**Pearson BTEC Level 3 Nationals Extended Diploma**

**Supervised Window:**
**9 December 2019 – 13 January 2020**

| Supervised period: 6 hours | Paper Reference **31629H** |
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# Applied Science

## Unit 7: Contemporary Issues in Science

**Part A**

**You do not need any other materials.**

## Instructions

- **Part A** contains material for the completion of the preparatory work for the set task.
- **Part A** is given to learners during the supervised window before **Part B** is scheduled. Learners are advised to spend no more than 6 hours on **Part A**.
- **Part A** must be given to learners on the specified date so that learners can prepare in the way specified.
- **Part A** is specific to each series and this material must only be issued to learners who have been entered to undertake the task in the relevant series.
- **Part B** materials must be issued to learners on the date specified by Pearson.

*Turn over* ▶



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## Instructions to Teachers/Tutors

This paper must be read in conjunction with the unit information in the specification and the *BTEC Nationals Instructions for Conducting External Assessments (ICEA)* document. See the Pearson website for details.

This set task has a preparatory period. **Part A** sets out how learners should prepare for the completion of the **Part B** task under supervised conditions.

**Part A** is given to learners during the specified window before **Part B** is scheduled. Learners are advised to spend no more than six hours on **Part A**.

Learners should undertake independent research on the case study given in this **Part A** booklet.

Centres must issue this booklet at the appropriate time and advise learners of the timetabled sessions during which they can prepare. It is expected that scheduled lessons or other timetabled slots will be used for the preparation.

Learners should familiarise themselves with the specific concepts and terminology used in the articles.

Learners may prepare summary notes on the articles. Learners may take up to four sides of A4 notes, which may be handwritten or word processed, into the supervised assessment (**Part B** booklet).

These notes should only include information about scientific terminology, quantities and concepts used in the articles and a summary of the scientific issue discussed. This will enable learners to interpret, analyse and evaluate the articles in **Part B**. Other content is not permitted.

**Part B** must be completed under supervision in a single 2 hours and 30 minute session timetabled by Pearson. A supervised rest break is permitted.

The supervised assessment should be completed in the **Part B** task and answer booklet. Teachers/tutors should note that:

- learners should not be given any direct guidance or prepared materials
- learners should not be given any support in writing or editing notes
- all work must be completed independently by the learner
- learner notes will be retained securely by the centre after **Part B** and may be requested by Pearson if there is suspected malpractice.

Refer carefully to the instructions in this taskbook and the *BTEC Nationals Instructions for Conducting External Assessments (ICEA)* document to ensure that the preparatory period is conducted correctly and that learners have the opportunity to carry out the required activities independently.

**Instructions for Learners**

Read the set task information carefully.

This is **Part A** of the set task and gives information you need to use to prepare for **Part B** of the set task.

In **Part B** you will be asked to carry out specific activities using the information in this **Part A** booklet and your preparatory notes.

In your preparation for **Part B**, using this **Part A** booklet, you may prepare short notes to refer to when completing the set task. Your notes may be up to four sides of A4 and may be handwritten or typed. Your notes should only include information about scientific terminology, quantities and concepts used in the articles and a summary of the scientific issue discussed. This will enable you to interpret, analyse and evaluate the articles in **Part B**. Other content is not permitted.

You will complete **Part B** under supervised conditions.

You must work independently throughout the supervised assessment period and must not share your work with other learners.

Your teacher/tutor may give guidance on when you can complete the preparation.

Your teacher/tutor cannot give you feedback during the preparation period.

You must not take your preparatory notes out of the classroom at any time and you must hand the notes in to your teacher/tutor on completion.

Your notes will be made available to you at the beginning of the supervised assessment.

**Set Task Brief**

You are provided with the following articles:

Article 1: The death of diesel: has the one-time wonder fuel become the new asbestos?
**https://www.theguardian.com/cities/2017/apr/13/death-of-diesel-wonder-fuel-new-asbestos**

Article 2: Researchers show how diesel fumes could cause 'flare up' of respiratory symptoms
**https://www.imperial.ac.uk/news/179526/researchers-show-diesel-fumes-could-cause/**

Article 3: Diesel, children and respiratory disease
**https://bmjpaedsopen.bmj.com/content/2/1/e000210**

Your notes should only include information about scientific terminology, quantities and concepts used in the articles and a summary of the scientific issue discussed.

You should spend up to a maximum of six hours to complete your preparatory notes. You may take up to four sides of A4 notes into the supervised assessment.

**Part A Set Task Information**

**Article 1**

**The death of diesel: has the one-time wonder fuel become the new asbestos?**

*This is an edited version of an article that appeared in 'The Guardian' newspaper in April 2017. The article was written by Adam Forrest.*

Photograph: Jinny Goodman/Alamy

Exhaust from a car. Air pollution kills 3.3 million people prematurely every year.

**Diesel was the dream fuel, promoted by governments and the car industry as a cheaper way to save the planet. Then the cracks started to appear.**

Air pollution now kills 3.3 million people prematurely every year – more than HIV, malaria and influenza combined – with emissions from diesel engines among the worst culprits; a joint investigation by the Guardian and Greenpeace showed hundreds of thousands of schoolchildren across England and Wales are being exposed to illegal air toxicity levels from diesel vehicles. And yet, such was the more or less widely accepted thinking as recently as 2010 that cars running on diesel fuel could be driven with a pure, unclouded conscience.

Diesel was touted at inception as a wonder fuel. It was a way of driving cost-efficiently while doing your bit to save the planet. Government, industry and science united to sell us the dream: cars running on diesel would help us cut our $CO_2$ emissions as we eased smoothly into a new eco-friendly age.

It was particularly owing to advances in engine technology that the diesel passenger car market was able to blossom in the 1990s, particularly in Europe. Drivers liked the fuel efficiency of diesel engines, which made running costs cheaper than petrol over the long term. Governments, meanwhile, alarmed by rising carbon emissions, began advising citizens to switch to diesels, which were thought to emit less $CO_2$ than their petrol counterparts. Diesel's biggest moment in the UK was probably in 2001, when Gordon Brown, then Chancellor of the Labour government, cut fuel duty on diesel vehicles as a deliberate effort to encourage people to switch.

The cracks took a long time to appear, but when they did they splintered rapidly. In 2012 came the first major evidence of some truly dreadful health impacts. Nitrogen oxides ($NO_X$) and dioxides ($NO_2$) and particulate matter (PM) pumped out by diesel exhausts were fingered as silent killers. The studies multiplied. The European Environment Agency found that nitrogen dioxide ($NO_2$) from diesel fumes had caused around 71 000 premature deaths across the continent in a single year. It said the UK experienced 11 940 annual premature deaths from $NO_2$, the second highest in Europe behind Italy. The World Health Organisation (WHO) declared diesel exhaust a carcinogen, a cause of lung cancer in the same category as asbestos and mustard gas.

