ISSN-E: 18735347-02779536

Environmental exposure to dust among family members and its repercussions on respiratory health

By:
Sultan Abdullah Alelyani
Nursing technician
Jazy Jaez Alharbi
Nursing technician
SAAD AEDH ALQAHTANI
Senior specialist in health services and hospitals management
AbdulMajeed Muhammad Al-Muiteq
Ambulance technician
TARIQ ABDULLAH ALMANNAA
X-Ray technician
Asman Marshad Alhrabi
Nursing technician
IBRAHIM ABDULAZIZ BIN OSFUR
Epidemiology technician

ISSN-E: 18735347-02779536

Introduction:

The most prevalent source of non-anthropogenic dust in the environment is fugitive dust, which occurs naturally as soil, sand, and rock erode. Fugitive dust (hereinafter referred to as "dust") originates predominantly in arid and dry places where powerful winds can remove and transport particles over a large area. Furthermore, human activity can increase fugitive dust through particular land, water, and farmland management methods. In some countries, blowing dust can be a significant component of the particle mix. Dust particles might be large or little, visible or invisible. They can be deposited close to their source or hundreds of miles distant, depending on how far the wind blows. The size of particles is often classified as coarse or fine. Coarse particles (CP; particles ranging in size from 2.5 to 10 microns) and fine particles (PM2.5; particles smaller than or equal to 2.5 microns) come from diverse sources and have distinct features and possible health impacts. CP are formed by resuspended material and mechanical grinding, and they are primarily composed of crustal matter (the principal source of fugitive dust), road dust, and metal. PM2.5 is typically produced by fuel combustion processes (e.g., power plants, mobile sources, and biomass burning) or photochemical reactions in the atmosphere, and it contains organic and elemental carbon, sulfate, nitrate, and metals. However, fugitive dust can be discovered in the fine-particulate range, exposing populations far downwind.

While PM2.5 has been linked to mortality in research conducted around the world (Brook et al. 2010; US EPA 2009), there have been significantly fewer investigations on CP, particularly the fugitive-dust component. Dust can be a substantial cause of ambient air pollution, especially in low- and middle-income nations, therefore its effects on public health warrant further investigation. Awareness of its effects can provide valuable information for government-issued episode alerts and appropriate mitigation measures. Furthermore, assessing the health consequences of dust exposure can have a considerable impact on the Global Burden of Disease assessment of particulate matter air pollution. Finally, if dust is considered to represent a health danger, it must be integrated into overall particle control methods for the ambient air. While mitigating fugitive dust may be difficult, if not impossible, in some areas, it can contribute to a high baseline concentration, amplifying the influence of other anthropogenic causes.

This paper reviews the available epidemiological studies on the public health effects of exposure to dust in both coarse and fine types and at varied distances from the dust's source. In addition, this report evaluates the potential impact of dust exposure on the disease burden linked with outdoor air pollution. Fine particles are the pollution metric utilized in the majority of air pollution burden of disease estimations, hence this paper focuses on them. This study is not intended to be a thorough assessment of the literature, as such may be found elsewhere, but rather to provide an indication of the sorts of research undertaken, their locations, general conclusions, and associated uncertainties. The ultimate goal is to provide policy recommendations for how exposure to dust should be considered in global or regional health assessments, based on currently available information, and research recommendations to gain a better knowledge of dust's effects.

Health Consequences of Dust Exposure in Dust Storm-Affected Areas

There have been very few epidemiological investigations undertaken in places where dust storms occur. The majority of existing investigations have been conducted far from Saharan or Asian dust storms. Abdo et al. (2016) present a review of studies on environmental variables and respiratory outcomes in the eastern Middle East. Only a few epidemiological studies have looked into the impact of dust storms or extremely high particle levels on health. For example, Houssaini et al. (2007) investigated schoolchildren (average age 12) in western Morocco to discover if there was a link between excessive pollution and respiratory problems. Over a four-year period, total suspended particulates (TSP) were recorded in a variety of locations. After controlling for a variety of individual characteristics and interior conditions, the region with the highest levels of TSP was found to be significantly linked with the risk of asthma.

