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Medical Full Length Article

Respiratory effects of long-term exposure to dust outbreaks

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Previous considerations of health effects attributable to air pollution exposure have been extensively assessed. Current study focused on reviewing the literature to determine association between prolonged dust outbreaks and respiratory dysfunction, independent of other risk factors as smoking habit, mining industry or in any other dusty occupation with a group of local controls who were not exposed. Frequent long-term dust exposure produced by global warming, climate changes, desertification, and other environmental factors, and its respiratory health effects correlated with the duration and number of dust storm days, composition of dusts whether heavy metals and microorganisms in atmospheric dust, particulate air pollution, accumulation of atmospheric dust in soil and water, precipitation, wind velocity, temperature, and geography region is discussed . Longitudinal studies are needed to investigate on human clearance rates, physical and chemical properties, biological toxicity, distribution and adverse effects of dust on lung, and changes of lung function. In addition to continuous monitoring, public health interventions and preventing the mechanism of generation process of air pollution locally according to its cause, we need to set design regional public health agencies to research on chemical constituents, its metrics, deposition fractions of inhaled dusts, as well as degree of pollution and implementing strategies for environmental protection measures to control them. In this review, the results of different epidemiological and toxicological studies on regional air quality are summarized. Understanding the geographic variations of air pollution and their intervention modeling would enable us to construct national and global methods strategies for improving pollution control and reducing burden of pulmonary disease .

Keywords: Long-term dust exposure, pollutants generated from the dust compounds, epidemiology, components, distribution, health side effects

INTRODUCTION

Billions of tons of desert dust move through the atmosphere each year. The primary source regions, which include the Sahara and Sahel regions of North Africa and the Gobi and Takla Makan regions of Asia, are capable of dispersing significant quantities of desert dust across the traditionally viewed oceanic barriers (1). Dust storms have a number of impacts upon the environment including radiative forcing, and biogeochemical cycling. They transport material over many thousands of kilometres. In recent years the identification of source areas for dust storms has been an important area or research, with the Sahara (especially Bodélé) and western China being recognized as the strongest sources globally (2). Desert dust is estimated to constitute about 35% of aerosol in the troposphere. Desertification, climatic variability and global warming all can contribute to increased dust formation (3). Desert winds aerosolize several billion tons of soil-derived dust each year, including concentrated seasonal pulses from Africa and Asia. These transoceanic and transcontinental dust events inject a large pulse of microorganisms and pollen into the atmosphere and could therefore have a role in transporting pathogens or expanding the bio geographical range of some organisms by facilitating long-distance dispersal events. Huge dust events create an atmospheric bridge over land and sea, and the micro biota contained within them could impact downwind ecosystems. Such dispersal is of interest because of the possible health effects of allergens and pathogens that might be carried with the dust (4). Sand and Dust storms are common phenomena in arid and semi-arid areas. West Asia Region, especially Tigris-Euphrates alluvial plain, has been recognized as one of the most important dust source areas in the world. The identification of SDS (Sand and Dust Storms) source areas and paths will improve our understandings on the mechanisms and impacts of dust storms on socio-economy and environment of the region (5). The Middle Eastern city of Tehran, Iran has poor air quality compared with cities of similar size in Europe and North America. In 2010, the entire population of Tehran lived in areas where the World Health Organization guidelines for 24-hour mean SO2 (7 ppb) and annual average PM10 (20 µg/m(3)) were exceeded (6). Dust storms in north China, which are associated with land deterioration from increasing human pressures, have intensified over the past decades. Sand stabilization and control projects may be compromised by the pursuit of short-term economic returns and lack of systematic and integrated understanding of land degradation. A policy of long-term ecologically sustainable development strategies is needed as well as a scientific research initiative combining biophysical and socioeconomic aspects (7).

In this review the impact of dust on air quality and health among different populations would be assessed.

METHODOLOGY

A review of literature was performed in 2015 to summarize scientific reports on the relationship between long-term dust exposures to respiratory dysfunction. Articles searched indexed in the PubMed database for medical journals. Papers published during recent years (1993-2015) were searched by using the following air pollution, chronic dust exposure, Asian dust, desert dust, health side effects, hospital admission, morbidity, mortality, pulmonary dysfunction. Also, we stratified our analyses by geographical region and composition of dusts . A total of 240 studies were identified and 98 were selected for review .

Dust outbreaks studies according to geographic region and its source

In recent years, Asia has experienced rapid economic growth and a deteriorating environment caused by the increasing use of fossil fuels. The results of a study demonstrated that air pollution in Asia is a significant public health burden, especially given the high concentrations of pollutants and high-density populations in major cities (8). With the recession of the Aral Sea in Central Asia, once the world's fourth largest lake, a huge new saline desert emerged which is nowadays called the Aralkum. Saline soils in the Aralkum are a major source for dust and salt storms in the region (9). Asian dust, called 'kosa' in Japan, is the long-range transport of atmospheric pollutants originating from the desert areas of China and Mongolia. Although Asian dust has a long history of appearing in Japan, it is only quite recently that there is increasing concern for its possible adverse health effects. Well-designed epidemiological studies are required to clarify any potential health effects of Asian dust events in Japan (10).

Many types of aerosols have lifetimes long enough for their transcontinental transport, making them potentially important contributors to air quality and climate change in remote locations. The mass of aerosols arriving at North American shores from overseas is comparable with the total mass of particulates emitted domestically. Curbing domestic emissions of particulates and precursor gases, therefore, is not sufficient to mitigate aerosol impacts in North America. The imported contribution is dominated by dust leaving Asia, not by combustion-generated particles. Thus, even a reduction of industrial emissions of the emerging economies of Asia could be overwhelmed by an increase of dust emissions due to changes in meteorological conditions and potential desertification (11).

In a study, based on a systematic review of the literature using the ISI Web of Knowledge database, they found 231 articles published over the last decade on the desert dust impacts on air quality. Of these, 48% concerned Asian dust and 39% Saharan dust, with the remaining 13% divided between the other dust source areas (12).

Recently, special attention has been given to mineral dust particles, which may be a serious health threat. The main global source of atmospheric mineral dust is the Sahara desert, which produces about half of the annual mineral dust. Sahara dust transport can lead to PM levels that substantially exceed the established limit values. An implication for public policy in Europe is that to protect public health, anthropogenic sources of particulate pollution need to be more rigorously controlled in areas highly impacted by the Sahara dust (13). Saharan dust is transported across the Atlantic and interacts with the Caribbean seasonal climatic conditions, becoming respirable and contributing to asthma presentments at the emergency department. This study investigated the relationships among dust, climatic variables, and asthma-related visits to the emergency room in Grenada. Saharan dust in conjunction with seasonal humidity allows for inhalable particulate matter that exacerbates asthma among residents in the Caribbean island of Grenada (14). In a study the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on both Terra and Aqua satellites was used to mapping of major atmospheric dust source points in the Middle East region on the basis of the improved version of the recently developed Middle East Dust Index (MEDI) applied to 70 dust storms, which occurred during the period between 2001 and 2012. Results indicated that 247 different source points have participated in dust storm generation in the Middle East region in which Iraq and Syria are the highest efficient sites for dust storm generation in this region, respectively. High-intensity dust storms were mainly located west of Iraq and the border of Iraq and Syria (15).

Dust storm occurs frequently in arid and semi-arid areas of the world. West of Iran, especially in spring and summer, suffers from significant increases of these events which cause several social and economic problems. Detecting and recognizing the extent of dust storms is very important issue in designing warning systems, management and decreasing the risk of this phenomenon (16). Over the past decades, Middle East dust storms have caused many problems for the residents of South and Southwest regions of Iran. During the recent years, there has been an increase in the trend of dust storm activities in this region, especially in spring and summer (17).

Ahvaz, the capital city of Khuzestan Province, which produces Iran's most oil, is on the rolls of fame in view of air pollution. It has also suffered from dust storm during the recent two decades. So, emissions from transportation systems, steel, oil, black carbon, and other industries as anthropogenic sources and dust storm as a new phenomenon are two major concerns of air pollution in Ahvaz. According to a study, ozone concentrations in winter due to more fuel consumption and sub adiabatic condition in tropospheric atmosphere were higher than those ground-level ozone (GLO) in summer (18).

Dust outbreaks studies according to dust composition and elements

Traffic-related sources have been recognized as a significant contributor of particulate matter particularly within major cities. Non-exhaust particles can be generated either from non-exhaust sources such as brake, tyre, clutch and road surface wear or already exist in the form of deposited material at the roadside and become suspended due to traffic-induced turbulence. Studies mention that in urban environments, brake wear can contribute up to 55 % by mass to total non-exhaust traffic-related PM10 emissions and up to 21 % by mass to total traffic-related PM10 emissions, while in freeways, this contribution is lower due to lower braking frequency (19).

In the near future the nonexhaust emissions will dominate the road transport PM emissions. Based on the limited available evidence, it is argued that dedicated research is required on nonexhaust emissions and dispersion to urban areas from both an air quality and a public health perspective. The implicated message to regulators and policy makers is that road transport emissions continue to be an issue for health and air quality, despite the encouraging rapid decrease of tailpipe exhaust emissions (20). Dissolved organic matter, measured as dissolved organic carbon (DOC), is an important component of aquatic ecosystems and of the global carbon cycle. It is known that changes in DOC quality and quantity are likely to have ecological repercussions. More studies are needed concerning the the effects of changing DOC quality and quantity on trace metals and nutrients, and how runoff and temperature-related changes in DOC export affect metal and nutrient export to rivers and lakes (21). Major components of suspended particulate matter (PM) are inorganic ions, organic matter (OM), elemental carbon (EC), geological minerals, salt, non-mineral elements, and water (22).