Then in 2015 came Dieselgate. In September of that year Volkswagen rocked the industry by admitting that it had cheated on its emission tests. Following that disclosure, David King, the UK government's former Chief Scientific Adviser on climate change, admitted ministers had made a huge mistake by promoting diesel. They had trusted the car industry when it said the fuel was clean. "It turns out we were wrong," he said.

Cities worldwide have scrambled. The mayors of Paris, Madrid, Athens and Mexico City have agreed to completely outlaw diesel vehicles from the centre of their cities by 2025. The political leaders that make up the C40 group of global megacities are all taking steps to crack down on diesel vehicles and reduce smog. But other cities, including British ones, are tinkering around the edges; London is proposing low-emission zones and toll charges but has stopped short of a ban.

Banning diesel is trickier than it seems. The scale of the problem remains enormous. Diesel never made huge inroads into the US, where gasoline remained cheap, and where American automakers focused their innovation efforts on hybrid and electric vehicles. But in Europe, diesel passenger cars remain a major part of the auto industry: astonishingly, they still account for nearly 50% of all new cars sold across the continent.

Meanwhile, a study of the latest diesel cars by the International Council for Clean Transportation (ICCT) says real-world emissions of nitrogen oxides ($NO_X$) are, on average, seven times higher than safety limits allow. A separate ICCT study showed that the latest diesel cars produce 10 times the $NO_X$ of heavy trucks or buses, which are more strictly regulated than cars.

The car manufacturers, too, have a hugely powerful lobby still at their disposal. According to Greg Archer, who once managed the UK government's air pollution research, automakers used their influence to ensure a "regulatory holiday" after the financial crash of 2008. They claimed that the Euro 5 and Euro 6 emissions standards, aimed at limiting pollutants from exhausts, led to significant reduction in pollutants. But a recent study of real-world performance shows those claims were bogus: Emissions Analytics found that 97% of the diesel cars made since 2011 exceed $NO_X$ safety limits.

Governments were complicit too. Germany agreed in 2013 to halt a proposed EU cap on bankers' bonuses – dreaded by the City of London – in return for British support to protect the German car industry and thwart a stricter emissions regime.

Nor is it easy to persuade drivers to switch. Many motorists are understandably angry that they were encouraged to invest in diesel engines but are now expected to face clean air zones, pollution charges and other restrictions. Many feel that they are, in effect, being punished for what they were told was the smart, responsible choice.

The UK government is keenly aware of the hypocrisy. The government must publish updated clean air plans but the Prime Minister, Theresa May, is "very conscious of the fact that past governments have encouraged people to buy diesel cars, and we need to take that into account".

While national governments wring their hands, it is cities that are taking the lead. In Germany, Berlin has already banned the oldest, highest-polluting diesel cars from its centre, while Munich is developing a clean air ban that will bring in some form of diesel ban in 2018. The Spanish capital, Madrid, has now introduced a system to halve the number of cars on the roads during smog outbreaks, based on odd or even number plates on alternate days; various other cities have experimented with similar trials.

In January, Oslo city council introduced a ban on diesel cars for the first time, halting their use completely for one day during a high pollution alert. The city also plans to raise the road toll for diesel cars entering the city centre from 33 Krone (£3) to 58 Krone (£5.50) in rush hour.

Green party councillor Lan Marie Nguyen Berg stated, "Since 2012 we've been talking about how bad diesel is for people's health, and people are adjusting to the science. In the past year we've seen quite a big change in attitudes. People are well aware of the health implications now. They don't think children and elderly people should have to stay in their homes to avoid pollution."

Paris has been typically one of the more aggressive cities. Under Mayor Anne Hidalgo, it introduced a system of coloured stickers to classify car types and emission levels. Any diesel-run car made before 2000 will not be allowed on the roads inside the French capital. Diesel cars built between 2000 and 2010 could soon be subject to tighter restrictions, as the mayor tries to phase out diesel entirely by 2025.

Some French drivers are unhappy. A national campaign group, 40 Million Motorists, says the new system is unfair to poorer diesel drivers who cannot afford to buy a new cleaner car.

Romain Lacombe, founder of Plume Labs, a Paris-based organisation that monitors air quality around the world, is not persuaded by their argument. He backs the new system because "it means the oldest cars will be the first off the road, which makes a lot of sense".

"The stock of diesel vehicles will take time to be phased out, but I only see momentum building to move away from diesel," says Lacombe. "There is a rising understanding of how damaging to health diesel emissions are. People are beginning to realise they are the first victim of their own vehicle. It's a personal health issue, a life or death issue."

Sadiq Khan, the Mayor of London, has stopped short of an outright ban on diesel, but he has ordered the replacement of the capital's current diesel bus fleet with clean alternatives. The mayor's office will also enforce a £10 toxicity charge on the highest-polluting cars entering the city centre. The measures are part of a wider plan to create an ultra-low-emission zone (ULEZ) in central London.

Khan has expressly urged drivers to "ditch dirty diesel", and has backed it up by urging the UK government to come up with a "national diesel scrappage fund" to fairly compensate diesel drivers, suggesting a sum of up to £3,500 offered for each car or van taken off the road.

The black cabs are a test of whether diesel is on its way out. Many of the cabs use diesel, and drivers had initially complained about clean-air restrictions. But the Licensed Taxi Drivers' Association (LTDA) now backs Khan's idea of a scrappage fund. And last month the government and City Hall both announced a plug-in taxi grant scheme giving cabbies £7,500 to buy new electric models built in Coventry. Steve McNamara, General Secretary of the LTDA, predicts diesel cabs will be "a thing of the past" within six years.

**'The most unpopular measure'**

Although nearly three-quarters of all the world's diesel cars are driven on European roads, bold moves are being made elsewhere, too. Hong Kong has introduced subsidies to help phase out older diesel vehicles. Later this year Seoul will ban all diesels made before 2006 from a city-centre low emission zone.

But it is in Mexico City, where mountains surrounding the metropolis help trap a semi-permanent blanket of smog over the city, that Mayor Miguel Ángel Mancera has decided to ban diesel completely by 2025.

"I know it is a good thing for the city," Mancera said on a recent visit to London to meet Khan's team. "It's something that is absolutely essential to protect the environment. We're changing: our taxis have to be electric or hybrid, and our buses are being changed from diesel to new technologies."

The mayor has also pledged to invest more in the public transport system and cycling lanes, and persuaded delivery companies to use their diesel trucks at night to reduce daytime emissions.

Worldwide, polls suggest citizens of some big cities are beginning to put clean air before convenience. A YouGov poll last year showed 52% of Londoners would support a ban on diesel cars in London's city centre; a similar poll in France on a ban on diesel in the centre by 2020 was backed by 54% of Parisians.

