



Policy statement

Air pollution

Introduction

The association between elevated levels of air pollution and increased cardiac death rates was first recognised in the early 1950s. Since this time scientists have been researching the nature of the link, and the evidence shows a causal relationship. Experts believe that air pollution can make existing heart conditions worse and cause cardiovascular events in vulnerable groups.

Policy statement

Research shows that air pollution can make existing heart conditions worse and can cause cardiovascular events including heart attacks and strokes amongst vulnerable groups. Given the large number of people living in the UK with heart disease and the likelihood of their exposure to air pollution, it is important that UK governments ensure they are meeting European Commission targets to improve air quality.

More research is needed to identify the constituents of polluted air which cause heart disease. Understanding this will allow us to develop ways to reduce levels of these particular pollutants. The BHF is funding research looking at how air pollution causes abnormalities in the blood vessels, which may help explain the link between heart disease and pollution.

BHF funded scientists have also investigated the role of facemasks in protecting against the damaging effects of pollution on the heart. Although the research suggests that high performance facemasks may improve some risk factors, the research was carried out in Beijing where levels of pollution are very high. There is not currently enough evidence to support the routine use of facemasks in the UK.

As aerobic physical activity is very good for the heart, the benefits of exercising outdoors outweigh the risks associated with air pollution for most people. However, people with coronary heart disease should avoid spending long periods outdoors in areas where traffic pollution is likely to be high - near busy roads for example. Local air quality reports could help people to understand when they might be most at risk.

Background

The majority of air pollution comes from the burning of fossil fuels. Road transport is a main source, as vehicle engines release nitrogen dioxide, carbon monoxide and particles into the atmosphere. Burning fuel for power generation and industrial purposes also causes air pollution.

Pollution is made up of many different components, including

- **Particulate matter (PM)**, consisting of solid and liquid particles such as soot and dust, suspended in air
- **Gases** such as nitrogen dioxide, ozone, sulphur dioxide and carbon monoxide
- **Organic compounds** such as methane and benzene

Scientific research suggests that PM is a main cause of human disease, including CVD.¹ There are thousands of chemicals within PM that may individually or in combination have an effect in our bodies. Although we don't yet know which of these are responsible for causing disease.

The World Health Organisation has estimated that outdoor PM air pollution is the 13th leading cause of mortality worldwide.² It is responsible for approximately 800,000 deaths each year, and deaths from cardiovascular disease make up the largest portion of this.³

Studies suggest that traffic pollution is specifically associated with cardiovascular risk. Experts believe this one of the major public health burdens today because we're all exposed to traffic pollution so often.⁴

Particulate Matter

Particles are grouped according to their size, which ranges from clusters of molecules called ultrafine particles (UFPs), through to fine particles with a diameter of 2.5µm or less (PM_{2.5}), and coarse particles with a diameter between 2.5µm and 10µm (PM₁₀).

The majority of research has focussed on fine particles and cardiovascular disease, and there is now enough evidence to support a causal link. PM_{2.5} contains many of the disease causing toxic compounds released on combustion, and most studies show a stronger link with PM_{2.5} than other size particles.⁵

UFPs are a main component of traffic pollution, and are present in much higher concentrations than fine particles near their source. It is likely that UFPs are also important in causing disease. The limited evidence available suggests that they may pose a particularly high risk to the cardiovascular system.⁶ However, more research is needed to understand this.

¹ Brook et al (2008) *Cardiovascular effects of air pollution*. Clinical science 115, 175-187

² World Health Organisation (2002) *World Health Report 2002: Reducing Risks and Promoting a Healthy Life*. WHO Geneva

³ Brook et al (2008) *Cardiovascular effects of air pollution*. Clinical science 115, 175-187

⁴ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association*. Circulation May10, 2010.

⁵ Brook et al (2008) *Cardiovascular effects of air pollution*. Clinical science 115, 175-187

⁶ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association*. Circulation may10, 2010.

PM air pollution and heart disease

The cardiovascular effects of air pollution were first observed after the major smog that occurred in London in 1952. Based on available data from the previous year, it was estimated that there were 4,000 extra deaths during the three weeks after the smog began.⁷

Since the 1970s hundreds of epidemiological studies have demonstrated an association between PM and adverse health effects. In 2009 an advisory committee to the UK governments – the Committee on the Medical Effects of Air Pollutants - reported that the evidence suggests an association between long term exposure to PM and effects on mortality, and that this is ‘almost certainly a causal relationship’.⁸ The report also highlights that European studies have confirmed the link between mortality and PM concentrations found in US studies.