Thalib and Al-Taiar (2012) studied the impact of dust storms (defined as days with PM10 > 200 µg/m3) on age-specific hospital admissions for asthma and respiratory disorders in Kuwait during a 5-year period. Statistical approaches were utilized to determine whether there was a link between the dust storms and same-day or delayed admissions. Thalib and Al-Taiar (2012) conducted a population-based retrospective time-series study of daily emergency asthma admissions and admissions from respiratory reasons in public hospitals. Overall, 34 percent of the days experienced dust storms, which were strongly related with an elevated risk of asthma and respiratory admissions, particularly among those under the age of 15. Over the same five-year timeframe, Al-Taiar and Thalib (2014) investigated the daily impact of dust storms on mortality in Kuwait. While some beneficial connections were found, none were statistically significant in terms of all-cause, cardiovascular, or respiratory mortality. However, considering the average of 9 fatalities per day, including 4.5 for cardiovascular mortality and fewer than one for respiratory mortality, the trial may have lacked statistical power to find an effect.

Meo et al. (2013) chose healthy volunteers in Saudi Arabia to study the effects of a sandstorm that lasted an average of 24 minutes. They discovered that a large proportion of the individuals experienced coughing (48%), wheezing (33%), and acute asthma (21%). Vodonos et al. (2014) examined data from 2,100 verified COPD patients living in Be'er Sheva, a southern Israeli municipality bordering the Sahara-Arab dust belt. A time-series analysis was conducted to evaluate if an exacerbation was more frequent during high dust-storm days, defined as a day when the PM10 concentration exceeded 71 µg/m3, which is two standard deviations above the background value. Days with PM10 levels above 200 µg/m3 were classified as intense dust storm days. They discovered a statistically significant link between dust-storm days and COPD hospitalization, with substantially higher chances on intensive dust-storm days.

In one of the few studies examining cardiovascular outcomes, Ebrahimi et al. (2014) investigated the link between dust-storm days (as defined by the local environmental agency) and emergency visits for cardiovascular and respiratory diseases among residents of Sanandaj, Islamic Republic of Iran. The average PM10 concentration during dust outbreaks was 187 µg/m3. Using a basic analytic technique, daily concentrations were found to be moderately linked with cardiovascular and respiratory visits, with correlations of 0.48 and 0.19, respectively.

Crooks et al. (2016) investigated the mortality connection with 209 dust storms in the United States (mostly in California and Arizona) from 1993 to 2005. The US National Weather Service widely characterized dust storms in this case, drawing on data from disaster management officials, law enforcement, media reporting, and the insurance business. Two days following the dust storm, all-cause mortality increased by 7.4 percent (95 percent CI: 1.6, 13.5), with links also found for cardiovascular but not respiratory mortality.

A Nigerian cardiologist who has firsthand experienced the impacts during the Harmattan season provides potential biologic reasons for the observed effects of dust storm exposure (Okeahialam 2016). The Harmattan season lasts from December to March and is distinguished by cooler temperatures and dry dusty winds that transport Saharan dust to the West African region. During this time, there is an increase in hospital visits for cardiovascular problems (around 10% higher than the baseline); the increased visits are assumed to be due to a combination of dust and cooler temperatures. According to the author, the relative cold dries the mucus, reducing the body's usual defense systems and increasing the number of inhaled particles. This causes increased airway inflammation and an increased oxygen-stress burden, which is a risk factor for cardiovascular disease.

Consequences for Health of Coarse Particle Exposure Downwind from Dust Origins

An investigation into dust-specific coarse particles can contribute to the comprehension of the effects that their downwind exposures may have and offer valuable knowledge regarding the possible repercussions of both direct and immediate dust exposure. A number of investigations pertaining to Saharan coarse particle (CP) dust have been undertaken in Barcelona, Spain. The methodology employed by Perez et al. (2012) determined the coarse particle concentration on hazy days in Barcelona from 2003 to 2007. Differing analyses were conducted on days with and without dust. Dusty days accounted for approximately 10 percent of the total dusty days, during which CP concentrations rose by an average of 14 µg/m3, peaking at 43 µg/m3 on a single day. On days without dust, CP was substantially associated with cardiovascular and respiratory mortality, whereas on days with dust, the association was limited to cardiovascular mortality and not respiratory mortality. A prior study (Perez et al. 2008) documented an association between all-cause mortality and coarse particles on hazy days that was statistically significant. There was no observed correlation for CP on days without Saharan dust. Crustal material comprised sixty-five percent of the CP. Furthermore, studies have documented correlations between mortality rates in Madrid, Italy; Rome, Spain; and Cyprus, as well as daily CP and PM10 levels from Saharan dust (Tobias et al. 2011; Neophytou et al. 2013).