Particulate and SO2 pollution were strongly implicated in the acute morbidity and mortality associated with the severe pollution episodes in Donora (Pennsylvania), London, and New York in the 1940s, 1950s, and 1960s. There is new evidence that even current ambient levels of PM10 (30 to 150 micrograms/m3) are associated with increases in daily cardiorespiratory mortality and in total mortality, excluding accidental and suicide deaths (23).

In a study of the influence of ecologic factors on respiratory diseases development in urban residents of Kazakhstan Republic, analysis demonstrates that chronic obstructive lung disease development is contributed by high concentration of nitrogen oxide in ambient air in Temirtau, Kamenogorsk and Aktau cities, high lead content of sedimented dust in Temirtau, Ust'-Kamenogorsk and Ekibastuz cities(24). A study mentioned road dust and vehicle exhaust are the main sources of air pollution by particulate matter, and good results can be envisioned if curbing urban air pollution through governing these two factors. It will be more effective to reduce air pollution by taking different measures in traffic control according to different land use purposes (25). Occupational and environmental lung disease remains a major cause of respiratory impairment worldwide. Dust exposures are occurring in new industries, for instance, silica in hydraulic fracking. Nonoccupational environmental lung disease contributes to major respiratory disease, asthma, and COPD. Knowledge of the imaging patterns of occupational and environmental lung disease is critical in diagnosing patients with occult exposures and managing patients with suspected or known exposures (26).

Third hand smoke (THS) is defined as residual tobacco components that remain on indoor surfaces after tobacco has been smoked, such as walls furniture, and dust particles, which are re-emitted into the air. THS also includes secondary pollutants generated from the reaction of surface residual smoke compounds with reactive indoor air pollutants. THS is a new hidden health hazard, with infants and children being most at risk of higher exposure (27).

According to a study, in the Jiuzhaigou National Nature Reserve (JNNR), China: 96%, 82%, and 87% of the SO42-, NO3- and NH4+ deposition fluxes are in the form of wet deposition of the corresponding aerosol species. Industry and power plants are the two major sources of SO42- deposition flux, accounting for 86% of the total wet deposition of SO42-, and industry has a higher contribution (56%) than that of power plants (30%). Power plants and industry are also the top sources that are responsible for NO3- wet deposition, and contributions from power plants (30%) are generally higher than those from industries (21%). The major sources of NH4+ wet deposition flux in JNNR are fertilizer (48%) and manure management (39%). This study demonstrates that S and N deposition in JNNR is mostly from long-range transport rather than from local emissions, and to protect JNNR, regional emission reduction controls are needed (28).

Organic markers can be measured on currently acquired PM2.5 filter samples by thermal methods. These markers can complement element, ion, and carbon fraction measurements from long-term speciation networks. Applying the positive matrix factorization and effective variance solutions for the chemical mass balance equations provides useful information on the accuracy of the source contribution estimates (29).

Heavy metals, trace metals, volatiles

Polybrominated diphenyl ethers (PBDEs) constitute an important group of brominated flame retardants that have been massively produced and extensively used in numerous everyday products, providing longer escape times in case of fire and thus saving lives, as well as reducing the damage of property. In recent years, PBDEs have been recognized as significant pollutants of the indoor environment (30).
30-Besis A, Samara C. Polybrominated diphenyl
ethers (PBDEs) in the indoor and outdoor environments--a review on occurrence and human exposure. Environ

In a paper, the pollution and health risks over a year of seven heavy metals in the atmospheric dust of Ebinur Basin, a typical oasis in Northwest China was studied. This research showed that both human activity and natural factors, such as wind and altitude, influenced the heavy metal contents in the atmospheric dust of the study area. Furthermore, recent human activity in the study area had the most negative influence on the accumulation of the heavy metals and the corresponding health risks, especially for Hg, Pb, and Cd, which is worthy of attention (31).

Analysis of dust samples that were collected around Qingdao, showed that the average contents of Cd, Cr, Cu, Hg, Pb, Zn in the atmospheric dust of Shinan, Shibei and Laoshan districts were the highest, and the air pollution of these districts was more serious than the districts of Licang, Chengyang and Huangdao. The heavy metals in atmospheric dust was harmful in some samples to human health if the contents of Cr and Pb in atmospheric dusts of Shinan, Laoshan and Chengyang districts were always kept at such high densities (32).

In a study, 110 school children in Seoul, Korea with daily measurement of peak expiratory flow rate (PEFR) from May 13 to June 15, 2007 were examined. PM(2.5), PM(10) and metals bound to the particles were also determined daily during the study period in Ala Shan and Beijing (China) as well as in Seoul (Korea). Three-day back trajectories showed that air parcels arrived at Seoul mostly from the desert areas in China and Mongolia through eastern China during ADS event affecting levels of particulate pollutants in the areas. This result indicates that exposure to the metals bound to particles during the Asian Dust Storm (ADS) period reduces children's pulmonary function (33).

A study was conducted to identify and quantify the sources of selected volatile organic compounds (VOCs) and fine particulate matter (PM2.5) by using a partially constrained source apportionment model suitable for multiple time resolution data. Results showed that the evaporative emission factor was the largest contributor (25%) to VOC mass concentration, while the largest contributor to PM2.5 mass concentration was soil dust/regional transport related factor (26%). In terms of risk prioritization, traffic/industry related factor was the major cause for benzene, ethylbenzene, Cr, and polycyclic aromatic hydrocarbons (29-69%) while petrochemical related factor contributed most to the Ni risk (36%). This indicated that a larger contributor to mass concentration may not correspond to a higher risk (34).

The distribution, sources and potential

ecological risk of heavy metals in the sediment of lakes in eastern China and other areas of the world that have undergone rapid economic development have been widely researched by scholars. According to a study, recent economic development of the Aibi Lake Basin has negatively influenced the accumulation of heavy metals in the sediments of the lake. This work can provide a scientific basis for an early warning of heavy metal pollution and for protection of the environment (35).

Silica

Farm workers are exposed to crystalline silica, but there are no established questionnaires to assess silica dust exposure from farm work in epidemiologic studies. This study examines aspects of farm work that were used to estimate potential silica dust exposure in a population-based study conducted in the southeastern United States. Specific questions on dusty tasks and frequency are needed to accurately assess silica exposure from farm work (36).

Exposure to crystalline silica ranks among the most frequent occupational exposures to an established human carcinogen. Health-based occupational exposure limits can only be derived from a reliable dose-response relationship. Because the establishment of a JEM is crucial for risk estimates, sufficient information should be made accessible to allow an estimation of the uncertainties in the assessment of exposure to crystalline silica. The impressive number of silica dust measurements and the evaluation of methodological uncertainties allow recommendations for a best practice of exposure assessment for epidemiological studies (37).

Radio-active

The Jordan Rift Valley (JRV) is considered the food bowl of Jordan, especially during the winter season. In this study, soil and vegetable samples collected from greenhouses in the northern JRV were analyzed for their radioactive content. The activity concentrations of (238)U, (235)U, (232)Th, (226)Ra, (137)Cs and (40)K in soil were found to be (+/-SD) 33 +/- 12, 2.2 +/- 0.7, 11.2 +/- 3.3, 40.5 +/- 15.5, 3.5 +/- 1.3 and 156.0 +/- 46.6 (Bq kg(-1)), respectively. In vegetables, the activity concentration of (40)K was found in the range of 698-1439 Bq kg(-1), while those of (226)Ra and (228)Ra were found to be in the range of <0.61-2.56 and <0.69-3.35 Bq kg(-1), respectively. Transfer factors for (40)K were found to be high and ranged from 5 to 8, while those for (226)Ra and (228)Ra were found to be from <0.01 to 0.07 and from <0.09 to 0.42, respectively. The calculated external annual effective dose is found to be within the worldwide range (38).

The activity concentrations of naturally occurring radioactive materials such as (238)U, (232)Th and (40)K were measured for 38 soil samples collected from diverse zones in the southern area of West Bank, Palestine using gamma-ray spectroscopy. The measured activities of (238)U, (232)Th and (40)K were found to range from 32.9 to 104.7, 14.5 to 76.6 and 297 to 962 Bq kg(-1) with averages value of 68.7, 48.0 and 630 Bq kg(-1), respectively. The obtained values of activity concentrations are higher than the world average of 35, 30 and 500 Bq kg(-1) for (238)U, (232)Th and (40)K, respectively. The measured (137)Cs activity concentration was found to range from 1.8 to 36.1 Bq kg(-1) with an average value of 8.5 Bq kg(-1). The detected activities were attributed to the fallout of (137)Cs, which is the only man-made radionuclide. The calculated average of the total gamma-radiation dose rate of natural radionuclides, (137)Cs and cosmic radiation is 121.4 nGy h(-1). The radium equivalent activity (R(aeq)), dose rate (D(r)), external hazard index (H(ex)) and radioactivity level index (I(gamma)) in all samples are presented. Some values were found to be in the range of worldwide values, whereas others were above the worldwide values (39).

Dust storms in the Middle East are common during spring. Some of these storms are massive and carry a large amount of dust from faraway regions, which pose health and pollution risks. The huge dust storm event occurred in early May, 2012 was investigated for its radioactive content using gamma ray spectroscopy. Dust samples were collected from Northern Jordan and it was found that the storm carried a large amount of both artificial and natural radioactivity. The average activity concentration of fallout $_{(137)}$ Cs was $_{17.0}$ Bq/kg which is larger than that found in soil ($_{2.3}$ Bq/kg), and this enrichment is attributed to particle size effects. $_{(7)}$Be which is of atmospheric origin and has a relatively short half-life, was detected in dust with relatively large activity concentrations, as it would be expected, with an average of 2860 Bq/kg, but it was not detected in soil. Despite the large activity concentration of (7)Be, dose assessment showed that it does not contribute significantly to the effective dose through inhalation. The concentrations of the primodial nuclides $_{(40)}$K, (232)Th and (238)U were 547, 30.0 and 49.3 Bq/kg, respectively. With the exception of ($_{40}$)K, these were comparable to what was found in soil (40) .