In 2010 the American Heart Association conducted a review⁹ to update their position on the link between PM air pollution and cardiovascular disease. The review concludes that the evidence is consistent with a causal relationship between particulate matter exposure and cardiovascular disease and cardiovascular mortality. Whilst in England, the House of Commons Environmental Audit Committee wrote that ‘poor air quality probably causes more mortality and morbidity than passive smoking, road traffic accidents or obesity’.¹⁰

In addition to this negative effect, it appears that there is also no safe thresholds for PM. Adverse health effects appear to have a linear relationship with exposure¹¹, and there is no clear threshold below which pollution levels have found to be consistently safe.¹²

The effects of PM air pollution are seen following short and long term exposure. Breathing in PM for a few minutes or hours can trigger cardiovascular events like heart attacks and strokes amongst vulnerable groups. More long term exposure may enhance the risk of developing chronic cardiovascular diseases.¹³ Reducing PM levels can help decrease cardiovascular mortality within a timeframe as short as a few years.¹⁴

Increases in acute cardiovascular morbidity and mortality are mainly amongst susceptible, but not critically ill, individuals such as older people with existing coronary artery disease.¹⁵ Women and obese people may also be at higher risk.¹⁶ Research suggests factors that increase the risk of a heart attack, such as high blood pressure and high cholesterol, may also increase the risk from particles.¹⁷

⁷ Wilkins, E.T. (1954). Air pollution and the London fog of December, 1952. *J.R. Sanit. Instit.* 74, 1-21

⁸ COMEAP (2009) Long term exposure to air pollution: effect on mortality

⁹ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association.* Circulation may10, 2010.

¹⁰ House of Commons Environmental Audit Committee (2010) *Air Quality* Fifth report of the session 2009-10 Volume 1 <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm>

¹¹ As above

¹² Araujo.J & Nel.A (2009) *Particulate Matter and Atherosclerosis: role of particle size, composition and oxidative stress* Particle and Fibre Toxicology 2009, 6:24doi:10.1186/1743-8977-6-24

¹³ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association.* Circulation May10, 2010.

¹⁴ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association.* Circulation may10, 2010.

¹⁵ Ibid

¹⁶ Ibid

¹⁷ Air Now. Accessed at http://www.airnow.gov/index.cfm?action=particle_health.page1#3

Children are at risk because their lungs are still developing. They also spend more time at high activity levels and are more likely to have asthma.¹⁸ A study in Mexico found that the heart begins to show adverse effects of air pollution in young adults. Researchers believe this may be due to an inflammatory response which leads to chronic inflammation in the heart, although they note that this inflammation doesn't appear to create any immediate harm.¹⁹

This evidence shows how air pollution disproportionately affects vulnerable groups, such as children, older adults, and people with existing medical conditions. Individuals and families with a low income may also be affected in this way, as they are more likely to live in accommodation near the busiest, most polluted roads because it tends to be cheaper.²⁰

Other air pollutants may also pose cardiovascular risk alone or in conjunction with fine particle exposure. Additional research is needed to find out about the risks of several gaseous pollutants e.g. ozone and nitrogen dioxide.²¹

Understanding the link

Research suggests there are three potential mechanisms by which PM may contribute to CVD. Developing an understanding of these pathways has helped strengthen scientific belief in a causal relationship.²²

- PM may alter our nervous system, causing dangerous changes to our heart rhythm
- Breathing in PM may trigger the release of chemicals from the lungs into circulation, which are then free to act on our cardiovascular system
- Very small particles and particles dissolved in the blood, may directly affect blood vessels²³

The pathways are thought to affect the cardiovascular system by making the fatty deposits in the arteries less stable, narrowing the blood vessels, causing cardiovascular inflammation, and increasing coagulation and blood clots. The effects of this include hypertension, atherosclerosis, arrhythmias, myocardial ischaemia, heart attacks, heart failure, and strokes.²⁴

The three mechanisms are not mutually exclusive. They may overlap temporally or be activated at different time points, for example within minutes, hours or days of exposure. The types and sizes of pollutants inhaled may also determine their toxicity and importance of each pathway.

¹⁸ Air Now. Accessed at http://www.airnow.gov/index.cfm?action=particle_health_page1#3

¹⁹ Federation of American Societies for Experimental Biology (2010, April 28). *Mexico City air pollution adversely affects the hearts of young people*. *ScienceDaily*. Retrieved May 19, 2010, from <http://www.sciencedaily.com/releases/2010/04/100428153256.htm>

²⁰ LACORS (2010) 'A Clean Bill of Health'

²¹ American Heart Association (2010) *Particulate matter air pollution and cardiovascular disease. An update to the scientific statement from the American Heart Association*. *Circulation* may10, 2010.

²² Pope & Dockery (2006) *Health effects of fine particulate air pollution: Lines that connect*. *Air & Waste Management Assoc.* 56:709-742

²³ Brook et al (2008) *Cardiovascular effects of air pollution*. *Clinical science* 115, 175-187

²⁴ Brook et al (2008) *Cardiovascular effects of air pollution*. *Clinical science* 115, 175-187

Effects of air pollution in the UK

Whilst air pollution from road transport has fallen 50% since 1990, we are driving more and traffic has increased by a fifth. The number of vehicles on our roads increased from 19 to 34 million between 1980 and 2007.²⁵

Research suggests that in the UK as many as 35,000 to 50,000 people could die prematurely each year, as a result of short term exposure to air pollution.²⁶ The Westminster Government's 2007 air quality strategy estimates that PM reduces life expectancy by around seven to eight months averaged over the whole population of the UK. For sensitive individuals the reduction in life expectancy could be as high as nine years.