This is probably how the death of diesel will come about – not through regulation but through consumer disgust. Many auto experts expect the global sales dip that followed Dieselgate to continue as consumers turn up their noses and manufacturers correspondingly invest less in new models. "The regulations will deter people, at least people in big cities, from buying diesel cars at their next purchase if they think they are going to be restricted," says Professor David Bailey of Aston University.

Are car buyers entitled to have any confidence at all in buying diesel, or do we need to get rid of it altogether? Unfortunately it is difficult to determine precisely how the latest breed of diesel cars compare with petrol ones, pollution-wise. Since the Volkswagen scandal, no one has a great deal of faith in emission testing done in the laboratory.

A tougher on-the-road testing regime, the "real driving emissions" (RDE) tests, is set to take place across the EU. "There is going to be a tightening up on testing and it will make diesel cars more expensive to make," says Bailey. "It will mean a lot of diesel cars disappearing because it won't be worth it for the manufacturers."

"I think a substantial reorientation will take place away from diesel, part of a larger shift away from the combustion engine toward electric cars in the 2020s."

According to Steve Gooding, Director of the RAC Foundation, a UK motoring research group, "the mere talk of action might already be altering buying behaviour". He points to a recent dip in diesel car sales in the UK. But Gooding also argues that schemes to remove the highest-polluting diesel cars from the roads are impractical, mainly because working out exactly how "dirty" a car is remains difficult. "The issue is not just the age of a car, but where it's driven, how far it's driven and under what conditions," he says. "Unfortunately, the data needed to target the most polluting vehicles accurately are not easily available."

Yet the prize for hastening the decline of diesel could be huge – not least because, with so many big climate battles ahead of us, it would demonstrate that we and our political leaders can fix crises when science identifies them.

"I'm optimistic we can see the end of diesel vehicles," says Berg. "The end of diesel would be a pretty big change in a relatively short period of time."

## Article 2

### Researchers show how diesel fumes could cause 'flare up' of respiratory symptoms

*This is an edited version of an article published by Imperial College London in May 2017. The article was written by Ryan O'Hare.*

**Scientists have shown how diesel fumes trigger respiratory reflexes which could potentially worsen underlying conditions, such as asthma.**

The study, led by researchers at Imperial College London, is the first to demonstrate a mechanism by which diesel exhaust particles, a major component of air pollution in European cities, directly affect the lungs to initiate symptoms such as a tightening of the airways and coughing.

Previous research has shown a strong association between urban air pollution and respiratory symptoms such as coughing, wheezing and shortness of breath, but the underlying mechanism has been unclear.

In a recent study, published in the *Journal of Allergy and Clinical Immunology*, an international team has shown that by-products from burning diesel fuel – called polycyclic aromatic hydrocarbons (PAHs) – directly stimulate nerves in the lungs, causing a reflex response in the airways.

The findings may provide a key link between exposure to air pollution on city streets and respiratory symptoms, which can lead to hospitalisation for people at higher risk, such as the very young, the elderly, and those with respiratory diseases.

"In major European cities, such as London, we are already exceeding the recommended levels for air pollution and these findings provide another reason why we need to curb these levels," said Professor Maria Belvisi, head of the Respiratory Pharmacology Group at Imperial's National Heart and Lung Institute, who led the research. "Pollution will affect everyone, but it affects people with underlying conditions, such as asthma, even more."

Previously, scientists showed that the effects of air pollution on the lungs of asthmatics correlated with the concentration of small, ultrafine particles inhaled, although the exact mechanism was unclear. These tiny particles (less than 100 nm in diameter) can get deep into lungs and are so small that cells recognise them as biological molecules which can be absorbed and processed, possibly accounting for their adverse health effects. However, the new findings suggest a more complicated mechanism.

When the particles in diesel exhaust were processed to separate the insoluble carbon core from the soluble, outer organic fraction, the researchers found that it was chemicals on their surface (the PAHs) which directly stimulated nerves, while the central carbon particles did not. The researchers say that the small size of the particles helps the chemicals to reach deep into the lungs, and cross membranes, where they can activate the nerves.

Professor Terry Tetley, co-lead author and also from Imperial's National Heart and Lung Institute, said: "This study, which brought together a multidisciplinary team of scientists, helps to address the previously unknown effects of particulate air pollution on respiratory symptoms. The findings further highlight the potential health impacts of urban air pollution on the public, particularly on those with underlying health conditions."

**Uncovering the mechanism**

Working with researchers from King's College London and University of British Columbia, Professor Belvisi's team used commercially available diesel exhaust and generator diesel, which mimics 'real-world' urban environment conditions, to test the effects of exposure on mice in laboratories and animal nerve tissue. The effects were also tested on human tissue, using sections of vagus nerve from donor lung tissue that was surplus to transplant requirement.

The researchers found that when the tissue had been exposed to PAHs, sensory nerves responsible for the reflex events and initiating common respiratory symptoms, such as coughing and wheezing, were stimulated. The evidence suggests that when these organic compounds are inhaled, they interact with receptors in the airways to cause oxidative stress. This stress then cascades and opens ion channels, tipping the electrochemical balance and causing the nerves to 'fire'.

These findings were further supported using nerve tissue from mice lacking the functioning ion channel (called TRPA1), in which this change to the electrochemical balance in the nerves, and subsequent symptoms, was not seen.

"Our work shows that particles from diesel exhaust can activate these ion channels, stimulating the nerves in the lungs. This may be responsible for the respiratory symptoms we see following exposure to urban air pollution," explained Professor Belvisi.

In a previous study in 2013, a group including researchers at Imperial College showed that high levels of air pollution on London's busy Oxford Street had a measurable effect on the lungs of people with asthma, compared with exposure in less polluted areas of the city. The results showed a link between the levels of ultrafine particles (including diesel exhaust particles) at street level and reductions in lung function.

Professor Belvisi explained that the latest work adds to a growing body of evidence demonstrating the direct effects of air pollution on public health.

Combined with previous clinical exposure studies, in which people were exposed to real world levels of diesel exhaust particles in the lab, the mechanism illustrates the effects of typical exposure for people living and working in an urban environment.

"The main message here is about prevention," said Professor Belvisi. "A significant number of hospital admissions are for people suffering with exacerbations of respiratory disease. If we can prevent these exacerbations which are as a consequence of the increase in symptoms, we're going to have fewer people needing hospital treatment."

Dr Chris Carlsten, from the University of British Columbia and a co-author on the study, said: "Linking traffic-related pollution to cough broadens the scope of those affected by this ongoing public health challenge and this can engage citizens to voice concern so that government responds with appropriate action. This is a great example of top-notch air pollution science once again motivating real-world action."

Dr Ian Mudway, from the Environmental Research Group at King's College London, added: "This study further highlights the adverse impacts diesel exhaust emissions can have on sensitive individuals and strengthens the scientific evidence base supporting moves to improve air quality in the UK."

**Article 3**

**Diesel, children and respiratory disease**

*This is an edited version of an article published by the British Medical Journal (BMJ) in May 2018. The article was written by Norrice M Liu and Jonathan Grigg from the Centre for Genomics and Child Health, Queen Mary University of London.*

What is already known on this topic?