In their 2012 publication, De Longueville et al. conduct an exhaustive review of fifty studies that examined the health consequences of dust cyclones originating in the Saharan or Asian regions and occurred between 1999 and 2011. The majority of the studies (32) investigated the effects of arid dust from Asia on other Asian nations. A total of thirteen studies investigated the effects of Saharan-origin dust on Europe (eight studies), the Caribbean (three studies), or other regions (two studies). Five additional investigations were devoted to alternative source areas. A dust episode was defined by a variety of metrics in the studies, including limited visibility, high PM10 levels, a binary variable, and back-trajectory analysis. Furthermore, a variety of statistical methodologies were implemented. A total of thirty of the studies document correlations between dust events and respiratory or cardiovascular mortality or morbidity that are statistically significant. The majority of the articles examined the impact on hospital admissions and emergency room visits associated with asthma and COPD. A total of eight out of ten studies that investigated cardiovascular mortality and six out of seven studies that investigated respiratory mortality identified statistically significant correlations between dust and these two health outcomes. In Sydney, Australia; Seoul, Korea; the Canary Islands, Spain; Emilia-Romagna, Italy; and Taipei, China, associations with respiratory or cardiovascular mortality were also documented. However, no such associations were found in Athens, Greece; Nagasaki, Japan; or Spokane, Washington, within the United States.

An examination of the consequences of brief exposure to CP (not limited to dust episodes in and of themselves), Adar et al. (2014) performed a meta-analysis of existing research that employed a random-effects model to assess daily correlations with mortality and hospitalization. Although the majority of the studies were conducted in the United States and Western Europe, one study from China and one from Chile provided additional evidence. In the end, 23 studies were accessible pertaining to mortality (19 for all-cause, 14 for cardiovascular, and 11 for respiratory), while 10 studies were accessible concerning hospitalization (9 for respiratory and 7 for cardiovascular). The correlations between CP and the health outcomes were, on the whole, statistically significant. ICUization and respiratory mortality constituted the most significant hazards associated with CP exposure. In particular, the hazards associated with mortality per 10 μg/m3 were as follows: 0.6% (95 percent CI = 0.3, 0.8) for all-cause mortality, 1.4% (95 percent

ISSN-E: 18735347-02779536

CI = 0.5, 2.4) for cardiovascular mortality, and 0.75 (95 percent CI = 0.2, 1.2) for respiratory mortality. Respiratory risks were 1.0 percent (95 percent CI = 0.1, 1.8) and cardiovascular risks were 0.5 percent (95 percent Ci = 0.3, 0.7) in relation to hospitalization. Further examinations revealed that the respiratory impacts were relatively strong, and notably, persisted even when the correlation between CP and PM2.5 was weak. As a consequence, the probability that the CP effects were caused by PM2.5 was diminished. Upon examining correlations with PM2.5, all-cause and cardiovascular mortality were more significantly impacted (larger confidence interval and loss of statistical significance), despite the fact that the associations remained positive. Additionally, the meta-analysis revealed a correlation between CP and cardiovascular and respiratory disease-related hospitalizations.

An examination of the consequences of brief exposure to CP (not limited to dust episodes in and of themselves), Adar et al. (2014) performed a meta-analysis of existing research that employed a random-effects model to assess daily correlations with mortality and hospitalization. Although the majority of the studies were conducted in the United States and Western Europe, one study from China and one from Chile provided additional evidence. In the end, 23 studies were accessible pertaining to mortality (19 for all-cause, 14 for cardiovascular, and 11 for respiratory), while 10 studies were accessible concerning hospitalization (9 for respiratory and 7 for cardiovascular). The correlations between CP and the health outcomes were, on the whole, statistically significant. ICUization and respiratory mortality constituted the most significant hazards associated with CP exposure. In particular, the hazards associated with mortality per 10 µg/m3 were as follows: 0.6% (95 percent CI = 0.3, 0.8) for all-cause mortality, 1.4% (95 percent
CI = 0.5, 2.4) for cardiovascular mortality, and 0.75 (95 percent CI = 0.2, 1.2) for respiratory mortality. Respiratory risks were 1.0 percent (95 percent CI = 0.1, 1.8) and cardiovascular risks were 0.5 percent (95 percent Ci = 0.3, 0.7) in relation to hospitalization. Further examinations revealed that the respiratory impacts were relatively strong, and notably, persisted even when the correlation between CP and PM2.5 was weak. As a consequence, the probability that the CP effects were caused by PM2.5 was diminished. Upon examining correlations with PM2.5, all-cause and cardiovascular mortality were more significantly impacted (larger confidence interval and loss of statistical significance), despite the fact that the

associations remained positive. Additionally, the meta-analysis revealed a correlation between CP and cardiovascular and respiratory disease-related hospitalizations.

