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Impact of Middle Eastern Dust storms on human health

Yusef Omidi Khaniabadi [a, b, *], Seyed Mohammad Daryanoosh [c], Abdeltif Amrane [d], Riccardo Polosa [e, f], Philip K. Hopke [g, h], Gholamreza Goudarzi [a, i], Mohammad Javad Mohammadi [j, k], Pierre Sicard [l], Houshang Armin [m]

[a] Air Pollution and Respiratory Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[b] Health Care System of Karoon, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[c] Health Center of Hendijan, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[d] Ecole Nationale Supérieure de Chimie de Rennes, CNRS, UMR 6226, 11 allée de Beaulieu, CS 50837, 35708, Rennes Cedex 7, France
[e] Department of Clinical and Experimental Medicine, University of Catania, Catania, Italy
[f] Institute of Internal and Emergency Medicine, Teaching Hospital 'Policlinico-Vittorio Emanuele', Catania, Italy
[g] Center for Air Resources Engineering and Science, Clarkson University, Potsdam, NY, 13699, USA
[h] Department of Public Health Sciences, University of Rochester School of Medicine and Dentistry, Rochester, NY, 14619, USA
[i] Environmental Technologies Research Center (ETRC), Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[j] Abadan School of Medical Sciences, Abadan, Iran
[k] Student Research Committee, Department of Environmental Health Engineering, School of Public Health and Environmental Technologies Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
[l] ACRI-HE, 260 route du Pin Montard, Sophia-Antipolis, France
[m] Health Center of Ilam, Ilam University of Medical Sciences, Ilam, Iran

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ABSTRACT

Air pollution is emerging as a significant risk factor for human health in developing countries, particularly in Iran where air pollutant concentrations are elevated. Currently, knowledge of health effects of air pollution in developing countries is limited. The objective of this study was to estimate the excess number of hospitalizations for Chronic Obstructive Pulmonary Disease (COPD) and the number of excess cases of Respiratory Mortality (RM) associated with daily averages levels of particulate matter less than 10 μm in diameter (PM_{10}) in Ilam (Iran) over 1-year period (2015–2016). The excess instances of COPD and RM were estimated based on relative risk (RR) and baseline incidence (BI). The numbers of excess cases for COPD and RM during normal, dusty and Middle Eastern Dust (MED) storm days were 60 and 5, 200 and 15, and 78 and 6 persons, respectively. The results also showed that about 4.9% (95% CI: 3.0–6.8%) of hospital visits for COPD and 7.3% (CI: 4.9–19.5%) of RM could be attributed to 10 $\mu g/m^3$ increase in PM_{10} concentration, respectively. It was found that a higher number of people were admitted to hospital when PM_{10} concentrations exceed 200 $\mu g/m^3$ related to the MED events. Significant exposure to air pollutants, particularly during MED event, led to an excess of hospital admissions for COPD and an excess of the respiratory mortality. Several immediate actions such as strategic management of water bodies or planting of tree species in suburbs particularly bare area around the city could be effective to mitigate the impact of desert dust on respiratory illness.

1. Introduction

Many studies have shown that airborne particulate matter (PM) is a harmful airborne pollutant adversely affecting cardiovascular health and has respiratory health effects (e.g. USEPA, 2009; Crooks et al., 2016). PM pollution is ubiquitous with direct emissions and also generated as secondary aerosol from biogenic and anthropogenic precursors (Sarigiannis et al., 2015). Airborne particles were

* Corresponding author. Air Pollution and Respiratory Diseases Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
E-mail address: yusef_omidi@yahoo.com (Y.O. Khaniabadi).
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characterized by measuring the PM with aerodynamic diameter less than 10 μm (PM_{10}) because below this size, particles can penetrate into the lung where they may have elicit harmful effects and strongly contributing to the health end-points observed in urban environments (WHO, 2006; Sicard et al., 2010, 2011; Martinelli et al., 2013; Zhou et al., 2014; Neisi et al., 2016).

Incidences of dust storms have increased in recent years and there is evidence that these dusts can move across long distances (Crooks et al., 2016). Indeed, in the last decades, southern, western, and southwestern Iran was frequently affected by Middle Eastern Dust (MED) storms, increasing the number of dusty days as well as the daily PM_{10} mean concentrations (Goudie, 2014; Nourmoradi et al., 2016). These dust storms provide not only long-range transport of crustal particles (Kellogg and Griffin, 2006) but also were reported to carry several pathogenic and non-pathogenic microorganisms (including *Mycobacterium, Brucella, Aspergillus, Cladosporium, Coxiella Burnetii, Mycobacterium, Actinomycetes, Clostridium perfingens, and Bacillus),* toxins and influenza viruses (Chen et al., 2010a; Griffin, 2007; Leski et al., 2011; Goudie, 2014; Soleimani et al., 2015, 2016). Furthermore, metallic elements are bound to inhalable dust particles, and they could potentially affect respiratory function (Hong et al., 2010; Naimabadi et al., 2016).

