

Interventions to reduce individual exposure of elderly individuals and children to haze: a review

Sini Zhang, Lingling Li, Wei Gao, Yujie Wang, Xin Yao

Department of Respiratory Medicine, the First Affiliated Hospital of Nanjing Medical University, Nanjing 210029, China

Contributions: (I) Conception and design: S Zhang, X Yao; (II) Administrative support: None; (III) Provision of study materials or patients: None; (IV) Collection and assembly of data: None; (V) Data analysis and interpretation: None; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Xin Yao. Department of Respiratory Medicine, the First Affiliated Hospital of Nanjing Medical University, 300 Guangzhou Rd, Nanjing 210029, China. Email: xyao1998@126.com.

Abstract: Given rapid economic developments and urbanization over the last few decades, China has experienced frequent haze episodes, which have adverse effects on public health. Children and elderly individuals are more susceptible than the general population to air pollution. In this study, we introduce interventions to reduce the exposure of elderly individuals and children to air pollution during hazy weather. These interventions include avoiding outdoor activities, wearing a dust mask, reducing burning biomass fuels, reducing frying and smoking at home, using an air filtration unit and taking supplemental antioxidants. However, the actual benefits of these measures remain unproven and are unlikely to be adequate. Sustained clean air policies remain the most important and efficient solution to reduce air pollution-related health effects.

Keywords: Haze; intervention; children; elderly

Submitted Jun 04, 2014. Accepted for publication Dec 04, 2015.

doi: 10.3978/j.issn.2072-1439.2016.01.17

View this article at: <http://dx.doi.org/10.3978/j.issn.2072-1439.2016.01.17>

Introduction

Rapid economic development and urbanisation in China over the last few decades has led to the increased occurrence of hazy weather in some regions (1,2). In December 2013, a hazardous large-scale haze covered China and affected 25 provinces and over 100 cities. According to information from China Meteorological Administration, in 2013, the average number of haze weather days in the eastern area of China was 36, which is 27 days more than those previously tallied during the same period every year since 1961. Recent studies demonstrate that haze pollution and outdoor air pollutants are associated with increased hospital admissions and mortality risk in Guangzhou, China (3,4). According to the Global Burden of Disease Study (5), a staggering 3.2 million people died from air pollution in 2010, 2.1 million of whom were from Asia. Haze is now a worldwide phenomenon that has gained attention because of its adverse effects on public health.

Air pollutants in haze

Haze is an atmospheric phenomenon characterised by visibility of less than 10 km. Haze is created by complex materials, such as dust, smoke and other fine particles that are suspended in air. The main components of haze are particulate matter (PM) and gaseous pollutants (6). Studies on the health effects of haze have mainly focused on PM_{2.5}, which is defined as fine PM with an aerodynamic diameter of less than 2.5 µm. PM_{2.5} is the main health hazard among the components of haze because it can penetrate deep into the lungs. A study found that the proportion of PM_{2.5} was three times larger than that of coarse PM in distal pulmonary tissues (7). PM₁ is a subset of inhalable PM_{2.5} particles that can eventually spread into the systemic circulation through the alveolar-capillary membrane. PM₁ can trigger inflammation of blood vessels, the heart and other organs. Air pollution in China is mainly caused by fossil fuels, motor vehicles, industrial dust, furnaces, stoves

and agricultural practices (e.g., controlled burns) (8).

Health effects of haze

A good understanding of how air pollution affects human health is essential to the advocacy of developing intervention measures geared towards improving air quality and prevention strategies to reduce subsequent impacts on human health. Specific populations, particularly children and older adults, are potentially more susceptible than the general population to PM-induced effects. Children and older adults are more susceptible to PM-induced effects because of physiological differences (9). Children are more susceptible than adults to the effects of PM because of the greater amount of time spent outdoors, activity levels and minute volume per unit body weight of this subpopulation that lead to increases in PM dose per lung surface area and, in turn, increases in the susceptibility of developing lungs to adverse effects. The elderly are generally considered a susceptible population because of the gradual decline in physiological processes over time. Compared with children or younger adults, elderly individuals have a higher prevalence of pre-existing cardiovascular and respiratory diseases, which may also confer susceptibility to PM.