- Air pollution is a global problem with negative health effects on the respiratory, cardiovascular and neurological systems.
- There is robust evidence that the effects of air pollution span over a lifetime, with growing children being particularly vulnerable.
- Diesel vehicles produce disproportionally more air pollution and should be a focus of exposure-mitigation policies.

What this study hopes to add?

- The role of emissions from diesel in contributing to exposure of UK children is reviewed.
- The adverse health effects of diesel emissions on UK children is reviewed.
- Ways of reducing exposure of children to fossil fuel-derived air pollution in the UK, on personal and national levels, are discussed.

**Introduction**

There is strong epidemiological evidence that air pollution is associated with a wide range of adverse health effects on the respiratory, cardiovascular and neurological systems[1–3]. Indeed, in the UK, the combination of new-onset (incident) diseases associated with long-term exposure and exacerbation of diseases, once disease is established, results in approximately 40 000 excess deaths a year that are attributable to air pollution. This has increased health service and social costs by over £20 billion a year[2]. Although deaths associated with air pollution are mainly in adults, there is also increasing concern that air pollution, especially from diesel vehicles, has major adverse effects in children and that this has long-term consequences[4–6]. In this review, we report the evidence that underpins the need for exposure reduction policy to focus on diesel vehicles and the potential beneficial effects of such a policy on children’s health. Although this review focuses on the heavily dieselised UK environment, it is also relevant to countries where diesel vehicles remain a major source of emissions.

**Components of air pollution**

The major outdoor pollutants in urban areas are inhalable particulate matter ($PM_{10}$ less than 10 $\mu$m in diameter or the even smaller $PM_{2.5}$), nitrogen oxides ($NO_X$), such as nitrogen dioxide ($NO_2$), ozone ($O_3$), sulfur dioxide ($SO_2$), carbon monoxide (CO) and hydrocarbons (HC). Sources of these include gasoline-powered and diesel-powered engines from vehicles, trains and, in port towns, ships; vehicle tyre and brake wear, power stations and factories from coal combustion and biomass burning[7–9], and wood burning heating that is increasingly popular, contributing up to 9% of PM in London during winter[10]. For diesel engines, an important component of emissions is black carbon, that is, the fraction of PM that most strongly absorbs light—a component that is often called ‘diesel soot’. Another pollutant, ozone, is formed by the reaction of $NO_X$ with carbon compounds called volatile organic compounds (VOCs) in the presence of sunlight.

**Why focus on diesel?**

Many parts of the UK breach the EU legal limits and WHO guidelines (**Table 1**) for pollutants on a regular basis[12]. While London often exhibits the biggest breach of pollution limits, other parts of the UK are also affected. Indeed, a recent report from the Department of Environment, Food and Rural Affairs and the Department of Transport showed 37 out of 43 reporting zones across the UK had maximum annual mean $NO_2$ concentrations over the EU legal limit[13].

**Table 1**

EU limits, WHO guidelines and main sources of ambient (outdoor) air pollutants. Adapted from European Commission Air Quality Standards (updated September 2017), WHO Ambient (outdoor) air quality and health fact sheet (updated Sept 2016), and Lethal and Illegal, Solving London's Air Pollution Crisis by Institute for Public Policy Research, November 2016

| **Pollutants** | **EU legal limits (averaging period)** | **WHO guidelines (averaging period)** | **Main sources** |
|---|---|---|---|
| Nitrogen dioxide ($NO_2$) | 200 $\mu g/m^3$ (1 hour)<br>40 $\mu g/m^3$ (1 year) | 200 $\mu g/m^3$ (1 hour)<br>40 $\mu g/m^3$ (1 year) | Transport, combustion |
| Ozone ($O_3$) | 120 $\mu g/m^3$ (8 hours) | 100 $\mu g/m^3$ (8 hours) | Reaction of hydrocarbons, nitrogen oxides and volatile organic compounds in sunlight |
| Particulate matter ($PM_{10}$) | 50 $\mu g/m^3$ (24 hours)<br>40 $\mu g/m^3$ (1 year) | 50 $\mu g/m^3$ (24 hours)<br>20 $\mu g/m^3$ (1 year) | Transport (exhaust, tyre, brake wear), combustion, industrial processes and construction |
| Particulate matter ($PM_{2.5}$) | 25 $\mu g/m^3$ (1 year) | 10 $\mu g/m^3$ (24 hours)<br>25 $\mu g/m^3$ (1 year) | |
| Sulfur dioxide ($SO_2$) | 350 $\mu g/m^3$ (1 hour)<br>125 $\mu g/m^3$ (24 hours) | 500 $\mu g/m^3$ (10 min)<br>20 $\mu g/m^3$ (24 hours) | Coal combustion and road transport |

While there are other sources of outdoor air pollution, the largest contributor to air pollution in urban areas in the UK is road traffic, which has been rising over the last 60 years. By contrast, active forms of transport such as walking and cycling have been declining[2]. In the UK, approximately 50% of $NO_2$ emissions come from the roads[14], with diesel engines powering half the cars and the majority of heavy vehicles[15]. At a global level, diesel vehicles contribute about 20% of $NO_X$[16].

Compliance with European standards is assessed under laboratory conditions only and these are less strict for diesel engines. But even given this leeway, recent measurements under real-life driving conditions have shown that diesel cars produce significantly more toxic emissions than the European standard. Thus, over 2000 education or childcare providers in England and Wales are located close to busy roads with concentrations of $NO_X$ that are regularly higher than legal limits (40 $\mu g/m^3$ annual mean or 200 $\mu g/m^3$ 1 hour mean)[14, 21, 22]. In addition, children attending these schools are exposed to high concentrations of freshly generated diesel pollutants during the commute to and from school and during outdoor activities. (**Figure 1**)

