British Cardiovascular Society
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Will smog affect my heart doctor?

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Context

Diversity indeed reflects many unique challenges in patient care. My patient, a Pakistani by descent, recently visited Lahore, the capital of the Punjab province, for holidays, with the following concern,

"I have just come back to UK from Lahore, which is full of smog at this time of the year. Will this affect my heart, doctor?"

What does smog in the subcontinent mean for patient care, and routine consultation visits in the UK?

Take Home Messages

- Smog incidents are on the rise, especially in Asia, frequently visited by a significant population of UK residents and the effects on cardiovascular health presents a cause for concern.
- There is an association of smog and increased incidence of ischaemic stroke and acute coronary syndromes.
- Travel advice to patients should include a word of caution particularly to high-risk patients about the possible exacerbation of pre-existing diseases.
- Smog masks and air purifiers help, but laws concerning fossil fuel burning need to be updated to mitigate short and long-term effects on cardiovascular and overall health.

Introduction

Cardiovascular disease (CVD), a leading cause of morbidity and mortality worldwide, has been thoroughly studied, and as such, has well known risk factors, including age, diet, family history, obesity and comorbidities like diabetes, hypertension and race (1). Genetics and environment play a role in the disease process, and epigenetic studies show that several processes like altered DNA methylation might predispose individuals to atherogenesis (2). Indeed, South Asians (Pakistanis, Indians and Bangladeshis) remain particularly affected as regards to cardiovascular health, with epidemiological

evidence affirming the increased likelihood of atherosclerotic processes in the population (6.8% vs 4.4%; p<0.0001) (3).

A significant population of the South Asian diaspora reside in the United Kingdom, around 4% of the population, a number that has steadily risen in the past few years (4). As it happens, revisiting 'home' for holidays is a frequent practice, predisposing the population to risk factors abroad, with air pollution being perhaps the most prominent one.

According to 2021 European Society of Cardiology guidelines for cardiovascular disease prevention, individuals with a high risk of CVD should avoid regions with poor air quality and regular screening is recommended for the population living in such areas (5).

In recent years, Lahore, along with other parts of Punjab in Pakistan, has seen dense smog with air quality index (AQI) levels far exceeding the safe limit (6) which causes respiratory problems like asthma exacerbation, coughing and chronic bronchitis, but also has been particularly detrimental to cardiovascular health (7). However, despite the almost yearly occurrence, little to no data has emerged from Pakistan detailing the effects on cardiovascular system (CVS) associated mortality and morbidity (8), particularly from Punjab.

Effects of smog on health

Particulate matter (PM), particularly with aerodynamic diameters of < 2.5 ($PM_{2.5}$) and <10 μm (PM_{10}) form a major component of smog, and is responsible for the inflammation that contributes to cardiotoxicity (7). PM mediates CVD by exerting toxic effects on the CVS due to its inflammatory effects, leading to pro-thrombotic cascades, alteration in the activity of the autonomic cardiac system, vascular spasms and plaque disruptions. Much of PM emanates from automobiles, burning of crops and factory emissions, and can, hence, be subjected to regulations that help improve air quality. Other components like nitrogen dioxide (NO2), sulphur dioxide (SO2) and carbon monoxide (CO) also contribute to the CVD burden (7).

Cardiovascular disease and smog: recent literature

Epidemiological studies from Karachi, a megacity in Pakistan, described an association between elevated levels of $PM_{2.5}$, and emergency visits pertaining to cardiovascular diseases (CVD) (9). $PM_{2.5}$ from burning of fossil fuels was found to be associated with more adverse CVD outcomes than crop burning as per an investigation from Bangladesh (10). A study from Lahore demonstrated higher systolic (SBP) [108.3 (106.1-110.6) vs 115.9 (114.0 to 117.9); p<0.0001] and diastolic blood pressure (DBP) [66.4 (64.4 to 68.4) vs 70.9 (69.2 to 72.7); p=0.002] in children exposed to PM (11). The association for SBP and

PM remained positive in another study from peri-urban villages in Hyderabad, India (12). Concentrations of $PM_{2.5}$ and PM_{10} and nitrogen oxide were responsible for smog formation, particularly in winter months when the temperature caused trapping of air pollutants (13). Another study from Karachi implicated nickel to be particularly associated with increased hospital admissions secondary to CVD, necessitating further epidemiological studies investigating the relation between the constituents of PM and CVD (14).