Environmental epidemiology research conducted in recent decades has proven that short-term or long-term exposure to ambient PM increases mortality and morbidity, reduces life expectancy and increases the risk of respiratory and cardiovascular diseases (10-12). Studies on asthmatic children have reported that increases in respiratory symptoms, increased medication use and decreases in pulmonary function are associated with short-term PM_{2.5} exposure (13-15). A case-crossover study in Taipei found that chronic obstructive pulmonary disease (COPD) admissions are significantly and positively associated with higher PM_{2.5} levels during warm and cool days (16). Moreover, large amounts of toxic compounds, such as gases, organic compounds and heavy metals, adhere to the surface of PM_{2.5}, resulting in increased toxicity, interference with chromosomes, DNA and other genetic material. PM_{2.5} and toxic compounds are also implicated in the development of cancers. Long-term fine particulate air pollution exposure is associated with small but measurable increase in lung cancer mortality (17,18).

Consistent evidence from epidemiological studies demonstrates that short- and long-term exposure to PM, specifically PM_{2.5}, is associated with cardiovascular morbidity and mortality (19). PM concentration is also

linked to myocardial infarction (20), heart failure (21) and arrhythmia (22). The elderly, diabetics and those with known coronary artery disease appear specifically susceptible to the harmful effects triggered by PM exposure. Long-term exposure to fine particulate air pollution is also an important risk factor influencing cardiovascular disease mortality via mechanisms that include pulmonary and systemic inflammation, accelerated atherosclerosis and altered cardiac autonomic function (23).

Ultrafine particles of even smaller size can easily reach the brain from the respiratory tract via sensory neurons and travel from the distal alveoli into the blood or lymph as free particles. A study found that increases in PM_{2.5} concentration are associated with increased risks of emergency hospital admissions for cerebrovascular diseases (24). Motor, cognitive and behavioural changes are observed after particulate metal exposure in children (25). Children may be at particular risk from air pollution exposure because childhood and adolescence are crucial periods of brain development associated with dynamic behavioural, cognitive and emotional changes.

Besides particles, other air pollutants, such as ambient ozone, carbon monoxide, sulphur oxides, nitrogen oxides and lead also have hazardous effects on human health. Ozone is a powerful oxidant and respiratory tract irritant in adults and children. Increases in ambient ozone are associated with increased respiratory admissions among young children and the elderly (26) and reduced lung function in children (27). A study found that short-term exposure to Black Carbon (BC) presents a positive monotonic dose—response relationship with acute respiratory inflammation in school children living in Beijing (28). This relationship was not confounded by PM_{2.5}, which is not as strongly associated with eNO. Lead is neurotoxic, especially during early childhood. A study found that blood lead levels are more sensitive to changes in air lead concentrations among children and older adults compared with teenagers and adults (29).

Interventions

National and regional air pollution policies and regulations are important to reduce air pollution and decrease hazy days. The Chinese Government has committed to spend 3.4 trillion on environmental protection in the 12th Five Year Plan. The air pollution prevention action plan, published in September 2013, calls for strict controls on pollution, industry production and coal consumption,

implementation of clean production processes and promotion of clean vehicles. Although the Chinese public and government have paid increased attention to air pollution, changing the current situation entails a long process of improvement. Individual protection to reduce air pollution exposure is also necessary. In this study, we introduce interventions to reduce the exposure of elderly and children to pollutants during hazy weather.

Outdoor interventions

In developed countries, motor vehicles are a major source of air pollution. The pollution created by motor vehicles has substantial impacts on ambient air pollution and personal exposures. Traffic-related emissions include large amounts of reactive gases and ultrafine particles. Very high local concentrations of reactive gases, ultrafine particles and other combustion products are observed on or near major highways and roadways. People who live close to major roads are expected to be exposed to higher concentrations of traffic-related air pollutants and have higher risks of adverse health effects. During hazy weather, traffic-related air pollutants may be more difficult to diffuse. Therefore, outdoor interventions are very important during hazy weather.