Soil samples were collected from six different locations in Araba valley, situated between Aqaba port and Dead sea. The samples have been analysed by using gamma-ray spectrometry. The results indicate that the mean concentrations of ($_{238}$)U, ($_{232}$)Th and (40)K in the populated Araba valley are lower than those in other populated areas. High potassium and iron content in some samples might be attributed to the active faults, which refer to the Dead sea transform fault (41 .(

The identification of major putative mutagenic/genotoxic compounds in most surface waters with high mutagenic/genotoxic activity in the world have not been performed. Further efforts on chemical isolation and identification by bioassay-directed chemical analysis should be performed (42).

Fars province is a large populated large province located in the southwest of Iran. The average annual effective dose (AED) from the radioactivity content of soil in this province was found to be 39.9 ± 1.8 μSv (43). The issue of natural radioactivity in groundwater is reviewed, with emphasis on those radioisotopes which contribute in a significant way to the overall effective dose received by members of the public due to the intake of drinking water originating from groundwater systems (44).

Microbial-fungal

The presence of pathogenic microorganisms in the dust storm can cause diseases such as Asthma, Pneumonia, and respiratory infections. The aim of this study was to determine the relationship between air-borne particles with airborne microorganisms in normal and dusty days in Sanandaj, a city located in the west of Iran.

Air sampling was conducted during the normal and dusty days through Andersen single-stage impactor (28.3 L/min) for 2.5 min. The predominant species of bacteria and fungi during the occurrence of Dust storm was Bacillus spp. (56.2% of total bacteria) and Mycosporium spp. (28.6% of total fungi), respectively. The results showed that the number of airborne microorganisms (bacteria and fungi) increased during the dust storm. Therefore, the microorganisms in the dust storm can cause biological harmful effects on human health (45).

Non tuberculous mycobacterial infection occurs by the inhalation of dust or aerosols (46).

Fungal spores can be transported globally in clouds of desert dust. Many species of fungi (commonly known as molds) and bacteria--including some that are human pathogens--have characteristics suited to long-range atmospheric transport. Dust from the African desert can affect air quality in Africa, Europe, the Middle East, and the Americas. Asian desert dust can affect air quality in Asia, the Arctic, North America, and Europe. Atmospheric exposure to mold-carrying desert dust may affect human health directly through allergic induction of respiratory stress. In addition, mold spores within these dust clouds may seed downwind ecosystems in both outdoor and indoor environments (47).

Hospital construction and renovation activities are an ever-constant phenomenon in healthcare facilities, causing dust contamination and possible dispersal of fungal spores. A study, reviewed fungal outbreaks that occurred during construction and renovation over the last 4 decades as well as current infection prevention strategies and control measures. Fungal outbreaks still occur in healthcare settings, especially among patients with hematological malignancies and those who are immunocompromised. The causative pathogens of these outbreaks were usually Aspergillus species, but Zygomycetes and other fungi were occasionally reported. Aspergillus most commonly caused pulmonary infection. The overall mortality of construction/renovation-associated fungal infection was approximately 50%. Performing infection control risk assessments and implementing the recommended control measures is essential to prevent healthcare-associated fungal outbreaks during construction and renovation (48).

Examples of other accompanying risk factors of dust exposures:

High temperature- In the analysis of the effect modification of extremely high temperature on the association between air pollution and daily mortality, only the interaction of PM10 with temperature was statistically significant. Few published papers have reported synergistic effects of extremely high temperatures and air pollution on mortality, and further studies are needed. Establishing causal links between heat, PM10, and mortality will require further toxicologic and cohort studies (49).

Occupation-A study was conducted in a cement factory in the United Arab Emirates to assess cement dust exposure and its relationship to respiratory symptoms among workers. Cough and phlegm were found to be related to exposure to dust, cumulative dust and smoking habit, while chronic bronchitis was related to smoking habit. The few factory workers (19.5%) who used masks all the time had a lower prevalence rate of respiratory symptoms than those not using them. It is recommended that control measures be adopted to reduce the dust and workers should be encouraged to use respiratory protection devices during their working time (50).

Dust exposures studies and health side effects

Animal studies

Crystalline forms of silica have been proposed as positive control material for the toxicity test of inhaled particulate/fibrous matter, although mechanism of silica-induced inhalation toxicity has not yet been established. Inhalation exposure of α-quartz to rodents induces severe lung inflammation and fibrosis only after a certain period of latency, despite strong surface reactivity. The delayed occurrence of inhalation toxicity by α-quartz may be largely attributed to the sequestration of α-quartz particles by alternatively activated (M2) macrophages that express abundant levels of scavenger receptors but are relatively insensitive to inflammatory stimuli. The elevated levels of inflammatory cytokines produce progressive lung inflammation and fibrosis (51).

An Asian dust storm (ADS) contains airborne particles that affect conditions such as asthma, but the mechanism of exacerbation is unclear. The objective of this study was to compare immune adjuvant effects and airway inflammation induced by airborne particles collected on ADS days and the original ADS soil (CJ-1 soil) in asthma model mice. These results suggest that substances attached to ADS airborne particles that are not in the original ADS soil may play important roles in immune adjuvant effects and airway inflammation (52).

Immunologic effects

African dust storm events (ADE) travel across the Atlantic Ocean (ADEAO) and reach the Puerto Rican coast (ADEPRC), potentially impacting air quality and human health. A study, concluded that: Endotoxins (ENX) and traces of metals (TMET) may be responsible, in part for triggering PM-respiratory adverse responses in susceptible and predisposed individuals (53).

In order to better understand how ambient air particulate matter (PM) affect lung health, the two main airway cell types likely to interact with inhaled particles, alveolar macrophages (AM) and airway epithelial cells have been exposed to particles in vitro and followed for endpoints of inflammation, and oxidant stress. Diesel particles did not affect cytokine mRNA induction nor protein accumulation but interfered with the release of cytokine from the cells. Ambient coarse and fine PM, on the other hand, inhibited both mRNA induction and protein production. Exposure to coarse and fine PM decreased the expression of the toll like receptor 4 (TLR4) in the macrophages. Particle-induced decrease in TLR4 and hyporesponsiveness to LPS may be related to LPS tolerance induced by low levels of LPS (54).

The immunological consequences of organic dust exposure in the farming industry are likely explained by the diversity of microbial motifs in dust that can elicit differing innate immune receptor signaling pathways. Repeated organic dust exposures modulate innate and adaptive immune function with a resultant adaptation-like response. However, repetitive exposures cause lung parenchymal inflammation, chronic disease, and lung function decline over time (55).

The associations between particulate matter from Asian dust storms (ADS) and health disorders differ among studies, and the underlying mechanisms remain unclear. Thus, the effects of particulate matter on cytokine responses differed according to collection period, and the effects of ADS particles differed for each ADS event. Additionally, the levels of pro-inflammatory cytokines induced by ADS particles were not always higher than those induced by non-ADS particles (56).

Asian dust storms (ADS) contain various airborne particles that may augment airway inflammation by increasing the level of interleukin-8. Exposure to ADS aggravates upper and lower tract respiratory symptoms in patients with adult asthma. ADS airborne particles may increase airway inflammation through enhancement of interleukin-8 transcriptional activity (57).

A study compared the effects of PM2.5 collected in dust storm days (dust storm PM2.5) with that in sunshiny and non-dust storm days (normal PM2.5) on cell proliferation and cell cycle in human lung fibroblasts. The results showed that both dust storm and normal PM2.5 had biphasic effects on cell proliferation, namely, stimulated cell proliferation at lower concentrations while inhibited it at higher concentrations (58). A study concluded: Therapeutic blockade of γδT cells prevented the typical resolution of acute airway inflammation characterised by elevated eosinophil and Th2 cell numbers. Moreover, the lung displayed exacerbated airway remodelling, typified by excess peribronchiolar collagen deposition (59).

Pig farmers are exposed to organic material in pig barns on a daily basis and have signs of an ongoing chronic airway inflammation and increased prevalence of chronic inflammatory airway diseases, predominantly chronic bronchitis. Interestingly, the inflammatory response to acute exposure to organic dust is attenuated in farmers. The aim of the study was to closer characterize innate immunity features in blood and airways in farmers and in naïve, non-exposed, controls. In conclusion, farmers have signs of local and systemic inflammation associated with altered innate immunity characteristics (60).

A study reported a unique case of pulmonary alveolar proteinosis that developed 3 weeks after the Great East Japan Earthquake and the subsequent tsunami. The patient had inhaled dust repeatedly while visiting her devastated neighborhood without wearing a protective mask. Five weeks after the earthquake, lung samples taken from the patient showed foreign particle deposition; however, her serum was negative for GM-CSF autoantibody. The patient's clinical symptoms resolved following whole lung lavage. Inhalation of fine dust particles after natural disasters may cause the onset of pulmonary alveolar proteinosis (61). According to a study, Toll-like receptor 4 (TLR4) expression by hematopoietic and airway epithelial cells controls distinct arms of the immune response to inhaled allergens (62). In contrast to allergic asthma, in which type 2 helper T cell (Th2) activation is dominant, exposure to farm dust extracts (FDE) induces Th1/Th17 lung inflammation, associated with neutrophil infiltration. The polarization of macrophages diverged depending on the exposure and inflammatory status of the tissue. Interfering with this polarization could be a target for treatment of different types of lung inflammation (63).

Respiratory effects

Dust storms may originate in many of the world's dry lands and have an effect not only on human health in the dry lands themselves but also in downwind environments, including some major urban centers, such as Phoenix, Kano, Athens, Madrid, Dubai, Jedda, Tehran, Jaipur, Beijing, Shanghai, Seoul, Taipei, Tokyo, Sydney, Brisbane and Melbourne. In some parts of the world dust storms occur frequently throughout the year. They can transport particulate material, pollutants, and potential allergens over thousands of km from source. The main sources include the Sahara, central and eastern Asia, the Middle East, and parts of the western USA. Among the human health effects of dust storms are respiratory disorders (including asthma, tracheitis, pneumonia, allergic rhinitis and silicosis) cardiovascular disorders (including stroke), conjunctivitis, skin irritations, meningococcal meningitis, valley fever, diseases associated with toxic algal blooms and mortality and injuries related to transport accidents (64).