Health Consequences of Dust and Its Determinants

The presence of PM2.5 in the Saharan dust has been established through empirical evidence. An investigation conducted by Sajani et al. (2012) spanned an eight-year duration and was conducted at the Mount Cimone observatory, which is situated in the mountainous region bordering Florence and Bologna, Italy. The rural region remains impervious to typical urban pollution. The findings of their research indicated that, on average, around 35% of the bulk of the particles is measured at or below 2.5 microns. Considering the probable presence of PM2.5 in dust storms, research on the impacts of PM2.5 during dust events is significant.

In Rome, Italy, and Madrid, Spain, associations between PM2.5 and dust days (or non-dust days) were not identified in a number of studies that examined the impact of coarse particles or PM10 on Saharan dust days (Mallone et al. 2011; Tobias et al. 2011). In contrast, non-Saharan dust days were statistically significant in the Madrid PM2.5 with a risk of cardiovascular mortality of 2.7% (95 percent CI = 1.4, 4.1), while Saharan dust days had a comparable risk of 2.6% (95 percent CI = 0.5.8) and were close to significance.

Perez (2012) gathered daily PM2.5 data in Barcelona, Spain, from 2003 to 2007. On the basis of back-trajectory analysis and the detection of elevated PM10 levels at a background, rural monitoring location, Saharan dust days were identified. By employing a time-series model, the impacts of PM2.5 were ascertained both with and without the inclusion of Saharan dust. There were discernible correlations between cardiovascular mortality and the interquartile range of dust days (the difference between the 75th and 25th percent of the distribution): non-Saharan dust days were associated with a 5.5 percent increase in risk (95 percent CI = 2.3, 8.9), while Saharan dust days were linked to a 9.3 percent risk (95 percent CI = 1.8, 17.3). When the effects per 10 µg/m3 are converted from dust and non-dust days, the hazards associated with dust days are 13.3 percent and those of non-dust days are 10.3 percent.

From 2003 to 2006, Kim et al. (2012) analyzed the effects of PM2.5 from Asian dust cyclones in Seoul, Korea. The attribution of Asian Dust (AD) events to the Korean Meteorological Administration was formally established. Statistically significant associations were observed between AD events and natural mortality (0.3 percent [95% CI] = 0.1, 0.5] per 10 μg/m3) and cardiovascular mortality (0.5 percent [95% CI = 0, 1.1]) for individuals aged 75 and above. In general, these risk estimates were greater than those observed on days devoid of pollution or AD episodes; this was true for the entire population of all ages.

Díaz et al. (2017) conducted a study in Spain that established a correlation between PM2.5 and all-cause mortality during dusty days in the Canary Islands. This finding corroborated an earlier study by López-Villanueva et al. (2012). However, no such association was observed during non-dusty days. Kashima et al. (2012) ultimately measured particles below 8 microns (PM8) on days with and without incursions from AD over a six-year period. Days exceeding 100 μg/m3 were considered as the latter, while the average concentration observed throughout the research was 25 μg/m3. The analysis revealed that days with AD were associated with stronger associations and higher risk estimates per μg/m3 for cardiovascular diseases (including arrhythmia and heart attacks), all respiratory diseases, and pneumonia in particular.

Thus, in five of the six studies that examined PM2.5 dust days, associations with natural or cardiovascular mortality were found to be statistically significant (or nearly significant in the case of Madrid). In the remaining studies, which were carried out in Rome, Italy, no correlations with PM2.5 were observed on days with or without dust.

The Health Consequences of Prolonged Dust Exposure

Long-term studies incorporating dust or other particulate matter constituents are crucial for establishing the mortality effects of outdoor air pollution, which is why the Global Burden of Disease and other global estimates rely on them. Regrettably, such studies are scarce. This segment comprises research on extended periods of exposure to dust or its indicators (such as silicon), and it furnishes context by incorporating results pertaining to the remaining components.

An initial published endeavor to investigate the correlation between mortality and long-term exposure to PM2.5 constituents was a cross-sectional analysis of mortality rates in 98 metropolitan areas of the United States in 1980 (Ozkaynak and Thurston 1987). This study examined the correlation between annual average PM2.5 concentrations at the metropolitan area level and mortality rates at that level, as opposed to utilizing data at the individual level. Further investigation was undertaken to examine the correlation between mortality and source-specific PM2.5, which included metals, coal combustion, soil, vehicular emissions, and residual oil combustion (Thurston et al. 1984). Among the sources examined, coal combustion exhibited the most substantial influence on mortality, while soil showed no discernible correlation (Ozkaynak and Thurston 1987).

