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The impact of air pollution on hospital admission for respiratory and cardiovascular diseases in an oil and gas-rich country

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KEY WORDS

Epidemiology, air pollution, PM10, SO2 and O3 pollutant, Qatar, respiratory and coronary heart diseases

SUMMARY

Objectives: Aim of this study was to evaluate the impact of air pollution on hospital admissions for respiratory and cardiovascular diseases in an oil rich developing country, State of Qatar. **Methods:** A prospective cohort population based study was conducted at different stations of Qatar during the period (2002–2005) for recording the concentration of air pollutants daily for sulphur dioxide (SO₂), nitric oxide (NO), nitrogen dioxide (NO₂), carbon monoxide (CO), ozone (O₃) and particulate matter (PM₁₀). Hospital admission data were collected from the inpatient discharge database of the Medical Records Department, Hamad General Hospital. **Results:** An average of 5.36 admissions from ischemic heart diseases was counted daily in all the population which was even higher than the respiratory diseases (3.4/day). Minimum temperature was inversely correlated with all pollutants except for O₃ and SO₂. **Conclusion:** There was an association between increasing air pollutant levels and patients admitted for respiratory and cardiovascular diseases.

Introduction

Air pollution and its public health impacts are drawing increasing concern from the environmental health research community, environmental regulatory agencies, industries as well as the public. The quality of the air, both indoors and outdoors, is closely related to morbidity and mortality from respiratory and cardiovascular diseases. Air pollution is composed of many environmental factors which include Carbon Monoxide (CO), Nitrates, Sulphur dioxide (SO₂), Ozone (O₃), lead, tobacco smoke and Particulate Matter. Urban atmospheric pollution has a well-known impact on acute and chronic respiratory disease (1). The United Nations estimated that over 600

million people in urban areas worldwide were exposed to dangerous levels of traffic generated air pollutants (2). Air pollution and its impact on human health have been considered a serious problem in urban areas.

At the present time, motor vehicle emissions are the main source of urban pollution than other sources such as heating and industrial activities. Daily levels of air pollutants have been associated with increased daily mortality and morbidity. The time series studies in North America have indicated that particles and ozone are related to emergency hospital admissions for respiratory conditions (3). Some studies showed strong correlations between air pollutants levels and causes of morbidity with respiratory and cardiovascular diseases (4–11). Also, a study reported as-

sociation between ambient carbon monoxide levels and hospitalizations for congestive heart failure in the elderly in (10) Canadian cities (12,13), air pollution and hospital admissions for cardiovascular disease in Tucson (14) and stroke in Kaohsiung, Taiwan (15) and effects of temperature and air pollutants on cardiovascular and respiratory diseases for males and females older than 65 years of age in Tokyo (16). There is substantial epidemiological evidence indicating a link between respiratory and cardiovascular morbidity and outdoor air pollution levels.

Air pollution in the State of Qatar originates mostly from motor vehicle traffic and industry. As a result, concentrations of CO, NO₂, O₃, and airborne particles are generally high. Expanding industrialization and increasing traffic volumes in the developing countries will drastically increase total emissions of many air pollutants as has been predicted by a study in East Asian Country (17). Hence, the present study was designed to investigate the air pollution and evaluate the impact of air pollution on hospital admissions for respiratory and cardiovascular diseases in Qatar.

Subjects and methods

This is a prospective cohort population based study aiming to investigate the air pollution and the impact of air pollution on respiratory and cardiac diseases in the State of Qatar during the period (2002 – 2005). The State of Qatar is located halfway along the western coast of the Arabian Gulf. The length of the peninsula from south to extreme north is about 160 km, and the total area including the islands is about 11493sq.km. The population estimate of Qatar for the year 2005 was 796186. Doha is the capital and commercial centre of the country. Mesaieed as the second important town is a modern industrial town. Qatar is characterized by a hot summer starting from June till August. Winter is warm with little rainfall. It starts from December to February; Spring starts from March to May; and Autumn starts from September to November.

Data on Air quality and weather

Data on six air pollutants CO, NO₂, NO, O₃, SO₂, PM₁₀ were obtained from the Environmental health department of the Qatar Petroleum. There were stations for monitoring general air quality across the territory and we have taken the readings from the important stations of the urban areas. The hourly concentration record of each

air pollutant from each individual station was retrieved during the period 2002 – 2005 and the daily mean of each air pollutant was calculated. Pollutant concentrations are obtained from 24-h average (starting at 4:00 P.M. of the preceding day). Meteorological data including temperature and humidity were obtained from the department of Meteorology, Civil Aviation Department.