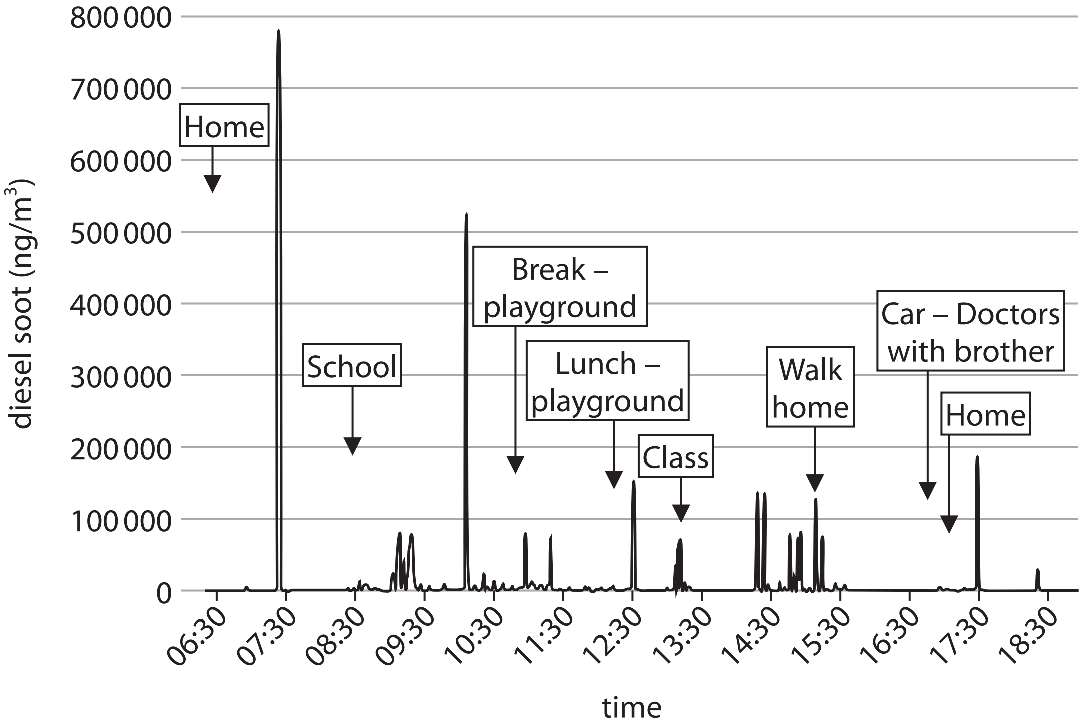


**Figure 1**

Diesel soot levels exposed to children in London on a typical school day.

**Health effects of diesel emissions on children**

Few epidemiological studies address the effects of diesel emissions alone. However, it is reasonable to extrapolate from studies that have assessed exposure to either PM or $NO_X$ since (a) diesel PM is not less toxic than other types of PM and (b) the adverse effects of gases such as $NO_X$ are independent of source. One way of estimating the health burden from diesel emissions alone is to use source data. For example, in London where most taxis, buses, heavy goods vehicles and vans are powered by diesel (**Table 2**), 48% of $NO_X$ and 54% of $PM_{10}$ is from road transport[19, 23]. These vehicles, along with diesel cars, are responsible for 34% of total $PM_{10}$ and 38% of total $NO_X$ emissions[23].

**Table 2**

Fuel sources of vehicles in London, 2015 (adapted from Lethal and Illegal, Solving London's Air Pollution Crisis by Institute for Public Policy Research, September 2016)

| Vehicles | Petrol (%) | Diesel (%) | Other (%) |
|---|---|---|---|
| Buses | 0 | 89 | 11 |
| Taxis | 0 | 100 | 0 |
| Private vehicles | 42 | 57 | 1 |
| Light goods vehicles | 2 | 97 | 1 |
| Heavy goods vehicles | 0 | 100 | 0 |

**Antenatal exposure**

When considering effects measured in later childhood, it is difficult to separate the effect of maternal exposure to air pollution from postnatal effects—since there is a strong correlation between exposure to traffic-derived air pollutants (TRAPs) of pregnant women and their children. But independent associations between antenatal exposure to $NO_2$ and reduced forced expiratory reserve volume ($FEV_1$) later in childhood are reported. By contrast, effects on the fetus or on the newborn infant must be due to maternal exposure. These epidemiological studies report that maternal exposure to TRAP has adverse effects on the fetus leading to increased infant mortality, reduced fetal growth, low birth weight at term and premature birth[25, 26]. It is likely that these antenatal effects, coupled with postnatal pollution exposures increase susceptibility to common respiratory conditions such as wheeze, bronchiolitis and asthma[28–30].

**Childhood exposure**

Air pollutants, particularly $NO_X$ (reflecting exposure to both $NO_X$ and PM), are associated with reduced lung function in children—for both forced vital capacity (FVC) and $FEV_1$[5]. Both FVC and $FEV_1$ are measures of lung function. Urman et al[5] showed that an increase in $NO_X$ exposure was associated with a decrease in both FVC and $FEV_1$, and similar findings were seen in children with or without asthma. Residing in areas with high concentrations of PM and $NO_2$ can also lead to suppression of lung function growth in school children[4, 31]. This reduction can potentially be halted and reversed with better air quality. For example, Gauderman et al[32] showed that reducing the levels of $NO_2$, $PM_{10}$ and $PM_{2.5}$ were associated with improvements in $FEV_1$ and FVC growth in adolescents. Children with existing chronic illnesses, particularly respiratory conditions, are most vulnerable. Air pollution can predispose individuals to new-onset asthma; preschool children are more prone to new-onset of wheeze. A meta-analysis (an examination of many studies) concluded that exposure to $NO_2$ is linked to new-onset asthma, while exposure to PM is linked to new-onset wheeze[33]. An effect of diesel PM on reactivity to inhaled allergens is supported by the association between long-term traffic pollution exposure and allergies[34–36]. Asthma exacerbations are also closely associated with short-term variations in $PM_{2.5}$[37]. Although increasing inhaled corticosteroids (asthma inhalers that reduce inflammation and help prevent an attack) prior to high pollution days may seem logical[38], it is unclear whether this strategy is effective.

There is emerging evidence that air pollution impacts on children's neurological systems and development. For example, associations between exposure to air pollutants and reduced IQ and neurocognitive ability such as working memory, autism and reduced brain-derived neurotrophic factor are widely reported[39–41]. In particular, Basagaña et al[39] reported that traffic-related $PM_{2.5}$ was more strongly associated with reduction in cognitive function compared with fine particulates from other sources such as mineral, heavy oil combustion or road dust. In addition, exposure to high levels of traffic-induced pollutants may delay maturation of the brain[42]. An additional emerging link is between air pollution and the endocrine system. For example, Thiering et al[43] reported an association between insulin resistance and either $NO_2$ or PM exposure in healthy children.

**Implications for adult life**

It is increasingly recognised that impaired fetal wellbeing is a substrate for adult-onset cardiovascular disease such as atherosclerosis[44]. Prolonged exposure to air pollutants may increase mean pulmonary arterial pressure and diastolic blood pressure[45, 46], predisposing to cardiovascular events and premature death in adulthood. The effect on cognition lingers onto adulthood, where associations with dementia and Parkinson's disease have been found[47, 48].

Although the epidemiological evidence for the health effect of fossil fuel-derived pollution is very strong, there are important confounders (other factors) that must be considered. For example, in England, increased exposure to mean annual $NO_2$ concentrations is higher in areas of increased social deprivation and reduced access to healthcare[49]. Furthermore, children from more deprived areas are also more likely to be exposed to other sources of pollution such as second-hand cigarette smoking[50].