Avoid outdoor activities

Motor vehicles are the major source of air pollution in many communities. Motor vehicles pollute the air through tailpipe exhaust emissions and fuel evaporation, which contribute to carbon monoxide, PM_{2.5}, nitrogen oxides, hydrocarbons, other hazardous air pollutants and ozone formation. The concentration of traffic pollutants is greater near major roads than in minor ones. A large and growing number of studies have reported that children living near traffic or high levels of ozone, nitrogen dioxide or PM have increased risks of adverse respiratory effects (30-33). Other studies report that increased risks of cardiac and respiratory adverse effects are associated with air traffic-related pollution inhalation in elderly individuals (34,35). Therefore, the public, especially children and the elderly, should avoid outdoor activities when the air quality index is in the unhealthy range. Susceptible individuals should avoid walking or riding on a bicycle along streets when traffic is heavy.

Wear facemasks

Studies conducted in China confirm that the use of face

masks in extremely polluted cities could reduce exposure and result in lower inflammatory and cardiovascular responses. A study showed that wearing a facemask appears to abrogate the adverse effects of air pollution on blood pressure and heart rate variability in healthy volunteers (36). Another study also found that face masks are a simple and practical intervention to reduce an individual's exposure to particulate air pollution. The use of facemasks improves several cardiovascular health measures in individuals with coronary heart disease (37). Different types of masks are available in the market. Knowing which type of mask is suitable for haze is essential. The mask penetrance of fresh diesel exhaust particulates is highly dependent on the mask type. In two studies, the 3M Dust Respirator (Model 8812, 3M, St Pauls, USA) was selected for an intervention study because it provided good filtration performance and was extremely efficient and comfortable to wear. The 3M Dust Respirator mask is made of a light-weight polypropylene filter that is effective in removing airborne PM without affecting ambient gases. The mask has an expiration valve and an assigned protection factor of four. Several respirator types are specially designed for children. However, wearing masks for extended periods of time may elicit feelings of breathlessness, especially in elderly individuals and people with cardiovascular diseases.

Indoor interventions

The health effects of exposure to air pollution are mainly related to outdoor levels, monitored or modelled in areas around residences. Unfortunately, most people, especially the elderly spend over 80% to 90% of their day indoors (38). The amount of traffic-related particles transported into the indoor environment by ventilation and infiltration is highly variable. Moreover, a large proportion of indoor particulates comes from a variety of indoor sources (e.g., frying, heating devices, environmental tobacco smoke and human activity) and may account for the majority of total personal exposure. A study found that household air pollution is a major avoidable risk factor for cardiorespiratory disease (39). Higher indoor PM concentrations are linked to respiratory symptoms and lower lung functions in children with asthma (40). Therefore, indoor intervention is also important.

Burn fuel more cleanly

Nearly half of the world population burns biomass fuels (e.g., wood, charcoal, dung or crop residues), coal and kerosene (paraffin) as energy sources for household cooking, heating

and lighting (41). Burning of biomass fuels, coal and kerosene is a form of energy usage associated with high levels of indoor air pollution and increases in the incidence of acute lower respiratory infections, COPD, lung cancer, asthma, low birth weight, other adverse birth outcomes (42-46), headache (47), neurodevelopment impairments (48), cardiovascular condition (49) and eye diseases, such as cataracts and blindness (50,51). A woodstove change out program conducted in a Rocky Mountain valley community significantly reduced indoor PM_{2.5} concentrations (52). Although many Chinese families now use coal gas or natural gas for cooking, traditional stoves are still used for cooking in rural China. Burning fuel more cleanly, having a separate kitchen, using kitchen ventilators or electronic fans when cooking and reducing frying can eliminate smoke and reduce indoor air pollution exposure.

Forbid smoking at home

Scientific evidence clearly shows that second-hand smoke exposure causes diseases in adults and children. Children are more vulnerable than adults to the health effects of second-hand smoke; these effects include acute respiratory infection, asthma, sudden infant death syndrome and slow lung growth (53,54). Although many public places have banned indoor smoking in China, in-home smokers have not taken effective precautions to limit the impact of smoking on the home environment. Children's exposure is involuntary and occurs primarily through adults who smoke in places where children live and play. Despite the known health risks of second-hand smoke to very young children at home, parents have yet to take precautions for protecting their children. Public health messages have not effectively led to changes in smoking behaviours in the home. A study conducted in America reported that the mortality risk brought about by ambient PM exposure is greater for smokers than non-smokers (23). Therefore, the higher prevalence of cigarette smoking amongst Chinese males may increase their mortality risk relative to air pollution exposure. As such, forbidding smoking at home, especially in areas experiencing haze where outdoor air pollution is severe, is necessary to preserve the health of family members.