Hospital admissions data

In the State of Qatar, there are five government hospitals under the umbrella of the Hamad Medical Corporation (HMC) managing 1567 beds and accounts for 90% of all hospital admissions. These hospitals provide in-patient services for all residents of Qatar and are the main tertiary care centers in the country making an ideal center for population-based studies. All hospital inpatient data including demographic characteristics, dates of admission and discharge, diagnoses and procedures on discharge using the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM), have been stored in a central-computerized database in the Medical Records departments. We have retrieved the data on monthly hospital admission during the study period for respiratory diseases including Pneumonia and Asthma [(460-466), (480-486), (490-492), & (493-496)], Ischemic heart disease (410-414) and Cardiovascular illness [(420-438) & (440-444)].

Statistical Analysis

Student-t test was used to ascertain the significance of differences between mean values of two continuous variables and confirmed by non-parametric Mann-Whitney test. One-way analysis of variance (ANOVA) was employed for comparison of several group means and to determine the presence of significant differences between group means of continuous variables. Multiple regression analysis was used to assess the relationship between the dependent variable and independent variables. Pearson's bivariate correlation was utilized for association between continuous variables. The level $p < 0.05$ was considered as the cut-off value for significance.

Results

Table 1 shows the summary of environmental variables and daily hospital admissions during the study period (2002 – 2005). A daily average of 3.4 respiratory diseases, 3.53 cardiovascular diseases, 5.36 Ischemic heart

diseases were observed in the study period. An average of 5.36 admissions from Ischemic heart diseases was counted daily in all the population which was even higher than the respiratory diseases (3.4/day).

Table 2 presents the day-to-day correlation between Air Pollution and Meteorological Measures. The concentrations of CO and NO₂ were highly correlated with other pollutants. PM₁₀ and SO₂ were weakly correlated with other pollutants. Minimum temperature was inversely

Table 1 - Summary of environmental variables and daily hospital admission from the respiratory and cardiovascular diseases 2002-2005

Variables	Daily Mean	Percentiles			Maximum
		25th	50th	75th	
Pollutant variable					
CO [ppm]	1.01	0.65	0.87	1.10	5.04
NO ₂ [ppm]	0.033	0.022	0.030	0.039	0.111
NO _x [ppm]	0.019	0.003	0.009	0.023	0.120
O ₃ [ppm]	0.027	0.015	0.027	0.039	0.098
SO ₂ [ppm]	0.005	0.002	0.004	0.041	0.113
PM ₁₀ (Îg/m ³)	98	47	73	264	495
Environmental variable					
Temperature [C]	26.25	20.60	26.90	31.70	46.85
Humidity [%]	59.58	47.55	64.00	75.70	86.40
Hospital admissions					
(All ages)					
Respiratory	3.40	4.79	6.21	6.93	4.82
Cardiovascular illness	3.53	3.29	3.54	3.80	3.88
Ischemic Heart diseases	5.36	5.16	5.29	5.61	5.74

Table 2 - Day-to-day correlation between Air Pollution and Meteorological Measures

Variable	CO	NO ₂	NO	O ₃	SO ₂	PM ₁₀	Tmin	Hmed
CO	1.00							
NO ₂	0.882*	1.00						
NO	0.679*	0.385*	1.00					
O ₃	0.378*	0.380*	0.283*	1.00				
SO ₂	0.581*	-0.350*	0.270†	0.213*	1.00			
PM ₁₀	0.753*	0.726*	-0.190	0.132†*	0.054	1.00		
Tmin	-0.191*	-0.264*	-0.030†	0.274*	0.111†	-0.219†	1.00	
Hmed	-0.182*	0.234*	0.031†	-0.323*	-0.228*	-0.317*	-0.663*	1.00

Tmin: Minimum temperature; Hmed: Relatively humidity

†p<0.05

*p<0.01

correlated with all pollutants except for O₃ and SO₂. But, humidity was inversely correlated with all the air pollutants except for NO and NO₂. The critical air pollutants in urban areas of Qatar were CO and NO₂.

Table 3 presents the effect of meteorological factors on the air pollutants in Qatar. There was a highly significant association between meteorological factors and air pollution.

Table 4 shows the trend in concentration of air pollutants and the number of daily admissions from respiratory and cardiovascular diseases during the study period 2002-2005. As there was a slight increase in the concentration of air pollutants in the year 2005, the daily admissions from the respiratory, Ischemic heart diseases and cardiovascular diseases also increased slightly.

Discussion

Exposure to air pollution has been considered to be one of the leading factors in public health problems in developing and oil-rich developing countries. This problem has long been the focus of attention in developed countries and their exposure rates have been greatly reduced whereas, relatively, there has not been much effect in reducing the magnitude of the problem in oil-rich developing countries. Documentation of air pollution and sources in the State of Qatar has never been reviewed in terms of its effect on health. No research by means of a population-based study has been conducted in order to define the important epidemiological characteristics of air pollution in human health.