Asthma

A cross-sectional, population-based study including 5539 subjects from 40 to 93 years selected by a probabilistic sampling technique in five cities in Colombia was conducted. Prevalence of asthma was 9.0%. Asthma underdiagnosis was 69.9% and increased to 79.0% in subjects 64 years or older. The risk factors related to asthma and/or wheezing were: living in Bogota or Medellin, female gender, first degree relative with asthma, respiratory disease before 16 years of age, obesity, no education, indoor wood smoke exposure and occupational exposure to dust particles, gases or fumes (65).

A study mentioned that the indoor factors most consistently associated with asthma and asthma-related symptoms in adults included fuel combustion, mold growth, and environmental tobacco smoke in both urban and rural areas. Environmental risk factors to which urban adults were more frequently exposed than rural adults were dust mites, high levels of vehicle emissions, and a westernized lifestyle. The main risk factors for developing asthma in urban areas are atopy and allergy to house dust mites, followed by allergens from animal dander. House dust mite exposure may potentially explain differences in diagnosis of asthma prevalence and morbidity among adults in urban vs. rural areas (66).

Asthma is one of the most prevalent chronic lung diseases, affecting 235 million individuals around the world. Exposure to the environmental allergen, house dust mite (HDM), results in airway inflammation with a variable degree of airway obstruction. By employing methylation-sensitive restriction fingerprinting, we identified a set of genes, showing aberrant methylation status, associated with the HDM-induced airway hyperresponsiveness (AHR). Hence, the results suggest that HDM exposure induces a series of aberrant methylated genes that are potentially important for the development of allergic airway hyperresponsiveness AHR (67).

A study considerd three important groups of environmental stimuli on the epithelium in asthma: oxidants, such as environmental pollution and acetaminophen; viruses, including rhinovirus; and agents that cause barrier disruption, such as house dust mite allergens (68).

In a study of the hospitalisation data from the Taiwan National Health Insurance research database covering the period from 2000 to 2009, the results show that Asian dust storms (ADSs) events do generate a critical influence upon the occurrences of asthma on post-ADS events from days 1 through 3, with an average of 17-20 more hospitalised admissions, and have stronger effects on preschool children, middle-aged people and the elderly. This study suggests that government should establish a forecast and alert system and release warnings about dust storms, so that the individuals predisposed to asthma can take precautionary measures to reduce their outdoor exposure (69).

COPD

SNP rs1828591 of HHIP gene is associated with occupational COLD development under exposure to dust and chemical factors. Study of association of genotype and phenotypic features of COLD revealed the following trends: "dust" COLD patients with genotype AA SNP rs1800470 of TGFbeta1 gene show lower level of C-reactive protein and TNF-alpha, if compared with other genotypes (70).

The authors represent associative study of 180 patients having chronic obstructive lung disease 1-2 stages, who exposed at work to industrial pollutants (58.3% exposed to moderately fibrogenous dust and 41.7%--to a complex of aromatic organic solvents). Findings are increased ($p < 0.05$) concentration of IL-1beta in individuals exposed to chemicals, when compared to those exposed to dust at work. Relation was seen between transforming growth factor beta1 (rs1804470 of TGFB1 gene) and rs1828591 of HHIP gene with propensity to COLD formation (71).

In a genome-wide interaction study to identify novel susceptibility loci for occupational exposure to biological dust, mineral dust, and gases and fumes in relation to FEV1 level in 12,400 subjects, identified several novel genes. Further research should determine whether the identified genes are true susceptibility loci for occupational exposures and whether these SNP-by-exposure interactions consequently contribute to the development of COPD (72).

Exposure to vapors, gases, dusts and fumes (VGDF) has been associated with a two- to threefold higher COPD risk. In a study, it was assessed that if VGDF, pesticides and solvents are associated with the level of lung function and the prevalence of airway obstruction in the general population. They included 11 851 subjects aged 18-89 years from the LifeLines cohort study. A second general population cohort (n=2364) was used to verify the initial findings. They concluded that, occupational exposure to both VGDF and pesticides is associated with airway obstruction in the general population (73).

Occupational exposures have been shown to be risk factors for chronic obstructive pulmonary disease (COPD) among never-smokers. In a Danish population-based cohort of 1575 subjects, more than a threefold increased risk was found for occupational exposure to vapor, gas, dust and fumes (predominantly organic dust) in this never-smoking population, with a corresponding 48% population attributable fraction among never-smokers(74).

Few longitudinal studies have been conducted on occupational exposure and lung function. The study population (1,332 participants) was from the Framingham Heart Study, in which participant lung function measures were available from up to five examinations over nearly 17 years. Participants with more likely dust exposure had a mean 4.5 mL/year excess loss rate of FEV1 over time. Occupational dust exposures may accelerate the rate of FEV1 loss but not FEV1 /FVC loss (75).

In a review of occupational COPD includes both population-wide and industry-specific exposures, final inclusion was based on a positive qualitative Scottish Intercollegiate Guidelines Network (SIGN) score (≥2+) for study quality, yielding 25 population-wide and 34 industry/occupation-specific studies, 15 on inorganic and 19 on organic dust exposure, respectively. According to this study, a nearly uniform pattern of a dose-response relationship between various exposures and COPD was found, adding to the evidence that occupational exposures from vapors, gas, dust, and fumes are risk factors for COPD (76).

A study used cross-sectional data from Multi-Ethnic Study of Atherosclerosis (MESA), a population-based sample of 45-84 year olds free of clinical cardiovascular disease at baseline. MESA ascertained the most recent job and employment, and the MESA Lung Study measured spirometry, and occupational exposures for 3686 participants. Associations between health outcomes (spirometry defined airflow limitation and Medical Research Council-defined chronic bronchitis) and occupational exposure [self-reported occupational exposure to vapor-gas, dust, or fumes (VGDF), severity of exposure, and a job-exposure matrix (JEM)-derived score] were evaluated using logistic regression models adjusted for non-occupational risk factors. The prevalence of chronic bronchitis and wheeze was associated with exposure to VGDF. The association between airflow limitation and the combined effect of smoking and VGDF exposure showed an increasing trend (77).

The concerns on indoor contamination by semi volatile organic compounds (SVOCs) are increasing. Among SVOCs, there are a number of findings indicating that phthalates and pesticides use associated with allergy or bronchial obstruction. The adjuvant effect of phthalates, particularly monoesters, was shown in animal experiments and the association between allergy prevalence and exposure to phthalates or indoor materials containing plasticizers was observed in previous epidemiological studies. Because SVOCs were often found in air and house dust of residential dwellings, the risk of SVOC exposure should be assessed in the Japanese general population (78).

Cardiac arrest

Asian dust events are caused by dust storms that originate in the deserts of China and Mongolia and drift across East Asia. They hypothesized that the dust events would increase incidence of out-of-hospital cardiac arrests by triggering acute events or exacerbating chronic diseases. They concluded that: There was no significant relationship between Asian dust events and out-of-hospital cardiac arrests by area in either of the models (79).

Cancer

A study concluded that: Studies of workers, who have been exposed to relevant levels of dust, have not indicated an increase in lung cancer risk. Considerable shortcomings in the use of lung surface area, clearance rates, deposition fractions; as well as using the mass and volumetric metrics as opposed to the particle surface area metric limit the scientific reliability of the proposed "granular biopersistent particles without known specific toxicity" (GBS) occupational exposure limits (OELs) and carcinogen classification (80).

Mortality

In a meta-analysis on 33 time-series and case-crossover studies conducted in China mortality effects of short-term exposure to particulate matter with aerodynamic diameters less than 10 and 2.5 µm (PM10 and PM2.5), sulfur dioxide (SO2), nitrogen dioxide (NO2), ozone (O3) and carbon monoxide (CO) was assessed. Significant associations between air pollution exposure and increased mortality risks were observed in the pooled estimates for all pollutants of interest. In specific, each 10 µg/m(3) increase in PM2.5 was associated with a 0.38% increase in total mortality, a 0.51% in respiratory mortality, and a 0.44% in cardiovascular mortality. The authors recommend future studies on the nature of air pollution concentration and health effect relationships in Chinese population to support setting stringent air quality standards to improve public health (81).

In a study, collected airborne particles (n=118) at Dazaifu in Fukuoka, Japan, from June 2012 to May 2013 was collected, and Pb and SO4(2-) which are indicators of the long-range transport of anthropogenic air pollutants, as well as their mutagenicity was measured. The results of the present study suggest that high levels of anthropogenic air pollutants were transported with Asian dust. Similarly, long-range transport of air pollutants including mutagens occurred on days when Asian dust events were not registered (82).

This study investigates the association between different PM fractions and daily mortality during Saharan and non-Saharan days in Barcelona, Spain. Our results using independent fractions of PMs provide further evidence that the effects of short-term exposure to PM during Saharan dust days are associated with both cardiovascular and respiratory mortality. A better understanding of which of the different PM size fractions brought by Saharan dust is more likely to accelerate adverse effects may help better understand mechanisms of toxicity (83).

We investigated temporal variation in the association between PM and mortality in Seoul, Korea, 1998-2011. The present study showed temporally increasing trends in associations between PM and mortality. Current policies may not be as effective to reducing health risks attributable to PM as expected. Air quality interventions should be encouraged in terms of causal factors for time-varying association between PM and mortality (84).