**Mechanisms**

Many of the mechanisms underlying the robust epidemiological associations between air pollution and health across the lifetime remain to be defined. Effects on organs distant from the lungs are likely to be aided by substances released into the systemic blood circulation and organs[51]. A key type of cell for releasing these substances is alveolar macrophage (AM) since phagocytosis of PM by AM stimulates release of cytokines (cell signalling molecules)[52, 53]. PM that reaches the most distant airways is phagocytosed by airway macrophages[54, 55]. Indeed, Kulkarni et al[56] reported that in healthy children, the amount of carbon in AM is inversely associated with lung function. Phagocytosis of inhaled diesel PM by AM is also essential for normal removal of PM from the lungs, which minimises exposure of other airway cells. Conditions that impair AM phagocytosis will increase the proportion of PM impacting on and penetrating airway epithelial cells, further worsening inflammation[57–59].

**What can we do about diesel pollution?**

**National level**

In London, air pollution is mostly caused by road traffic, of which diesel vehicles are a major contributor, as discussed above. With an estimated 9400 premature deaths attributable to air pollution, it has the second biggest impact on public health[19]. These highly polluting vehicles should therefore be phased out to comply with legal limits of pollutants—and cleaner alternatives encouraged. Tougher national regulations on traffic emissions such as the expansion of Ultra Low Emission Zones and scrappage schemes for older generations of diesel vehicles should be considered. Indeed, the 2016 report from the Institute for Public Policy Research[23] estimated that phasing out diesel-powered vehicles in London would lead to large reductions in $NO_X$ and $NO_2$ levels, ultimately lowering $NO_2$ levels to comply with EU standards. This report estimated that with a 45% reduction in $NO_X$ and 56% reduction in $NO_2$, 1.4 million life-years would be gained along with a financial benefit of up to £800 million.

Planting trees can reduce air pollution by acting as a physical barrier to intercept PM and absorbing gaseous pollutants such as $O_3$[62], although the effect on pollution concentrations at schools is, to date, unclear. However, the amount of pollutants removed by these organic barriers will be proportional to the extent of plantation. Therefore, vast tall hedges around nurseries and schools should be encouraged, but this does not provide protection against pollution exposure during travel to and from schools.

**Individual level**

Various measures such as walking along less busy roads, cycling, use of public transport and carpooling may reduce exposure to air pollution[63], but the evidence base for whether this is achievable over the long term, and is sufficient to improve health, is limited. The Department for Environment, Food and Rural Affairs website provides information and forecast on UK air quality, while the British Lung Foundation provides information on various measures to take according to air pollution levels. These include avoiding spending time near busy roads, reducing strenuous activities outdoors, avoiding rush hours and using an inhaler to prevent triggering asthma.

Air cleaning systems are available commercially claiming to reduce indoor pollution—these can either remove particles and gaseous pollutants or have ultraviolet light technology to destroy indoor pollutants[64]. All have their limitations, for example large particles tend to settle before reaching filters, while gaseous pollutant filters may have short lifespans[64]. These systems also use electricity—which may not be from sustainable sources. Improvement in our air quality will benefit the whole population with lasting health and economic advantages. We should aim to build cities that promote and improve the health of the population.

In conclusion, in the UK, the phasing out of the current diesel car, van and taxi fleet, and replacing this fleet with greener alternatives must be central to the exposure-reduction strategy. Changes that would support such an initiative are:

- more active travel supported by better public transport infrastructure
- providing electric charging points on residential streets
- providing clinicians with the tools to discuss personal exposure reduction strategies with their patients.

**Acknowledgments**

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*This article has been edited and some references have been removed from the list.*

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**Pearson BTEC Level 3 Nationals Extended Diploma**

Centre Number

Learner Registration Number

# Monday 13 January 2020

Morning (Time: 2 hours 30 minutes) | Paper Reference **31629H**

# Applied Science

## Unit 7: Contemporary Issues in Science

**Part B**

**You will need:**
Up to four sides of A4 notes from **Part A**

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Part A** will need to have been used in preparation for completion of **Part B**.
- **Part B** must be undertaken in a single session of 2 hours and 30 minutes in the assessment session timetabled by Pearson.
- **Part B** materials must be issued to learners for the specified session.
- **Part B** is specific to each series and this material must only be issued to learners who have been entered to undertake the task in the relevant series.
- **Part B** should be kept securely until the start of the 2 hour and 30 minute supervised assessment.

## Information

- The total mark for this paper is 50.
- The marks for each question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- The three articles are at the back of **Part B**.

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶



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## Instructions to Teachers/Tutors

This paper must be read in conjunction with the unit information in the specification and the *BTEC Nationals Instructions for Conducting External Assessments (ICEA)* document. See the Pearson website for details.

**Part B** set task is undertaken under supervision in a single session of 2 hours and 30 minutes in the timetabled session. Centres may schedule a supervised rest break during the session.

**Part B** set task requires learners to apply understanding gained through familiarisation with the articles. Learners should bring in notes as defined in **Part A**.

Learners must complete the set task using this task and answer booklet.

**Maintaining security**

- Only permitted materials for the set task can be brought into the supervised environment.
- During any permitted break and at the end of the session materials must be kept securely and no items removed from the supervised environment.
- Learner notes related to **Part A** must be checked to ensure length and contents meet limitations.
- Learner notes from **Part A** will be retained securely by the centre after **Part B** and may be requested by Pearson if there is suspected malpractice.

After the session the teacher/tutor and/or invigilator will confirm that all learner work was completed independently as part of the authentication submitted to Pearson.

**Outcomes for submission**

This task and answer booklet should be submitted to Pearson.


P 6 3 9 5 1 A 0 2 3 6

**Instructions for Learners**

Read the set task information carefully.

Complete all your work in this taskbook in the spaces provided.

This session is of 2 hours 30 minutes (during the day). Your teacher/tutor will tell you if there is a supervised break. Plan your time carefully.

You have prepared for the set task given in this **Part B** booklet. Use your notes prepared during **Part A** if relevant. Attempt all the questions in **Part B**.

Your notes must be your own work and will be retained by your centre until results are issued.

You will complete this set task under supervision and your work will be kept securely during any breaks taken.

You must work independently throughout the supervised assessment period and should not share your work with other learners.

**Outcomes for submission**

You will need to submit the following document on completion of the supervised assessment period:

- a completed **Part B** task and answer booklet.

## Set Task

**Answer ALL questions in the spaces provided.**

**1** Discuss the implications of the scientific issue identified in the articles.

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(Total for Question 1 = 12 marks)

**2** Identify the different organisations/individuals mentioned in the articles and suggest how they may have an influence on the scientific issue.

**(6)**

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**(Total for Question 2 = 6 marks)**





Turn over

**3** Discuss whether Article 3 has made valid judgements.

In your answer you should consider:

- how the article has interpreted and analysed the scientific information to support the conclusions/judgements being made
- the validity and reliability of data
- references to other sources of information.