Ostro et al. (2011) investigated the long-term exposure of 102,000 California women teachers and administrators who were part of the California Teachers Study and were monitored from 2001 to 2007. In order to minimize misclassification of exposure, the sample was limited to women residing within a 30-kilometer radius of a ground-level monitor; this produced a study population of approximately 45,000 women. Utilizing a Cox proportional hazards model, the mortality risks were estimated. In relation to cardiopulmonary mortality, noteworthy correlations were identified between PM2.5 mass and the main constituents nitrate, sulfate, and silicon. There was no observed correlation between the aforementioned constituents and respiratory mortality.

By utilizing data obtained from the Women's Health Initiative–Observational Study, which comprised approximately 90,000 women residing in 45 locations throughout the United States, Vedal et al. (2013) examined the impact of various constituents and sources on cardiovascular mortality as a whole as well as several subclasses thereof. The model also analyzed data pertaining to elemental carbon, organic carbon, sulfur, and silicon, in addition to PM2.5. The components were calculated as means of the entire city and allocated to the addresses of each participant. According to the source-apportionment analysis conducted by the authors, these constituents served as indicators of regional combustion: traffic, combustion of primary fuels and biomass, secondary organic carbon formation, secondary sulfate formation, and crustal/soil emissions. Organic carbon was most consistently associated (p 0.05) with cardiovascular mortality and many of its subclasses, including atherosclerotic and cerebrovascular deaths, in the basic analysis across metropolitan areas. On the contrary, silicon was found to be correlated ($p < 0.05$) with fatalities that were identified as potentially attributable to coronary heart disease—specifically, plaque accumulation in the arteries of the heart.

An additional recent investigation explored the impact of PM2.5 sources and components on a subset of the Cancer Prevention Study-II cohort of the National American Cancer Society (Thurston et al. 2013). From 1982 to 2004, 446 thousand adults in one hundred metropolitan areas of the United States were observed. The pollutants' concentrations throughout the metropolitan area were determined using the mean of the US EPA speciation monitors that were accessible in each city. An analysis was conducted on sixteen components (including silicon and calcium, which serve as tracers for soil) and eight sources (including soil). Using standard Cox regression, the mortality risks were estimated. One of the models under consideration incorporated component data, while the other was constructed using a source-apportioned data set that distributed PM2.5 mass among all potential sources.

Conclusion

At the end of this study, we were able to clarify what the study aimed to achieve through studies conducted in areas directly affected by dust storms. Exposure to nearby dust storms, dominated by coarse particles, is significantly associated with hospitalization due to respiratory outcomes such as chronic obstructive pulmonary disease. Asthma worsens. Depending on the availability and use of health care, the effects of these respiratory diseases can kill people who are already at risk. Additional investigations into rapid exposure to dust storms show a strong association with cardiovascular disease and sometimes all-cause death, but not respiratory deaths. However, respiratory deaths may have been misdiagnosed as cardiovascular disease.

Studies on CP or PM10 downwind from the original dust source that isolated the dust component have consistently indicated effects on cardiovascular mortality and a weaker connection with respiratory mortality. There is also considerable evidence of asthma and COPD morbidity. However, the studies define dust-related particles using different methodologies, which entail uncertainties. In addition to dust, the wind may transport additional pollutants that harm local pollutants and health. Other than the CP and PM10 investigations that specifically detect dust, several dozen coarse-particle studies have found dust as a major ingredient. Together, these studies show statistically significant correlations with cardiovascular and respiratory mortality.

Studies in Barcelona, Madrid, the Canary Islands, and Seoul found a mortality effect from PM2.5 dust, notably for cardiovascular disease. Again, dust component methodologies are unknown, and studies utilize diverse statistical approaches to assess risk. Studies of daily exposures to dust or dust-like particles or tracers (including soil, crustal material, calcium, and silicon) from Chile and the US also suggest an association with all-cause, cardiovascular, and respiratory mortality. PM2.5 dust days appear to pose mortality risks, and Madrid and Barcelona investigations show that dusty days have similar risk estimates to non-dusty days.