A study was the first to explore the relationship between Asian dust storm events (ADS) and acute myocardial infarction (AMI) hospital admissions by applying time series models. Among the total population, 3.2 more cases of AMI admissions occurred on post-ADS day three. During the days after ADS, exposure to dust should be minimized by staying indoors as much as possible and by wearing a mask when exposure to dust is unavoidable. This is especially true for working and older adults (85).

Hospital admissions

To estimate the short-term effects of particulate matter ≤ 10 µm (PM10) on mortality and hospital admissions in 13 south-European cities, distinguishing between PM10 originating from desert and from other sources. We identified desert dust advection days in multiple Mediterranean areas for 2001-2010 by combining modeling tools, back-trajectories and satellite data. For each advection day, we estimated PM10 concentrations originating from desert, and computed PM10 from other sources by difference. We fitted city-specific Poisson regression models to estimate the association between PM from different sources (desert and non-desert) and daily mortality and emergency hospitalizations. PM10 originated from desert was positively associated with mortality and hospitalizations in Southern Europe. Policy measures should aim at reducing population exposure to anthropogenic airborne particles even in areas with large contribution from desert dust advections (86).

Short-term exposure to outdoor fine particulate matter (particles with a median aerodynamic diameter <2.5 µm (PM2.5)) air pollution has been associated with adverse health effects. In a systematic review and meta-analysis of 110 peer-reviewed time series studies indexed in medical databases to May 2011 the evidence for associations between PM2.5 and daily mortality and hospital admissions for a range of diseases and ages was assessed. Based upon 23 estimates for all-cause mortality, a 10 µg/m(3) increment in PM2.5 was associated with a 1.04% increase in the risk of death (87) .

In spring, windblown dust storms originating in the deserts of Mongolia and China make their way to Taipei city. These occurrences are known as Asian dust storm (ADS) events. The objective of this study was to assess the possible associations of ADS on the hospital stroke admissions of residents in Taipei, Taiwan, during the period from 1996 to 2001. The study results indicated a statistically significant association between ADS events and daily primary intracerebral hemorrhagic stroke admissions 3 days after the event (relative risk of 1.15; 95% CI, 1.01-10.10). This was due mainly to PM (10) (88). The harmful effect of dust storm on lung health is controversial. This study aimed to assess any associations between dust storms and emergency hospital admissions due to respiratory disease in Hong Kong. Significant increases in emergency hospital admission due to COPD were found 2 days after dust storm episode. The relative risk of PM(10) for lag 2 days was 1.05 (95% CI: 1.01-1.09) per 10 µg/m(3) .Dust storms have an adverse effect on emergency hospital admission for COPD in Hong Kong. This also suggests the adverse effect of coarse particles on lung healt. (89). The Australian dust storm during the week of September

22, 2009, resulted in the grounding of a large portion of the air medical retrieval fleet in Queensland. A 62.5% increase in respiratory cases was seen, and 13.3% increase in injury cases during the week of the dust storm event, when compared with the previous year. Neither of these results reached statistical significance, but they demonstrate a practically important difference (90). It has been found that Kawasaki disease (KD) cases diagnosed in Japan, Hawaii and San Diego, USA increase when tropospheric wind patterns arrive from central Asia, suggesting a common, wind-borne causal agent. We analyzed KD cases hospitalized in Santiago, Chile to look for associations with local, regional and large scale meteorological variables. A novel result is that ENSO dynamics also explain part of KD variability with a decrease in KD when La Niña is dissipating or El Niño is on the rise; hence climate scale dynamics might be taken into account in future studies worldwide - at least as a potential explanatory variable that may confound KD seasonality on a global scale (91).

CONCLUSION AND RECOMMENDATIONS

Recently, the amount of dust coming from Arabian countries has dramatically increased, especially dust storms that are affecting western and even central parts of Iran. This phenomenon has caused a lot of environmental problems. In a study, HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory) model dust module and trajectory simulation were utilized in this research and two case studies are investigated (in May and June 2010). Due to the results, dust storms started on May 17th and June 7th because of high wind shear (>8.5 m/s) from the western Syrian Desert. The source region limited to 32.50 °N to 33.80 °N and 38.00 °E to 38.80 °E coordinates. Dust plumes lifted and dispersed towards the east and southeast of the sources and reached Ahvaz on May 18th and June 8th. The average of PM10 concentration in these dates reached 625 and 494 µgm3 on Ahvaz monitoring stations, respectively (92). On June 2, 2014 a sandstorm hit Tehran, the capital city of Iran which killed 5 and injured 44 people. The early warning system did not operate properly and the alarm was not transferred to at risk population and the related organizations in time and in a right manner. Focusing much more on establishing EWS to alert the risk prone population timely and public education for taking safety measures when exposed to the disastrous situation is recommended (93). An assessment of how future climate change will impact regional air quality requires projecting emissions many decades into the future in a consistent manner. For the United States, the year-2050 emissions for nitrogen oxides (NOx), sulfur dioxide (SO2), PM2.5, anthropogenic volatile organic compounds (VOCs), and ammonia are projected to change by -55, -55, -30, -40, and +20%, respectively, compared with 2001(94). The expansion of U.S. air pollution policy to protect climate provides an opportunity for joint mitigation, with CH4 a prime target. Black carbon (BC) reductions in developing nations would lower the global health burden, and for BC-rich sources (e.g., diesel) may lessen warming. Controls on these emissions could offset near-term warming induced by health-motivated reductions of sulfate (cooling). Wildfires, dust, and other natural particulate matter (PM), and ozone (O3) sources may increase with climate warming, posing challenges to implementing and attaining air quality standards. Accountability analyses for recent and projected air pollution and climate control strategies should underpin estimated benefits and trade-offs of future policies (95). There is good evidence from epidemiology and toxicology studies that current dust exposures may still present a risk to workers and that for some of those who are affected, there are devastating health consequences. It is proposed that until regulators agree on the safe occupational exposure limits for low-toxicity dusts, health and safety professionals should consider 1mg m(-3) of respirable dusts as a more appropriate guideline than the value of 4mg m(-3) currently used in Britain (96).

Emissions of air pollutants and their precursors determine regional air quality and can alter climate. Climate change can perturb the long-range transport, chemical processing, and local meteorology that influence air pollution. Reducing the O(3) precursor, methane CH(4) would slow near-term warming by decreasing both CH(4) and tropospheric O(3). Reducing sulfate and nitrate aerosols would improve air quality and lessen interference with the hydrologic cycle, but lead to warming. A holistic and balanced view is thus needed to assess how air pollution controls influence climate (97). The risk assessment should be specifically intended to support local and national government agencies in their management of severe dust storm disasters in their efforts to : make resource allocation decisions; make high-level planning decisions; and raise public awareness of severe dust storm risk (98).

In conclusion, dust outbreaks mainly produced by climate changes, global warming, and desertification, wars and eco destruction, and changes in human activities has extent consequences in quality of life of human, ecosystems, emigration, social and environmental problems, transportation, communication systems, and consequent crisis. Long-term dust exposures have extent health impacts .

To control the effects and reducing burden of pulmonary disease need a national and global cooperation to conduct strategies for improving pollution control. Epidemiological studies should be carried out to determine:

The source and distribution of dust outbreaks, its chemical constituents, and microbial and metal load inside country or delivered outside from neighboring countries

To detect part of industry and city traffic, road traffic, industrial processes, the emissions from combustion utilities, domestic boilers, or sources originates from the low quality of fuels (coal, biomass) in producing or exaggerating dust effects

To detect errors produced by city architecture such as high buildings that obstacle the wind flow, the number of houses, dust of destruction and re-constructing new buildings, number of building renovations, building materials, the activities of occupants, pollution of traffic and houses for their fuel and warming, cooking products, number of parks and trees, distance of factories from cities.

Methods of measurement and monitoring the indoor and outdoor concentrations of particles by special institute with collaboration of lab and environmental public health

-Modeling practical interventions to control air pollution regarding its source whether climate and energy-use changes.

Health effects of nonindustrial indoor air pollution, environmental risk factors for respiratory symptoms, the number of respiratory and cardiovascular diseases, cardiovascular and respiratory admissions and hospitalizations, mortality, and childhood asthma.

Implementing environmental protection measures and public health interventions are required to reduce burden of air pollution-related diseases, especially reducing children's exposure to these elements.

Regarding indoor-outdoor factors that exaggerating previous lung diseases such as COPD, occupational lung disease, previous lung etiologies, agricultural workers, industrial air pollution, and coal miners.

Detecting modifiable factors that have negative impact on lung function such as smoking habits, obesity, and occupational dust exposure. Reduce the risk of work-associated respiratory morbidity especially in dust-exposed occupations, smoking cessation is recommended.

Follow-up of at-risk subjects with respiratory symptoms by questionnaire and spirometry.

Studies on possible cytotoxic and carcinogenic mechanisms of air pollution in the lungs

Educating people for limiting environment destruction or exaggerating air pollution and set-up public alarms for hours of increase of pollution .

Conflicts of Interest

The authors declare no conflict of interest.

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REFERENCES

1- Griffin DW. Atmospheric movement of microorganisms in clouds of desert dust and implications for human health. Clin Microbiol Rev. 2007 Jul;20(3):459-77.

2- Goudie AS .Dust storms: recent developments. J Environ Manage. 2009 Jan;90(1):89-94. doi: 10.1016/j.jenvman.2008.07.007. Epub 2008 Sep 9.

3-Kanatani KT, Adachi Y, Sugimoto N, Noma H, Onishi K, Hamazaki K, Takahashi Y1, Ito I, Egawa M, Sato K, Go T, Kurozawa Y, Inadera H, Konishi I, Nakayama T; Japan Environment & Children's Study Group.Birth cohort study on the effects of desert dust exposure on children's health: protocol of an adjunct study of the Japan Environment & Children's Study. BMJ Open. 2014 Jun 23;4(6):e004863. doi: 10.1136/bmjopen-2014-004863.