Promote air filtration

Substantial reductions in exposure to particles can be achieved by portable air filtration units placed in the indoor environment. In a study conducted on elderly people, an 8%

improvement in microvascular function (MVF) was detected 48 hours after air filtration was initiated in participant homes (55). A recent review concluded that residential air filtration can improve outcomes in the treatment of allergic respiratory diseases (56). Another study indicated that indoor air filtration may not be sufficient to reduce indoor PM levels to values approaching outdoor concentrations when indoor smoking is present. Therefore, the most obvious and cost-effective means of reducing indoor PM_{2.5}, before considering indoor air filtration, is elimination of indoor cigarette smoking (57).

Outdoor PM concentrations are higher than indoor levels during hazy weather. Therefore, windows should be kept close to prevent outdoor PM from entering. Sweeping shows a significantly positive relationship with indoor PM concentrations, in contrast to vacuuming (58). However, the use vacuum cleaners has not been shown to improve children's asthma (59). Parents may opt to use a vacuum cleaner rather than sweep when cleaning the house but must remember that cleaning activities should ideally be performed when asthmatic children are not present in the room.

Accept dietary supplementation

Among the plausible biological mechanisms explaining PM_{2.5} health effects, oxidative stress is often cited to have an important function in both respiratory and cardiovascular outcomes. A diet rich in antioxidants appears to reduce the oxidative and inflammatory effects of air pollution. A study in Mexico City, Mexico, reported that children with asthma who were given antioxidant supplements were less affected by ozone compared with children who did not receive supplementation (60). Another study showed that fish oil supplements, which provide n-3 polyunsaturated fatty acids (n-3 PUFA), could be considered as a preventive measure to reduce risks of arrhythmia and sudden death in elderly individuals exposed to ambient air pollution (61). Air pollution exposure has been linked to neuroinflammation and neuropathology in young urbanites. A study suggested that a short high flavonol cocoa intervention may be critical for early implementation of neuroprotection of highly PM exposed urban children (62).

Conclusions

Given rapid economic developments over the past last few decades, China has experienced frequent haze episodes, which have adverse effects on public health. Our study

focused on the use of individual protection by children and the elderly during hazy weather because these subpopulations are more susceptible than the general population to air pollution. In conclusion, outdoor activities must be generally avoided when air quality indices are in the unhealthy range. When going outdoors is unavoidable, wearing a suitable dust mask suitable is necessary. If possible, walking and riding a bicycle must be avoided to minimize exposure to air pollutants. As children and the elderly spend most of their time indoors, indoor air quality must also be monitored during haze episodes. Reducing the burning of biomass fuels, avoiding frying and smoking at home and using an air filtration unit may substantially reduce particle exposure. Antioxidant supplements, fish oil and flavonol-rich dark cocoa, may reduce some of the harmful effects of air pollution. However, the actual benefits of these measures remain unproven. Similarly, the proposal of pharmacological prophylaxis during high PM periods appears premature, and benefits, if any, are unlikely to be adequate. Given the large number of people exposed to haze, the overall air pollution-related health burden is rather extensive. As such, sustained clean-air policies are the most important and efficient solution to reduce air pollution-related health effects.

Acknowledgements

We thank prof. Ian Adcock for his kind revision on this review. *Funding:* This work was supported by National Natural Science Foundation of China (Grant 81470237), the Jiangsu Health Promotion Project, and the Priority Academic Program Development of Jiangsu Higher Education Institutions (Grant JX10231802).

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Zhang S, Li L, Gao W, Wang Y, Yao X. Interventions to reduce individual exposure of elderly individuals and children to haze: a review. *J Thorac Dis* 2016;8(1):E62-E68. doi: 10.3978/j.issn.2072-1439.2016.01.17