Aside from South Asia, an investigation from Poland demonstrated that smog was associated with ischaemic stroke (IS) and acute coronary syndromes (ACS) in a short-term follow-up after exposure. An increase in ACS associated mortality was observed with 10 $\mu g/m^3$ increase in $PM_{2.5}$ and PM_{10}. In addition, NO2 also was related to increased ACS mortality (15).

The results of this study are also corroborated by a recent meta-analysis (16), and another one of 53 studies with over 21 million participants from all over the world, including several European, North American and East Asian countries (17). More studies have been highlighted in table 1.

A randomized controlled trial investigating the efficacy of air filtration from China, which remains particularly affected by air pollution, demonstrated a decrease in the inflammatory markers, cytokines and DNA methylation, which helps in thrombosis formation, with air filtration (18, 19).

Prevention of smog inhalation

Steps taken by residents in smog-enveloped areas usually involve wearing anti-smog masks outdoors, and installing air purifiers, or even staying indoors (20). For a significant proportion of the population, though, even these measures are not achievable.

Incidents of smog have been on the rise in Pakistan, and other parts of Asia, including East Asian countries like China. While public health awareness definitely helps educating patients in avoiding risk factors, the problem lies with the laws concerning air pollution, which need to be formulated keeping current medical literature in mind. Secondly, patients particularly at risk need to be advised beforehand about the risks such an environment carries for them. Anti-smog masks and air respirators need to be made more accessible to the general population. General lifestyle changes in patients with a high-risk of CVD are always encouraged, and future literature could focus on medications that might help mitigate the pro-inflammatory effects of smog.

Limitations and future directions

Effect of smog on other CVD presentations, like heart failure and arrhythmias, remain less well studied and hence are not accounted for in the present editorial. The effect of physical activity, respirator use, and its role in CVD prevention from smog has not been validated yet. In addition, the role of a diet rich in anti-inflammatory substances can also be investigated further. The role of other components of smog, and how they vary from region to region warrants further comprehensive investigation. The studies cannot account for causation, and several confounders could be responsible for inducting bias in the results.

Conclusion

The effect of PM in smog has been investigated in recent times and found to have an impact on short-term adverse events like IHD and IS, as well as long-term complications like hypertension. So in short, did smog affect my patient's heart? Yes, but the degree to which this effect will manifest depends on a myriad of other factors. It is pertinent to warn patients visiting such areas of the risk and the precautions to take.

Table 1. Studies discussing the impact of smog on CVD

Author; year	Country	Population	Study design	Duration (months)	Results
Zhou et al; 2015	China	4,827,426	Retrospective study	12	Smog episodes found to be associated with respiratory and CVD mortality.
Kim et al; 2012	South Korea	10, 181, 466	Case control	36	Increased all cause and CVD mortality on smog days combined with Asian dust, as compared to smog days alone.
Zhang et al; 2017	China	209, 321	Retrospective study	48	Strong association between respiratory and CVD mortality, particularly with PM_{10}.
Huang et al; 2016	China	16, 800	Case-control study	3	The smog in Eastern China in 2013 was significantly associated with an increased risk of outpatient visits for CHD.
Święczkowskl et al; 2023	Poland	34, 907	Retrospective study	48	A 10 $\mu g/m^3$ increase in air pollutants during the Polish smog was associated with an increase in mortality due to ACS. Incidence of IS was also increased due to smog.
Curto et al; 2019	India	5531	Cross-sectional study	24	A positive association was noted between levels of $PM_{2.5}$, blood pressure and hypertension in women.
Khwaja et al; 2012	Pakistan	35, 147	Cross-sectional study	12	Hospital admission rates and ER visits elevated for CVD on days of high $PM_{2.5}$ concentrations.
Rahman et al; 2021	Bangladesh	594, 165	Retrospective study	51	$PM_{2.5}$ from fossil fuel burning was more likely to cause CVD related admissions and mortality than biomass burning.
Lu et al; 2019	Pakistan	31, 749	Cross-sectional study	Not specified	Nickel exposure found to be responsible for CVD related admissions.

CVD: cardiovascular disease. PM: particulate matter. ACS: acute coronary syndrome. IS: ischemic stroke. CHD: Coronary heart disease. ER: emergency room.

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