Dust (and its tracers calcium and silicon) may cause cardiovascular and respiratory death over time. Sulfate (a tracer for coal and other fuel combustion) and elemental carbon (a transportation tracer) have stronger associations than dust, which in some studies had no association. The measurement methods and statistical modeling of risks often affect the outcomes.

A separate recent investigation explored the levels of PM10 on sandy days across Spain (Diaz et al. 2017). An assessment of the influence on natural mortality was performed on a representative province from each of the nine principal regions of Spain. The identification of dusty days was accomplished through the utilization of daily dust forecast models, synoptic meteorological charts, satellite imagery, and interpretation of daily back trajectories. In the end, regression analyses were conducted to compare the acute impact of Saharan dust advections with PM10 on days with and without the advections. There were statistically significant correlations between PM10 and Saharan dust mortality in four of the regions. Two of the aforementioned regions exhibited no correlation with PM10 other than grit. In general, the risk assessments of the two instances that exhibited an association mirrored those of days contaminated with Saharan dust.

References:

Abdo, Nour, Yousef S. Khader, Mostafa Abdelrahman, Ashley Graboski-Bauer, Mazen Malkawi, Munjed Al-Sharif, and Ahmad M. Elbetieha. 2016. “Respiratory Health Outcomes and Air Pollution in the

Adar, Sara D., Paola A. Filigrana, Nicholas Clements, and Jennifer L. Peel. 2014. “Ambient Coarse Particulate Matter and Human Health: A Systematic Review and Meta-Analysis.” Current Environment Health Reports 1: 258–74.

Alastuey, Andres, Xavier Querol, Sonia Castillo, Miguel Escudero, Anna Avila, Emilio Cuevas, Carlos Torres, Pedro-Miguel Romero, Francisco Exposito, Omaira García, Juan P. Diaz, Rita Van Dingenen, and JeanPhilippe Putaud. 2005. “Characterization of TSP and PM2.5 at Izaña and Sta. Cruz de Tenerife (Canary Islands, Spain) during a Saharan Dust Episode (July 2002).” Atmospheric Environment 39: 4715–28.

Albani, Samuel, and Natalie M. Mahowald. 2018. “Paleodust Insights into Dust Impacts on Climate.” Journal of Climate 32: 7897–13.

Alessandrini, Ester, Annunziata Faustini, Gian Paolo Gobbi, and Francesco Forastiere. 2013. “Saharan Dust and the Association between Particulate Matter and Daily Hospitalizations in Rome, Italy.” Occup Environ Med 70: 432–34.

Alizadeh-Choobari, Omid, Peyman Zawar-Reza, and Andrew Sturman. 2014. “The Global Distribution of Mineral Dust and Its Impacts on the Climate System: A Review.” Atmospheric Research 138: 152–65.

Alolayan, Mohammad A., Kathleen W. Brown, John S. Evans, Walid S. Bouhamra, and Petros Koutrakis. 2013 “Source Apportionment of Fine Particles in Kuwait City.” Science of the Total Environment 448:14–25.

Al-Taiar, Abdullah, and Lukman Thalib. 2014. “Short-Term Effect of Dust Storms on the Risk of Mortality due to Respiratory, Cardiovascular and All-Causes in Kuwait.” International Journal of Biometeorology 58: 69–77.

Anenberg, Susan C., Larry W. Horowitz, Daniel Q. Tong, and Jason West. 2010. “An Estimate of the Global Burden of Anthropogenic Ozone and Fine Particulate Matter on Premature Human Mortality Using Atmospheric Modeling.” Environmental Health Perspectives 118: 1189–95.

Artaxo, Paulo, Pedro Oyola, and Roberto Martinez. 1999. “Aerosol Composition and Source Apportionment in Santiago de Chile.” Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms 150 (1): 409–16.

Bell, Michelle L., J. K. Levy, and Zhaohui Lin. 2008. “The Effect of Sandstorms and Air Pollution on Cause-Specific Hospital Admissions in Taipei, Taiwan.” Occupational and Environmental Medicine 65: 104–11.]

Brook, Robert D., Sanjay Rajagopalan, C. Arden Pope, Jeffrey R. Brook, Aruni Bhatnagar, Ana V. Diez-Roux, Fernando Holguin, Yuling Hong, Russell V. Luepker, Murray A. Mittleman, Annette Peters, David Siscovick, Sidney C. Smith, Laurie Whitsel, and Joel D. Kaufman. 2010. “Particulate Matter Air Pollution and Cardiovascular Disease. An Update to the Scientific Statement from the American Heart Association.” Circulation 121 (21): 2331–78.