Kanatani et al. (2010) found that in Japan, Asian Dust Storms (ADS) worsen diseases such as asthma exacerbation in children and caused increased morbidity. Chien et al. (2012) found that there was a significant association between dust events and clinical hospitalizations due to respiratory diseases in children in Taiwan (Chien et al., 2012). Yang (2013) found that asthma, pneumonia, and tracheitis are caused by ADS in East Asia (Yang, 2013). Epidemiological studies showed that high levels of airborne particles cause cardiovascular diseases such as myocardial infarction, stroke, heart failure, and venous thromboembolism (Martinelli et al., 2013; Crooks et al., 2016). Yang et al. (2005) and Kang et al. (2013) found that ADS were associated with an acute increase in hospital visits in Taiwan (Kang et al., 2013; Yang et al., 2005). In Cyprus, Middleton et al. (2008) found that cardiovascular visits increased after dust episodes (Middleton et al., 2008). Neophytou et al. (2013) reported that there was a 2.4% increase in daily cardiovascular mortality associated with a 10 $\mu g/m^3$ increase in PM_{10} levels during African Dust days (Neophytou et al., 2013).

Although quantification of exposure to MED was conducted on the adjacent of Ilam (i.e. Kermanshah, Marzouni et al., 2016), the main objective of present work was to assess impact of MED through an ecological study on the excess number of hospital admissions due to Chronic Obstructive Pulmonary Disease and on the excess of the Respiratory Mortality over the 1-year period (2015–2016) in the Iranian city of Ilam, which is frequently exposed to desert dust.

2. Material and methods

2.1. Study area

Ilam is a non-industrialized city with a population of 172,213 inhabitants in the center of Ilam Province, located in western Iran (Fig. 1). Ilam has a cold semi-arid climate with an elevation of 1387 m above the sea level. The mean annual precipitation is 619.5 mm with minimum and maximum temperatures of −13.6 °C and 41.2 °C, respectively. The Zagros Mountains enclose the city on three sides. The MED storms come from the desert areas of western Asia particularly Iraq and Saudi Arabia. During some storm days, the visibility can be reduced to 200 m.

2.2. Particulate matter sampling

To measure particulate matter, one air pollution-monitoring site (33°36′N, 47°22′E) has been established; its maintenance and operation is realized by the Ilam Environmental Protection Agency (IEPA). The hourly PM_{10} levels were determined for one-year daily monitoring using the beta attenuation method. Hourly PM_{10} concentrations from January 2015 to January 2016 were obtained from IEPA. The daily 24-h averages were calculated from more than 75% of validated hourly data.

2.3. Air quality health impact assessment

In this study, AirQ2.2.3 software, developed by the World Health Organization (WHO), was used to assess hospitalizations for Chronic Obstructive Pulmonary Disease (COPD) and the Respiratory Mortality (RM). Following the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), J00-J99 is associated to diseases of the respiratory system, RM corresponds to ICD-10 codes J100-J118, J120-J189, J209-J499, and J690-J700 and J44 code is associated to COPD.

AirQ is a tool enabling the assessment of the health effects of exposure to a common air pollutant in a defined region over a given time period (Khaniabadi et al.,2017; Fattore et al., 2011; Omidi et al., 2016; Yari et al., 2016; Goudarzi et al., 2016; Geravandi et al., 2015). The attributable proportion (AP) is defined as the fraction of health consequences in a population exposed to a specific air pollutant (Khaniabadi et al., 2016; Goudarzi et al., 2015a). The AP can be calculated as:

$$AP = \sum([RR(c) - 1]*P(c)) \Big/ \sum[RR(c)*P(c)] \qquad (1)$$

where AP is the attributable proportion of the health impact, RR is the relative risk for a certain health impact in category “c” of exposure taken from prior epidemiological studies, and P(c) is the population proportion in category “c” of exposure.

Relative risk (RR) is the attributable health risk associated with people who have defined exposures and can be calculated by means of Eq. (2):

$$RR = \frac{\text{Probability of a outcome in population exposed to pollutant}}{\text{Probability of the same outcome in population not exposed to pollutant}} \qquad (2)$$

The number of each case per population unit can be estimated as follows when the baseline frequency of the specific health impact in the population is known.

$$IE = I*AP \qquad (3)$$

where IE is the incidence of exposure which is the frequency of exposure within a given concentration level and I is the baseline incidence which is the baseline frequency of the given outcome in

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