The table below compares the health benefits of eliminating man-made PM air pollution with eliminating road traffic accidents and the elimination of exposure to passive smoking.²⁷

	Reduction in PM_{2.5}	Elimination of road traffic accidents	Elimination of passive smoking
Expected gain in life expectancy	7-8 months	1-3 months	2-3 months
Estimated equivalent gain in life years from 2005-2010 for whole population (including people born in that time)	39,058,000	8,126,000	13,194,000

The policy context

In 2010, the House of Commons Environmental Audit Committee held an inquiry into air quality in the UK. The Committee reported that the UK is failing to meet some EU and domestic targets on air quality, and is not on course to meet others coming into force in the future.²⁸

The European Commission has launched infringement proceedings against the UK for failing to comply with air quality standard for PM₁₀ limit values. London is the only part of the UK failing to meet PM₁₀ limits, having the 'worst air quality in the UK and the worst in Europe for PM and NO₂'.²⁹ The EC refused appeals for an extension in December 2009, now DEFRA and the Mayor of London must develop a robust plan to obtain an extension and avoid a significant fine.³⁰

The 6th Environment Action Programme sets out the framework for environmental policy-making in the European Union for the period 2002-2012. It outlines actions needed to work towards 'levels of air quality that do not give rise to unacceptable impacts on, and risks to, human health and the environment'.³¹

²⁵ House of Commons Environmental Audit Committee (2010) *Air Quality* Fifth report of the session 2009-10 Vol 1 <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm>

²⁶ Ibid

²⁷ House of Commons Environmental Audit Committee (2010) *Air Quality* Fifth report of the session 2009-10 Vol 1 <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm>

²⁸ House of Commons Environmental Audit Committee (2010) *Air Quality* Fifth report of the session 2009-10 Vol 1 <http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/229/22902.htm>

²⁹ Environmental audit Committee Fifth Report

³⁰ Environmental audit Committee Fifth Report

³¹ <http://ec.europa.eu/environment/air/quality/index.htm>

The first targets for PM_{2.5} were set in the EU Directive 2008/50/EC, which was adopted in May 2008 and came into force in 2010. This directive details the target values for PM_{2.5} that countries *should* be meeting, and the legal limit values which they *must*.³²

These objectives are set using an Average Exposure Indicator (AEI), which is determined as a 3-year running annual mean PM_{2.5} concentration averaged over selected monitoring stations. This method captures the general population's exposure to PM_{2.5}.

A PM_{2.5} target value of 25µg/m³ became valid in January 2010. A legally binding limit value of 20µg/m³ will be enforced from January 2015.³³

The AEI value in 2010 will determine the reduction target for PM_{2.5}, which is estimated to be set at 18µg/m³. All appropriate measures need to be taken to achieve this by 2020.³⁴

These European targets exceed the domestic targets set in 2007 in the UK - 25µg/m³ annual mean levels of PM_{2.5} by 2020.³⁵ The Department for Environment, Food and Rural Affairs has said there are no plans to revise the current strategy as it was recently renewed, but that the new EU legislation applies and they will be working towards it.

The 2007 UK air quality strategy document outlines current policies along with proposed new measures. These focus on reducing emissions from transport. For example by designing transport infrastructure to improve air quality, providing duty incentives for cleaner fuels, and promoting the uptake of less polluting vehicles.

The document describes an 'exposure reduction' strategy to tackle PM exposure. Whereas other pollutants will be tackled in local hotspots of high concentrations, PM is to be reduced nationally. This is because there is no safe threshold for this pollutant and driving improvement across the UK will help maximise the benefits to public health.

BHF activity

- We are funding research to determine how air pollution can cause heart disease. Led by BHF Chair Professor David Newby at the University of Edinburgh, this research looks at how air pollution causes abnormalities in blood vessels. These may explain why it is associated with an increased risk of heart attacks.
- In 2010 BHF funded research found some evidence that wearing a facemask may help protect against the harmful effects of pollution for people with existing coronary heart disease.³⁶ However, the research was carried out in Beijing where levels of pollution are very high. At present there is not enough evidence to advise the use of face masks in the UK.
- We advise patients that as aerobic physical activity is very good for the heart, the benefits of exercising outdoors outweigh the risks associated with air

³² <http://ec.europa.eu/environment/air/quality/legislation/directive.htm>

³³ <http://ec.europa.eu/environment/air/quality/standards.htm>

³⁴ <http://ec.europa.eu/environment/air/quality/standards.htm>

³⁵ DEFRA (2007) *The air quality strategy for England, Scotland, Wales and Northern Ireland*

³⁶ Langrish et al (2010) *Reducing particulate air pollution exposure decreases myocardial ischaemia, lowers blood pressure and improves heart rate variability in patients with coronary heart disease.*

pollution for most people. However, people with coronary heart disease should avoid going outside for long periods and undertaking strenuous exercise in areas where the traffic pollution is likely to be high.

- In October 2004 we hosted a joint event with the Department of Health on air pollution and heart disease. Here we concluded that the cardiovascular system is susceptible to attack by air pollution, but further research to examine the causal association is required.

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