4- Kellogg CA, Griffin DW. Aerobiology and the global transport of desert dust. Trends Ecol Evol. 2006 Nov;21(11):638-44. Epub 2006 Jul 14.

5- Cao H, Amiraslani F, Liu J, Zhou N. Identification of dust storm source areas in West Asia using multiple environmental datasets. Sci Total Environ. 2015 Jan 1;502:224-35. doi: 10.1016/j.scitotenv.2014.09.025. Epub 2014 Sep 26.

6-Amini H, Taghavi-Shahri SM, Henderson SB, Naddafi K, Nabizadeh R, Yunesian M. Land use regression models to estimate the annual and seasonal spatial variability of sulfur dioxide and particulate matter in Tehran, Iran. Sci Total Environ. 2014 Aug 1;488-489:343-53. doi: 10.1016/j.scitotenv.2014.04.106. Epub 2014 May 16.

7- Chen Y, Cai Q, Tang H. Dust storm as an environmental problem in north China. Environ Manage. 2003 Oct;32(4):413-7.

8-Wong CM, Vichit-Vadakan N, Vajanapoom N, Ostro B, Thach TQ, Chau PY, Chan EK, Chung RY, Ou CQ, Yang L, Peiris JS, Thomas GN, Lam TH, Wong TW, Hedley AJ, Kan H, Chen B, Zhao N, London SJ, Song G, Chen G, Zhang Y, Jiang L, Qian Z, He Q, Lin HM, Kong L, Zhou D, Liang S, Zhu Z, Liao D, Liu W, Bentley CM, Dan J, Wang B, Yang N, Xu S, Gong J, Wei H, Sun H, Qin Z; HEI Health Review Committee.Part 5. Public health and air pollution in Asia (PAPA): a combined analysis of four studies of air pollution and mortality. Res Rep Health Eff Inst. 2010 Nov;(154):377-418.

9-Löw F, Navratil P, Kotte K, Schöler HF, Bubenzer O . Remote-sensing-based analysis of landscape change in the desiccated seabed of the Aral Sea--a potential tool for assessing the hazard degree of dust and salt storms. Environ Monit Assess. 2013 Oct;185(10):8303-19. doi: 10.1007/s10661-013-3174-7. Epub 2013 Apr 7.

10-Hashizume M, Ueda K, Nishiwaki Y, Michikawa T, Onozuka D. Health effects of Asian dust events: a review of the literature. Nihon Eiseigaku Zasshi. 2010 May;65(3):413-21.

11-Yu H, Remer LA, Chin M, Bian H, Tan Q, Yuan T, Zhang Y. Aerosols from overseas rival domestic emissions over North America. Science. 2012 Aug 3;337(6094):566-9. doi: 10.1126/science.1217576.

12- De Longueville F, Hountondji YC, Henry S, Ozer P. What do we know about effects of desert dust on air quality and human health in West Africa compared to other regions? Sci Total Environ. 2010 Dec 1;409(1):1-8. doi: 10.1016/j.scitotenv.2010.09.025. Epub 2010 Oct 8.

13-Karanasiou A, Moreno N, Moreno T, Viana M, de Leeuw F, Querol X. Health effects from Sahara dust episodes in Europe: literature review and research gaps. Environ Int. 2012 Oct 15;47:107-14. doi: 10.1016/j.envint.2012.06.012. Epub 2012 Jul 15.

14- Akpinar-Elci M, Martin FE, Behr JG, Diaz R .Saharan dust, climate variability, and asthma in Grenada, the Caribbean. Int J Biometeorol. 2015 Feb 24. [Epub ahead of print]

15- Moridnejad A, Karimi N, Ariya PA. A new inventory for middle east dust source points. Environ Monit Assess. 2015 Sep;187(9):4806. doi: 10.1007/s10661-015-4806-x. Epub 2015 Aug 22.

16-Samadi M, Darvishi Boloorani A, Alavipanah SK, Mohamadi H, Najafi MS. Global dust Detection Index (GDDI); a new remotely sensed methodology for dust storms detection. J Environ Health Sci Eng. 2014 Jan 9;12(1):20. doi: 10.1186/2052-336X-12-20.

17- F, Najafi MS, Samadi M. An analysis on synoptic patterns of springtime dust occurrence inWest of Iran. Physical Geography Research Quarterly. 2012;2(80):99–124.

18-Goudarzi G, Geravandi S, Foruozandeh H, Babaei AA, Alavi N, Niri MV, Khodayar MJ, Salmanzadeh S, Mohammadi MJ. Cardiovascular and respiratory mortality attributed to ground-level ozone in Ahvaz, Iran. Environ Monit Assess. 2015 Aug;187(8):487. doi: 10.1007/s10661-015-4674-4. Epub 2015 Jul 4.

19-Grigoratos T, Martini G. Brake wear particle emissions: a review. Environ Sci Pollut Res Int. 2015 Feb;22(4):2491-504. doi: 10.1007/s11356-014-3696-8. Epub 2014 Oct 17.

20- van der Gon HA, Gerlofs-Nijland ME, Gehrig R, Gustafsson M, Janssen N, Harrison RM, Hulskotte J, Johansson C, Jozwicka M, Keuken M, Krijgsheld K, Ntziachristos L, Riediker M, Cassee FR. The policy relevance of wear emissions from road transport, now and in the future--an international workshop report and consensus statement. J Air Waste Manag Assoc. 2013 Feb;63(2):136-49.

21-Porcal P, Koprivnjak JF, Molot LA, Dillon PJ. Humic substances-part 7: the biogeochemistry of dissolved organic carbon and its interactions with climate change. Environ Sci Pollut Res Int. 2009 Sep;16(6):714-26. doi: 10.1007/s11356-009-0176-7. Epub 2009 May 22.

22-Chow JC, Lowenthal DH, Chen LW, Wang X, Watson JG. Mass reconstruction methods for PM2.5: a review. Air Qual Atmos Health. 2015;8(3):243-263. Epub 2015 May 7.

23-[No authors listed].Health effects of outdoor air pollution. Committee of the Environmental and Occupational Health Assembly of the American Thoracic Society. Am J Respir Crit Care Med. 1996 Jan;153(1):3-50.

24-Ibrayeva LK, Amanbekova AU, Turgunova LG, Lariushina EM: Influence of ecologic factors on respiratory diseases in urban residents of Kazakhstan Republic. Med Tr Prom Ekol. 2015;(3):29-33.

25- Xu P, Wang W, Ji J, Yao S: Analysis of the Contribution of the Road Traffic Industry to the PM2.5 Emission for Different Land-Use Types. Comput Intell Neurosci. 2014;2014:821973. doi: 10.1155/2014/821973. Epub 2014 Nov 4.

26- Seaman DM1, Meyer CA2, Kanne JP2. Occupational and Environmental Lung Disease. Clin Chest Med. 2015 Jun;36(2):249-268. doi: 10.1016/j.ccm.2015.02.008.

27- Hang B, Cheng S, Xia Y, Mao J. [Thirdhand smoke: current research status and future prospects]. Zhonghua Yu Fang Yi Xue Za Zhi. 2015 Apr;49(4):297-300.

28-Qiao X, Tang Y, Kota SH, Li J, Wu L, Hu J, Zhang H, Ying Q.Modeling dry and wet deposition of sulfate, nitrate, and ammonium ions in Jiuzhaigou National Nature Reserve, China using a source-oriented CMAQ model: Part II. Emission sector and source region contributions.