Many authors have reported the effects of air pollutants on the cardiovascular system (4, 16). Carbon monoxide

Table 3 - The effect of meteorological factors on the air pollutants in Qatar

Pollutants	Meteorological factors				Sig. of F	R-sq
	Wind Speed	Wind direction	Temperature	Relative humidity		
SO ₂	0.001 (-4.6)*	NS	0.013 (-2.6)	0.001 (-4.2)	0.001	58.2%
NO	0.001 (-5.9)	NS	0.001 (-3.7)	NS	0.0001	75.8%
NO ₂	NS	0.002 (3.3)	0.001(-4.1)	0.019 (-2.5)	0.0001	69.4%
O ₃	0.001 (3.7)	0.007 (2.9)	0.001 (-3.9)	NS	0.0001	67.2%
CO	0.001 (-5.4)	0.001 (4.2)	NS	NS	0.0001	67.1%
PM ₁₀	NS	0.025 (2.6)	0.002 (3.4)	NS	0.0001	73.6%

* Significance *p*-value and Student *t*-test

NS = Not -significant

† One-Way Analysis of variance and *p*-valu

Table 4 - The trend in concentration of air pollutants and the number of dailyadmissions from respiratory and cardiovascular diseases, 2002 - 2005

Variables	Yearly average			
	2002	2003	2004	2005
Air pollutants				
CO	1.070	1.050	1.13	1.19
NO ₂	0.027	0.030	0.032	0.033
NO	0.013	0.015	0.028	0.029
O ₃	0.028	0.025	0.027	0.029
S ₀₂	0.004	0.004	0.005	0.006
PM ₁₀	91.00	99.00	105.00	111.00
Hospital Admissions				
Respiratory diseases	4.428	5.121	5.064	5.300
Cardiovascular diseases	3.419	3.368	3.400	3.914
Ischemic Heart diseases	5.218	5.359	5.247	5.599

(CO) is a well recognised cardiovascular toxicant and its association with the exacerbation of Angina and Myocardial infarctions has already been reported (12, 18, 19). Another study reported that in Hong Kong and London SO₂ was associated with increases in cardiovascular disease hospital admissions (8). An increase in SO₂ was associated in more than one-third of the studies with increased hospital admissions for myocardial infarction, angina, or Ischemic heart disease (9). Also, the effects of particulate and gaseous air pollution on cardio respiratory hospitalizations was reported by Burnett et al. (20). It was found from our data that an average of 5.36 admissions

from Ischemic heart diseases was counted daily during the study period. Daily admissions of other cardiovascular diseases were 3.53 admissions. Also in our study, the data revealed that as the concentrations of CO, SO₂, increased in the year 2005, the admission of Ischemic and cardiovascular diseases also increased slightly in the same year.

CO and NO₂ have become a major air pollution problem in the urban areas of Qatar, resulting from, ongoing construction nearby, demolition activities, busy traffic, atmospheric chemical reactions, sea spray, and wind-blown sands. The air pollution data in the present study showed that the concentration of CO and NO₂ was highly correlated with other pollutants. But, PM₁₀ and SO₂ were weakly correlated with other pollutants. This is in consistent with the results reported by Burnett et al. (20) in ten Canadian Cities. In contrast, in south Boston, the concentrations of PM_{2.5} and PM₁₀ were highly correlated. CO and NO₂ were moderately correlated with PM₁₀ (21).

Among the gaseous pollutants, NO₂ and O₃, which are powerful oxidating agents, may also trigger an inflammatory pulmonary, then systemic reaction with an increase of blood coagulability and platelets (22, 23). The data showed that as the concentrations of NO₂ and O₃ increased, there was an increase in the number of admissions from respiratory diseases. This shows a positive association between air pollution and respiratory diseases, as has been reported elsewhere (24). These findings are supported by similar associations between hospitals admissions for respiratory diseases and mortalities that have been reported in a study done in China (9).

This study indicated the importance of following points: Developing a new control strategy to manage and improve air quality. Consideration should be given to the fu-

ture expansion of towns and cities towards industrial emission sources, and the potential effect on air quality of residential areas as a possible consequence. Enforcement of legislation and punishment of polluters is important according to type and intensity of pollution. It is good to establish educational programs for factory managers and workers to increase air pollution awareness. Furthermore, forming collaboration between the Municipality, Environmental Protection Agency and the National Health Authorities with regard to the effect of air pollution on human health is important for the future safety.

Conclusions

The present study findings showed that there was a significant association between the pollutants and meteorological conditions. Also, an association was found between increasing pollutant level and patients admitted for respiratory and cardiovascular diseases. Results showed that the critical air pollutants in the urban areas of Qatar were CO and NO₂.

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