**(12)**

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**(Total for Question 3 = 12 marks)**

**4** Suggest potential areas for further development and/or research of the scientific issue from the three articles.

**(5)**

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(Total for Question 4 = 5 marks)



P 6 3 9 5 1 A 0 1 5 3 6

*Turn over*

**5** You are a journalist working for your local newspaper.

Your local council wishes to ban diesel cars from your city centre next year.

Your task is to write a newspaper article about the advantages and disadvantages of banning diesel cars from your city centre.

Your article will be read by your local community. Many of your readers will not be scientists.

Use information from the three articles to write your newspaper article.

When writing your newspaper article, you should consider:

- who is likely to read the article
- what you would like the readers to learn from the article
- whether diesel cars should be banned nationwide by 2025.

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**(Total for Question 5 = 15 marks)**

**TOTAL FOR PAPER = 50 MARKS**

**Part A Set Task Information**

**Article 1**

**The death of diesel: has the one-time wonder fuel become the new asbestos?**

*This is an edited version of an article that appeared in 'The Guardian' newspaper in April 2017. The article was written by Adam Forrest.*

Photograph: Jinny Goodman/Alamy
Exhaust from a car. Air pollution kills 3.3 million people prematurely every year.

**Diesel was the dream fuel, promoted by governments and the car industry as a cheaper way to save the planet. Then the cracks started to appear.**

Air pollution now kills 3.3 million people prematurely every year – more than HIV, malaria and influenza combined – with emissions from diesel engines among the worst culprits; a joint investigation by The Guardian and Greenpeace showed hundreds of thousands of schoolchildren across England and Wales are being exposed to illegal air toxicity levels from diesel vehicles. And yet, such was the more or less widely accepted thinking as recently as 2010 that cars running on diesel fuel could be driven with a pure, unclouded conscience.

Diesel was touted at inception as a wonder fuel. It was a way of driving cost-efficiently while doing your bit to save the planet. Government, industry and science united to sell us the dream: cars running on diesel would help us cut our $CO_2$ emissions as we eased smoothly into a new eco-friendly age.

It was particularly owing to advances in engine technology that the diesel passenger car market was able to blossom in the 1990s, particularly in Europe. Drivers liked the fuel efficiency of diesel engines, which made running costs cheaper than petrol over the long term. Governments, meanwhile, alarmed by rising carbon emissions, began advising citizens to switch to diesels, which were thought to emit less $CO_2$ than their petrol counterparts. Diesel's biggest moment in the UK was probably in 2001, when Gordon Brown, then Chancellor of the Labour government, cut fuel duty on diesel vehicles as a deliberate effort to encourage people to switch.

The cracks took a long time to appear, but when they did they splintered rapidly. In 2012 came the first major evidence of some truly dreadful health impacts. Nitrogen oxides ($NO_X$) and dioxides ($NO_2$) and particulate matter (PM) pumped out by diesel exhausts were fingered as silent killers. The studies multiplied. The European Environment Agency found that nitrogen dioxide ($NO_2$) from diesel fumes had caused around 71 000 premature deaths across the continent in a single year. It said the UK experienced 11 940 annual premature deaths from $NO_2$, the second highest in Europe behind Italy. The World Health Organisation (WHO) declared diesel exhaust a carcinogen, a cause of lung cancer in the same category as asbestos and mustard gas.







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Then in 2015 came Dieselgate. In September of that year Volkswagen rocked the industry by admitting that it had cheated on its emission tests. Following that disclosure, David King, the UK government's former Chief Scientific Adviser on climate change, admitted ministers had made a huge mistake by promoting diesel. They had trusted the car industry when it said the fuel was clean. "It turns out we were wrong," he said.

Cities worldwide have scrambled. The mayors of Paris, Madrid, Athens and Mexico City have agreed to completely outlaw diesel vehicles from the centre of their cities by 2025. The political leaders that make up the C40 group of global megacities are all taking steps to crack down on diesel vehicles and reduce smog. But other cities, including British ones, are tinkering around the edges; London is proposing low-emission zones and toll charges but has stopped short of a ban.

Banning diesel is trickier than it seems. The scale of the problem remains enormous. Diesel never made huge inroads into the US, where gasoline remained cheap, and where American automakers focused their innovation efforts on hybrid and electric vehicles. But in Europe, diesel passenger cars remain a major part of the auto industry: astonishingly, they still account for nearly 50% of all new cars sold across the continent.

Meanwhile, a study of the latest diesel cars by the International Council for Clean Transportation (ICCT) says real-world emissions of nitrogen oxides ($NO_X$) are, on average, seven times higher than safety limits allow. A separate ICCT study showed that the latest diesel cars produce 10 times the $NO_X$ of heavy trucks or buses, which are more strictly regulated than cars.

The car manufacturers, too, have a hugely powerful lobby still at their disposal. According to Greg Archer, who once managed the UK government's air pollution research, automakers used their influence to ensure a "regulatory holiday" after the financial crash of 2008. They claimed that the Euro 5 and Euro 6 emissions standards, aimed at limiting pollutants from exhausts, led to significant reduction in pollutants. But a recent study of real-world performance shows those claims were bogus: Emissions Analytics found that 97% of the diesel cars made since 2011 exceed $NO_X$ safety limits.

Governments were complicit too. Germany agreed in 2013 to halt a proposed EU cap on bankers' bonuses – dreaded by the City of London – in return for British support to protect the German car industry and thwart a stricter emissions regime.

Nor is it easy to persuade drivers to switch. Many motorists are understandably angry that they were encouraged to invest in diesel engines but are now expected to face clean air zones, pollution charges and other restrictions. Many feel that they are, in effect, being punished for what they were told was the smart, responsible choice.

The UK government is keenly aware of the hypocrisy. The government must publish updated clean air plans but the Prime Minister, Theresa May, is "very conscious of the fact that past governments have encouraged people to buy diesel cars, and we need to take that into account."

While national governments wring their hands, it is cities that are taking the lead. In Germany, Berlin has already banned the oldest, highest-polluting diesel cars from its centre, while Munich is developing a clean air ban that will bring in some form of diesel ban in 2018. The Spanish capital, Madrid, has now introduced a system to halve the number of cars on the roads during smog outbreaks, based on odd or even number plates on alternate days; various other cities have experimented with similar trials.

In January, Oslo city council introduced a ban on diesel cars for the first time, halting their use completely for one day during a high pollution alert. The city also plans to raise the road toll for diesel cars entering the city centre from 33 Krone (£3) to 58 Krone (£5.50) in rush hour.

Green party councillor Lan Marie Nguyen Berg stated, "Since 2012 we've been talking about how bad diesel is for people's health, and people are adjusting to the science. In the past year we've seen quite a big change in attitudes. People are well aware of the health implications now. They don't think children and elderly people should have to stay in their homes to avoid pollution."