Sci Total Environ. 2015 Jun 3. pii: S0048-9697(15)30165-0. doi: 10.1016/j.scitotenv.2015.05.107. [Epub ahead of print]
29-Watson JG1, Chow JC, Lowenthal DH, Antony Chen LW, Shaw S, Edgerton ES, Blanchard CL. PM2.5 source apportionment with organic markers in the Southeastern Aerosol Research and Characterization (SEARCH) study. J Air Waste Manag Assoc. 2015 Sep;65(9):1104-18. doi: 10.1080/10962247.2015.1063551.
30- Besis A, Samara C. Polybrominated diphenyl ethers (PBDEs) in the indoor and outdoor environments--a review on occurrence and human exposure. Environ Pollut. 2012 Oct;169:217-29. doi: 10.1016/j.envpol.2012.04.009. Epub 2012 May 9.
31-Abuduwailil J, Zhaoyong Z, Fengqing J. Evaluation of the pollution and human health risks posed by heavy metals in the atmospheric dust in Ebinur Basin in Northwest China. Environ Sci Pollut Res Int. 2015 Sep;22(18):14018-31. doi: 10.1007/s11356-015-4625-1. Epub 2015 May 9.
32-Zhang CR, Wu ZL, Yao CH, Gao ZJ. [Health risk assessment of heavy metals in atmospheric dust of Qingdao City]. Huan Jing Ke Xue. 2014 Jul;35(7):2736-41.
33-Hong YC, Pan XC, Kim SY, Park K, Park EJ, Jin X, Yi SM, Kim YH, Park CH, Song S, Kim H. Asian Dust Storm and pulmonary function of school children in Seoul. Sci Total Environ. 2010 Jan 15;408(4):754-9. doi: 10.1016/j.scitotenv.2009.11.015. Epub 2009 Nov 24.
34-Liao HT, Chou CC, Chow JC, Watson JG, Hopke PK, Wu CF .Source and risk apportionment of selected VOCs and PM2.5 species using partially constrained receptor models with multiple time resolution data. Environ Pollut. 2015 Oct;205:121-30. doi: 10.1016/j.envpol.2015.05.035. Epub 2015 Jun 6.
35-Abuduwaili J, Zhang Zy, Jiang Fq. Assessment of the distribution, sources and potential ecological risk of heavy metals in the dry surface sediment of Aibi Lake in northwest China. PLoS One. 2015 Mar 17;10(3):e0120001. doi: 10.1371/journal.pone.0120001. eCollection 2015.
36-Parks CG, Cooper G, Nylander-French LA, Storm JF, Archer JD. Assessing exposure to crystalline silica from farm work: a population-based study in the Southeastern United States. Ann Epidemiol. 2003 May;13(5):385-92.
37-Dahmann D, Taeger D, Kappler M, Büchte S, Morfeld P, Brüning T, Pesch B. Assessment of exposure in epidemiological studies: the example of silica dust. J Expo Sci Environ Epidemiol. 2008 Sep;18(5):452-61. Epub 2007 Dec 5.
38-Ababneh AM, Masa'deh MS, Ababneh ZQ, Awawdeh MA, Alyassin AM .Radioactivity concentrations in soil and vegetables from the northern Jordan Rift Valley and the corresponding dose estimates. Radiat Prot Dosimetry. 2009 Feb;134(1):30-7. doi: 10.1093/rpd/ncp064. Epub 2009 Apr 22.
39- KM, Mashal LA, Hasan F. Radioactivity concentration in soil samples in the southern part of the West Bank, Palestine. Radiat Prot Dosimetry. 2008;131(2):265-71. doi: 10.1093/rpd/ncn161. Epub 2008 May 24.
40- Hamadneh HS, Ababneh ZQ, Hamasha KM, Ababneh AM. The radioactivity of seasonal dust storms in the Middle East: the May 2012 case study in Jordan. J Environ Radioact. 2015 Feb;140:65-9. doi: 10.1016/j.jenvrad.2014.11.003. Epub 2014 Nov 25.
41- Abusini M, Al-Ayasreh K, Al-Jundi J. Determination of uranium, thorium and potassium activity concentrations in soil cores in Araba valley, Jordan. Radiat Prot Dosimetry. 2008;128(2):213-6. Epub 2007 Jun 26.
42-Ohe T, Watanabe T, Wakabayashi K.Mutagens in surface waters: a review. Mutat Res. 2004 Nov;567(2-3):109-49.
43- Faghihi R, Mehdizadeh S, Sina S.Natural and artificial radioactivity distribution in soil of Fars Province, Iran. Radiat Prot Dosimetry. 2011 Apr;145(1):66-74. doi: 10.1093/rpd/ncq367. Epub 2010 Nov 15.
44-Dinh Chau N, Dulinski M, Jodlowski P, Nowak J, Rozanski K, Sleziak M, Wachniew P.Natural radioactivity in groundwater--a review. Isotopes Environ Health Stud. 2011 Dec;47(4):415-37. doi: 10.1080/10256016.2011.628123.
45-Nourmoradi H, Moradnejadi K, Moghadam FM, Khosravi B, Hemati L, Khoshniyat R, Kazembeigi F. The Effect of Dust Storm on the Microbial Quality of Ambient Air in Sanandaj: A City Located in the West of Iran. Glob J Health Sci. 2015 Mar 26;7(7):46888. doi: 10.5539/gjhs.v7n7p114.
46-Bös L, Schönfeld N, Schaberg T. Non Tuberculous Mycobacteria--a Short Review about Epidemiology, Diagnosis and Treatment. Pneumologie. 2015 May;69(5):287-93; quiz 294. doi: 10.1055/s-0034-1391971. Epub 2015 May 13.
47-Shinn EA, Griffin DW, Seba DB. Atmospheric transport of mold spores in clouds of desert dust. Arch Environ Health. 2003 Aug;58(8):498-504.

48-Kanamori H, Rutala WA, Sickbert-Bennett EE, Weber DJ .Review of Fungal Outbreaks and Infection Prevention in Healthcare Settings During Construction and Renovation. Clin Infect Dis. 2015 Aug 1;61(3):433-44. doi: 10.1093/cid/civ297. Epub 2015 Apr 13.

49-Qian Z, He Q, Lin HM, Kong L, Zhou D, Liang S, Zhu Z, Liao D, Liu W, Bentley CM, Dan J, Wang B, Yang N, Xu S, Gong J, Wei H, Sun H, Qin Z; HEI Health Review Committee.Part 2. Association of daily mortality with ambient air pollution, and effect modification by extremely high temperature in Wuhan, China. Res Rep Health Eff Inst. 2010 Nov;(154):91-217.

50- Ahmed HO, Abdullah AA. Dust exposure and respiratory symptoms among cement factory workers in the United Arab Emirates. Ind Health. 2012;50(3):214-22. Epub 2012 Mar 28.

51- Kawasaki H. A mechanistic review of silica-induced inhalation toxicity. Inhal Toxicol. 2015 Jul;27(8):363-77. doi: 10.3109/08958378.2015.1066905. Epub 2015 Jul 21.

52- Kurai J, Watanabe M, Tomita K, Sano H, Yamasaki A, Shimizu E .Influence of Asian dust particles on immune adjuvant effects and airway inflammation in asthma model mice. PLoS One. 2014 Nov 11;9(11):e111831. doi: 10.1371/journal.pone.0111831. eCollection 2014.

53-Rodríguez-Cotto RI, Ortiz-Martínez MG, Rivera-Ramírez E, Méndez LB, Dávila JC1, Jiménez-Vélez BD. African Dust Storms Reaching Puerto Rican Coast Stimulate the Secretion of IL-6 and IL-8 and Cause Cytotoxicity to Human Bronchial Epithelial Cells (BEAS-2B). Health (Irvine Calif). 2013 Oct;5(10B):14-28.

54-Becker S1, Mundandhara S, Devlin RB, Madden M . Regulation of cytokine production in human alveolar macrophages and airway epithelial cells in response to ambient air pollution particles: further mechanistic studies. Toxicol Appl Pharmacol. 2005 Sep 1;207(2 Suppl):269-75.

55- Poole JA1, Romberger DJ. Immunological and inflammatory responses to organic dust in agriculture. Curr Opin Allergy Clin Immunol. 2012 Apr;12(2):126-32. doi: 10.1097/ACI.0b013e3283511d0e.

56-Watanabe M, Kurai J, Sano H, Yamasaki A, Shimizu E .Difference in Pro-Inflammatory Cytokine Responses Induced in THP1 Cells by Particulate Matter Collected on Days with and without ASIAN Dust Storms. Int J Environ Res Public Health. 2015 Jul 9;12(7):7725-37. doi: 10.3390/ijerph120707725.

57-Watanabe M, Kurai J, Tomita K, Sano H, Abe S, Saito R, Minato S, Igishi T, Burioka N, Sako T, Yasuda K, Mikami M, Kurita S, Tokuyasu H, Ueda Y, Konishi T, Yamasaki A, Aiba S, Oshimura M, Shimizu E. Effects on asthma and induction of interleukin-8 caused by Asian dust particles collected in western Japan. J Asthma. 2014 Aug;51(6):595-602. doi: 10.3109/02770903.2014.903965. Epub 2014 Mar 27.

58-Deng F, Guo X, Liu H, Fang X, Yang M, Chen W. Effects of dust storm PM2.5 on cell proliferation and cell cycle in human lung fibroblasts. Toxicol In Vitro. 2007 Jun;21(4):632-8. Epub 2007 Jan 11.

59-Murdoch JR1, Gregory LG, Lloyd CM. γδT cells regulate chronic airway inflammation and development of airway remodelling. Clin Exp Allergy. 2014 Nov;44(11):1386-98. doi: 10.1111/cea.12395.

60-Sahlander K1, Larsson K, Palmberg L. Daily exposure to dust alters innate immunity. PLoS One. 2012;7(2):e31646. doi: 10.1371/journal.pone.0031646. Epub 2012 Feb 15.

61-Hisata S1, Moriyama H, Tazawa R, Ohkouchi S, Ichinose M, Ebina M. Development of pulmonary alveolar proteinosis following exposure to dust after the Great East Japan Earthquake. Respir Investig. 2013 Dec;51(4):212-6. doi: 10.1016/j.resinv.2013.04.005. Epub 2013 Jun 4.

62-McAlees JW, Whitehead GS, Harley IT, Cappelletti M, Rewerts CL, Holdcroft AM, Divanovic S, Wills-Karp M, Finkelman FD, Karp CL, Cook DN. Distinct Tlr4-expressing cell compartments control neutrophilic and eosinophilic airway inflammation. Mucosal Immunol. 2015 Jul;8(4):863-73. doi: 10.1038/mi.2014.117. Epub 2014 Dec 3.

63-Robbe P, Draijer C, Borg TR, Luinge M, Timens W, Wouters IM, Melgert BN, Hylkema MN. Distinct macrophage phenotypes in allergic and nonallergic lung inflammation. Am J Physiol Lung Cell Mol Physiol. 2015 Feb 15;308(4):L358-67. doi: 10.1152/ajplung.00341.2014. Epub 2014 Dec 12.

64-Goudie AS. Desert dust and human health disorders. Environ Int. 2014 Feb;63:101-13. doi: 10.1016/j.envint.2013.10.011. Epub 2013 Nov 26.

