	130.03
annual maximum	415.43	398.96	179.54
summer maximum	202.61	187.20	106.01
winter maximum	415.43	398.96	179.54

Table 2) Estimation of relative risk, attributed proportion and cases attributed to NO_2 for COPD in Ahvaz during 2014-2015 (BI=101.4)

	index		
	RR (Medium)	**AP (%)**	**Estimated number of excess cases (persons)**
low	1.0004	0.1677	1.6
medium	1.0038	1.5704	15.4
high	1.0094	3.7969	37.3

Table 3) O_3 concentrations based on microgram per cubic meter to be used in model (Ahvaz- 2014-2015)

	station		
	Meteorology (maximum)	**Office (minimum)**	**Ahvaz**
maximum one-hour average annually	81.81	66.98	72.67
maximum one-hour summer average	84.38	78.87	84.38
maximum one-hour winter average	66.64	54.62	60.51
98 percentile (one-hour annually)	121.24	133.98	185.62

According to table 4, relative risk for cases related to COPD has been estimated to 1.0058 during 2014-2015 with an acceptable scientific certainty (to 1.0094 in CI=0.95, to 1.0022 in

CI=0.05) and attributed proportion percent was estimated to 3.52% (to 1.36% in CI=0.05, to 5.58% in CI=0.95).

Table 4) Estimation of relative risk, attributed proportion and cases attributed to O_3 for COPD in Ahvaz during 2014-2015 (BI=101.4)

	index		
	RR (Medium)	AP (%)	Estimated number of excess cases (persons)
low	1.0022	1.3653	13.4
medium	1.0058	3.5208	34.6
high	1.0094	3.5840	54.9

Table 5 indicates the average and maximum amounts during the year; summer, winter and annual percentile of SO_2 in Ahvaz during 2014-2015. SO_2 concentration both in Naderi and Ahvaz University stations had the highest and lowest average, maximum quarterly and annual amount, respectively.

According to table 6, indexes including relative risk, attributed proportion and excess cases to SO_2 for COPD has been estimated to 1.0044, 2.0093 and 20 members during 2014-2015, respectively.

Table 5) SO_2 concentrations based on microgram per cubic meter to be used in model (Ahvaz- 2014-2015)

	station		
	Meteorology (maximum)	Office (minimum)	Ahvaz
annual average	76.39	44.98	56.30
summer average	45.31	37.02	39.19
winter average	74.09	53.25	74.09
98 percentile (annual)	273.14	204.36	142.66
annual maximum	366.65	257.67	210.09
summer maximum	158.00	135.15	114.33
winter maximum	366.65	257.67	210.09

Table 6) Estimation of relative risk, attributed proportion and cases attributed to SO_2 for COPD in Ahvaz during 2014-2015 (BI=101.4)

	index		
	RR (Low)	AP (%)	Estimated number of excess cases (persons)
low	1	0.000	0.00
medium	1.0044	2.0093	19.7
high	1.011	4.8763	47.9

Discussion

According to low amounts of attributed proportion for COPD in table 2, the relative risk is at low level (5%) and the number of persons at central cumulative level is estimated to 15 members (8 members increase compared to 2012-2013). The most numbers of deaths (15.56%) attributed to NO_2 has occurred in 50-60µg/m3 concentration and 1.57% of hospital admissions for COPD is attributed to concentrations which were more than 20µg/m^3. Each 10µg/m^3 increase in NO_2 concentration would lead to 0.38% increase in risk of this disease. Also, according to table 4, relative risk for cases of COPD attributed to O_3 has been estimated to 1.0058 during 2014-2015 with an acceptable scientific certainty (to 1.0094 in CI=0.95, to 1.0022 in CI=0.05) and attributed proportion percent estimated to 3.52% (to 1.36% in CI=0.05, to 5.58% in CI=0.95). With each 10µg/m^3 increase in O_3 concentration, the risk of this disease would increase by 0.58% in

CI=0.05 and 0.94% in CI=0.95. Cumulative number of this implication has been 35 members during 2014-2015 (10 members decrease compared to 2012-2013) and (13 members in CI=0.05 and 55 members in CI=0.95) while 83% of outpatient referrals for COPD attributed to O_3 are related to days with concentration lower than 110µg/m^3. Indexes including relative risk, attributed proportion and excess cases to SO_2 for COPD have been estimated in table 6. Equality of low estimation of relative risk to 1 indicates ineffectiveness of SO_2 in heath effect creating. Estimated cumulative number of patients referred to hospital due to exposure to high concentration of 20µg/m^3 of SO_2 estimated to 20 members during 2014-2015, with a 0.2% increase compared to 2012-2013. Obviously, per 10µg/m^3 increase in SO_2 concentration would lead to 0.44% increase in risk of COPD.

Biggeri et al in 2001 in 6 Italian cities studied the health effects of SO_2. They showed that an increase of 10µg/m^3 in SO_2 was associated with an increase of 2.4% in COPD and hospital admissions respiratory disease (30). Also, Lipmann et al reported that an increase of 10 µg/m^3 in the sulfur dioxide was associated with an increase of 2% in hospital admissions (31).

The results of this study showed that the concentration of sulfur dioxide in Ahvaz was higher than Italian cities and Detroit, USA. A similar work evaluates the health effects of ozone; using Air Q model in south west of Iran (kermanshah-bushehr) during 2010 by Zallaghi et al (32). They reported that in Kermanshah, 8.7 percent of COPD and respiratory mortalities was attributed to GLO concentrations over 20 µg/m^3 (32). Result of our study showed that number of cases of health effects was relatively higher because of a greater concentration in Ahvaz city. Goudarzi et al in another study estimated the cardiopulmonary mortalities and COPD related to ozone air pollution; using air Q model in Ahvaz city (33). Based on their results, concentrations over 20 µg/m^3 was responsible to 10.8 percent of all cardiopulmonary mortalities and COPD (33). The geographic, demographic, and climate characteristics can be the reasons of this similarity.

Conclusion

In conclusion, O_3 as a pollutant has the most effect on COPD compared to other two pollutants in Ahvaz city of Iran during 2014-2015. This might be because of more days with high concentration of this pollutant compared to other two pollutants in Ahvaz. According to table 4, if emission of this pollutant is not prevented, number of people who are suffering from COPD will increase to 55 members in 2016 and it will be reduced to 13 members in case of control. It is recommended for further studies to examine the matter related to emissions reduction scenarios (Euro 1-4); using AIR Q model and the effect of emission reduction scenarios as the third base of health plan in polluted megacities

Footnotes

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Conflict of Interest:

The authors declared no conflict of interest.

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