65-Gonzalez-Garcia M1, Caballero A, Jaramillo C, Maldonado D, Torres-Duque CA. Prevalence, risk factors and underdiagnosis of asthma and wheezing in adults 40 years and older: A population-based study. J Asthma. 2015 May 21:1-8. [Epub ahead of print]

66-Jie Y1, Isa ZM, Jie X, Ju ZL, Ismail NH. Urban vs. rural factors that affect adult asthma. Rev

Environ Contam Toxicol. 2013;226:33-63. doi: 10.1007/978-1-4614-6898-1_2.
67-Shang Y1, Das S, Rabold R, Sham JS, Mitzner W, Tang WY. Epigenetic alterations by DNA methylation in house dust mite-induced airway hyperresponsiveness. Am J Respir Cell Mol Biol. 2013 Aug;49(2):279-87. doi: 10.1165/rcmb.2012-0403OC.
68- Grainge CL, Davies DE. Epithelial injury and repair in airways diseases. Chest. 2013 Dec;144(6):1906-12. doi: 10.1378/chest.12-1944.
69-Wang CH, Chen CS, Lin CL.. The threat of Asian dust storms on asthma patients: a population-based study in Taiwan. Glob Public Health. 2014;9(9):1040-52. doi: 10.1080/17441692.2014.951871. Epub 2014 Sep 3.
70-Shpagina LA, Voevoda MI, Kotova OS, Maksimov VN, Orlov PS, Shpagin IS: Genetic aspects of occupational chronic obstructive lung disease under exposure to various risk factors. Med Tr Prom Ekol. 2014;(3):40-4.
71-Panacheva, Shpagina LA, Bazhenova KO, Ziubina LIu. Role of genetic factors in development of occupational obstructive lung disease. Med Tr Prom Ekol. 2014;(3):35-9.
72-de Jong K, Vonk JM, Timens W, Bossé Y, Sin DD, Hao K, Kromhout H, Vermeulen R, Postma DS, Boezen HM. Genome-wide interaction study of gene-by-occupational exposure and effects on FEV1 levels. J Allergy Clin Immunol. 2015 May 12. pii: S0091-6749(15)00496-0. doi: 10.1016/j.jaci.2015.03.042.
73-de Jong K, Boezen HM, Kromhout H, Vermeulen R, Postma DS, Vonk JM; LifeLines Cohort study.Pesticides and other occupational exposures are associated with airway obstruction: the LifeLines cohort study. Occup Environ Med. 2014 Feb;71(2):88-96. doi: 10.1136/oemed-2013-101639. Epub 2013 Oct 10.
74-Würtz ET, Schlünssen V, Malling TH, Hansen JG, Omland Ø. Occupational COPD among Danish never-smokers: a population-based study. Occup Environ Med. 2015 Jun;72(6):456-9. doi: 10.1136/oemed-2014-102589. Epub 2015 Jan 21.
75-Liao SY1, Lin X, Christiani DC. Occupational exposures and longitudinal lung function decline. Am J Ind Med. 2015 Jan;58(1):14-20. doi: 10.1002/ajim.22389. Epub 2014 Nov 10.
76-Omland O, Würtz ET, Aasen TB, Blanc P, Brisman JB, Miller MR, Pedersen OF, Schlünssen V, Sigsgaard T, Ulrik CS, Viskum S. Occupational chronic obstructive pulmonary disease: a systematic literature review. Scand J Work Environ Health. 2014 Jan;40(1):19-35. doi: 10.5271/sjweh.3400. Epub 2013 Nov 12.
77-Doney B1, Hnizdo E, Graziani M, Kullman G, Burchfiel C, Baron S, Fujishiro K, Enright P, Hankinson JL, Stukovsky KH, Martin CJ, Donohue KM, Barr RG. Occupational risk factors for COPD phenotypes in the Multi-Ethnic Study of Atherosclerosis (MESA) Lung Study. COPD. 2014 Aug;11(4):368-80. doi: 10.3109/15412555.2013.813448. Epub 2014 Feb 25.
78-Kanazawa A1, Kishi R.Potential risk of indoor semivolatile organic compounds indoors to human health. Nihon Eiseigaku Zasshi. 2009 May;64(3):672-82.
79-Nakamura T, Hashizume M, Ueda K, Kubo T, Shimizu A, Okamura T, Nishiwaki Y. The relationship between Asian dust events and out-of-hospital cardiac arrests in Japan. J Epidemiol. 2015;25(4):289-96. doi: 10.2188/jea.JE20140179. Epub 2015 Mar 21.
80-Morfeld P, Bruch J, Levy L, Ngiewih Y, Chaudhuri I, Muranko HJ, Myerson R, McCunney RJ.Translational toxicology in setting occupational exposure limits for dusts and hazard classification - a critical evaluation of a recent approach to translate dust overload findings from rats to humans. Part Fibre Toxicol. 2015 Apr 23;12:3. doi: 10.1186/s12989-015-0079-3.
81-Shang Y, Sun Z, Cao J, Wang X, Zhong L, Bi X, Li H, Liu W, Zhu T, Huang W. Systematic review of Chinese studies of short-term exposure to air pollution and daily mortality. Environ Int. 2013 Apr;54:100-11. doi: 10.1016/j.envint.2013.01.010. Epub 2013 Feb 19.
82-Coulibaly S, Minami H, Abe M, Hasei T, Sera N, Yamamoto S, Funasaka K, Asakawa D, Watanabe M, Honda N, Wakabayashi K, Watanabe T .Seasonal Fluctuations in Air Pollution in Dazaifu, Japan, and Effect of Long-Range Transport from Mainland East Asia. Biol Pharm Bull. 2015;38(9):1395-403. doi: 10.1248/bpb.b15-00443.
83-Perez L, Tobías A, Querol X, Pey J, Alastuey A, Díaz J, Sunyer J. Saharan dust, particulate matter and cause-specific mortality: a case-crossover study in Barcelona (Spain). Environ Int. 2012 Nov 1;48:150-5. doi: 10.1016/j.envint.2012.07.001. Epub 2012 Aug 28.
84-Kim H, Kim H, Lee JT .Effects of ambient air particles on mortality in Seoul: Have the effects changed over time? Environ Res. 2015 Jul;140:684-90. doi: 10.1016/j.envres.2015.05.029. Epub 2015 Jun 14.

85-Teng JC, Chan YS, Peng YI, Liu TC. Influence of Asian dust storms on daily acute myocardial infarction hospital admissions. Public Health Nurs. 2015 Jun 9. doi: 10.1111/phn.12209. [Epub ahead of print]

86-Stafoggia M, Zauli-Sajani S, Pey J, Samoli E, Alessandrini E, Basagaña X, Cernigliaro A, Chiusolo M, Demaria M, Díaz J, Faustini A, Katsouyanni K, Kelessis AG, Linares C, Marchesi S, Medina S, Pandolfi P, Pérez N, Querol X, Randi G, Ranzi A, Tobias A, Forastiere F; and the MED-PARTICLES Study Group. Desert Dust Outbreaks in Southern Europe: Contribution to Daily PM10 Concentrations and Short-Term Associations with Mortality and Hospital Admissions. Environ Health Perspect. 2015 Jul 24. [Epub ahead of print]

87- Atkinson RW, Kang S, Anderson HR, Mills IC, Walton HA. Epidemiological time series studies of PM2.5 and daily mortality and hospital admissions: a systematic review and meta-analysis. Thorax. 2014 Jul;69(7):660-5. doi: 10.1136/thoraxjnl-2013-204492. Epub 2014 Apr 4.

88-Yang CY, Chen YS, Chiu HF, Goggins WB. Effects of Asian dust storm events on daily stroke admissions in Taipei, Taiwan. Environ Res. 2005 Sep;99(1):79-84.

89-Tam WW, Wong TW, Wong AH, Hui DS. Effect of dust storm events on daily emergency admissions for respiratory diseases. Respirology. 2012 Jan;17(1):143-8. doi: 10.1111/j.1440-1843.2011.02056.x.

90-Holyoak AL, Aitken PJ, Elcock MS. Australian dust storm: impact on a statewide air medical retrieval service. Air Med J. 2011 Nov-Dec;30(6):322-7. doi: 10.1016/j.amj.2010.12.010.

91-Jorquera H, Borzutzky A, Hoyos-Bachiloglu R, García A. Association of Kawasaki disease with tropospheric winds in Central Chile: is wind-borne desert dust a risk factor? Environ Int. 2015 May;78:32-8. doi: 10.1016/j.envint.2015.02.007. Epub 2015 Mar 2.

92-Ashrafi K, Shafiepour-Motlagh M, Aslemand A1, Ghader S. Dust storm simulation over Iran using HYSPLIT. J Environ Health Sci Eng. 2014 Jan 7;12(1):9. doi: 10.1186/2052-336X-12-9.

93-Moradian MJ, Rastegarfar B, Rastegar MR, Ardalan A. Tehran dust storm early warning system: corrective measures. PLoS Curr. 2015 Feb 24;7. pii: currents.dis.14f3c645eb2e2003a44c6efd22c23f5e. doi: 10.1371/currents.dis.14f3c645eb2e2003a44c6efd22c23f5e.

94-Woo JH1, He S, Tagaris E, Liao KJ, Manomaiphiboon K, Amar P, Russell AG. Development of North American emission inventories for air quality modeling under climate change. J Air Waste Manag Assoc. 2008 Nov;58(11):1483-94.

95-Fiore AM, Naik V, Leibensperger EM .Air quality and climate connections. J Air Waste Manag Assoc. 2015 Jun;65(6):645-85. doi: 10.1080/10962247.2015.1040526.

96-Cherrie JW1, Brosseau LM, Hay A, Donaldson K. Low-toxicity dusts: current exposure guidelines are not sufficiently protective. Ann Occup Hyg. 2013 Jul;57(6):685-91. doi: 10.1093/annhyg/met038. Epub 2013 Jul 8.

97-Fiore AM, Naik V, Spracklen DV, Steiner A, Unger N, Prather M, Bergmann D, Cameron-Smith PJ, Cionni I, Collins WJ, Dalsøren S, Eyring V, Folberth GA, Ginoux P, Horowitz LW, Josse B, Lamarque JF, MacKenzie IA, Nagashima T, O'Connor FM, Righi M, Rumbold ST, Shindell DT, Skeie RB, Sudo K, Szopa S, Takemura T, Zeng G. Global air quality and climate. Chem Soc Rev. 2012 Oct 7;41(19):6663-83. doi: 10.1039/c2cs35095e. Epub 2012 Aug 6.

98-Liu X, Li N, Xie W, Wu J, Zhang P, Ji Z. The return periods and risk assessment of severe dust storms in Inner Mongolia with consideration of the main contributing factors. Environ Monit Assess. 2012 Sep;184(9):5471-85. doi: 10.1007/s10661-011-2354-6. Epub 2011 Sep 29.