Paris has been typically one of the more aggressive cities. Under Mayor Anne Hidalgo, it introduced a system of coloured stickers to classify car types and emission levels. Any diesel-run car made before 2000 will not be allowed on the roads inside the French capital. Diesel cars built between 2000 and 2010 could soon be subject to tighter restrictions, as the mayor tries to phase out diesel entirely by 2025.

Some French drivers are unhappy. A national campaign group, 40 Million Motorists, says the new system is unfair to poorer diesel drivers who cannot afford to buy a new cleaner car.

Romain Lacombe, founder of Plume Labs, a Paris-based organisation that monitors air quality around the world, is not persuaded by their argument. He backs the new system because "it means the oldest cars will be the first off the road, which makes a lot of sense".

"The stock of diesel vehicles will take time to be phased out, but I only see momentum building to move away from diesel," says Lacombe. "There is a rising understanding of how damaging to health diesel emissions are. People are beginning to realise they are the first victim of their own vehicle. It's a personal health issue, a life or death issue."

Sadiq Khan, the Mayor of London, has stopped short of an outright ban on diesel, but he has ordered the replacement of the capital's current diesel bus fleet with clean alternatives. The mayor's office will also enforce a £10 toxicity charge on the highest-polluting cars entering the city centre. The measures are part of a wider plan to create an ultra-low-emission zone (ULEZ) in central London.

Khan has expressly urged drivers to "ditch dirty diesel", and has backed it up by urging the UK government to come up with a "national diesel scrappage fund" to fairly compensate diesel drivers, suggesting a sum of up to £3,500 offered for each car or van taken off the road.

The black cabs are a test of whether diesel is on its way out. Many of the cabs use diesel, and drivers had initially complained about clean-air restrictions. But the Licensed Taxi Drivers' Association (LTDA) now backs Khan's idea of a scrappage fund. And last month the government and City Hall both announced a plug-in taxi grant scheme giving cabbies £7,500 to buy new electric models built in Coventry. Steve McNamara, General Secretary of the LTDA, predicts diesel cabs will be "a thing of the past" within six years.

**'The most unpopular measure'**

Although nearly three-quarters of all the world's diesel cars are driven on European roads, bold moves are being made elsewhere, too. Hong Kong has introduced subsidies to help phase out older diesel vehicles. Later this year Seoul will ban all diesels made before 2006 from a city-centre low emission zone.

But it is in Mexico City, where mountains surrounding the metropolis help trap a semi-permanent blanket of smog over the city, that Mayor Miguel Ángel Mancera has decided to ban diesel completely by 2025.

"I know it is a good thing for the city," Mancera said on a recent visit to London to meet Khan's team. "It's something that is absolutely essential to protect the environment. We're changing: our taxis have to be electric or hybrid, and our buses are being changed from diesel to new technologies."

The mayor has also pledged to invest more in the public transport system and cycling lanes, and persuaded delivery companies to use their diesel trucks at night to reduce daytime emissions.

Worldwide, polls suggest citizens of some big cities are beginning to put clean air before convenience. A YouGov poll last year showed 52% of Londoners would support a ban on diesel cars in London's city centre; a similar poll in France on a ban on diesel in the centre by 2020 was backed by 54% of Parisians.

This is probably how the death of diesel will come about – not through regulation but through consumer disgust. Many auto experts expect the global sales dip that followed Dieselgate to continue as consumers turn up their noses and manufacturers correspondingly invest less in new models. "The regulations will deter people, at least people in big cities, from buying diesel cars at their next purchase if they think they are going to be restricted," says Professor David Bailey of Aston University.

Are car buyers entitled to have any confidence at all in buying diesel, or do we need to get rid of it altogether? Unfortunately it is difficult to determine precisely how the latest breed of diesel cars compare with petrol ones, pollution-wise. Since the Volkswagen scandal, no one has a great deal of faith in emission testing done in the laboratory.

A tougher on-the-road testing regime, the "real driving emissions" (RDE) tests, is set to take place across the EU. "There is going to be a tightening up on testing and it will make diesel cars more expensive to make," says Bailey. "It will mean a lot of diesel cars disappearing because it won't be worth it for the manufacturers."

"I think a substantial reorientation will take place away from diesel, part of a larger shift away from the combustion engine toward electric cars in the 2020s."

According to Steve Gooding, Director of the RAC Foundation, a UK motoring research group, "the mere talk of action might already be altering buying behaviour". He points to a recent dip in diesel car sales in the UK. But Gooding also argues that schemes to remove the highest-polluting diesel cars from the roads are impractical, mainly because working out exactly how "dirty" a car is remains difficult. "The issue is not just the age of a car, but where it's driven, how far it's driven and under what conditions," he says. "Unfortunately, the data needed to target the most polluting vehicles accurately are not easily available."

Yet the prize for hastening the decline of diesel could be huge – not least because, with so many big climate battles ahead of us, it would demonstrate that we and our political leaders can fix crises when science identifies them.

"I'm optimistic we can see the end of diesel vehicles," says Berg. "The end of diesel would be a pretty big change in a relatively short period of time."

**Article 2**

**Researchers show how diesel fumes could cause 'flare up' of respiratory symptoms**

*This is an edited version of an article published by Imperial College London in May 2017. The article was written by Ryan O'Hare.*

**Scientists have shown how diesel fumes trigger respiratory reflexes which could potentially worsen underlying conditions, such as asthma.**

The study, led by researchers at Imperial College London, is the first to demonstrate a mechanism by which diesel exhaust particles, a major component of air pollution in European cities, directly affect the lungs to initiate symptoms such as a tightening of the airways and coughing.

Previous research has shown a strong association between urban air pollution and respiratory symptoms such as coughing, wheezing and shortness of breath, but the underlying mechanism has been unclear.

In a recent study, published in the *Journal of Allergy and Clinical Immunology*, an international team has shown that by-products from burning diesel fuel – called polycyclic aromatic hydrocarbons (PAHs) – directly stimulate nerves in the lungs, causing a reflex response in the airways.

The findings may provide a key link between exposure to air pollution on city streets and respiratory symptoms, which can lead to hospitalisation for people at higher risk, such as the very young, the elderly, and those with respiratory diseases.

"In major European cities, such as London, we are already exceeding the recommended levels for air pollution and these findings provide another reason why we need to curb these levels," said Professor Maria Belvisi, head of the Respiratory Pharmacology Group at Imperial's National Heart and Lung Institute, who led the research. "Pollution will affect everyone, but it affects people with underlying conditions, such as asthma, even more."

Previously, scientists showed that the effects of air pollution on the lungs of asthmatics correlated with the concentration of small, ultrafine particles inhaled, although the exact mechanism was unclear. These tiny particles (less than 100 nm in diameter) can get deep into lungs and are so small that cells recognise them as biological molecules which can be absorbed and processed, possibly accounting for their adverse health effects. However, the new findings suggest a more complicated mechanism.

When the particles in diesel exhaust were processed to separate the insoluble carbon core from the soluble, outer organic fraction, the researchers found that it was chemicals on their surface (the PAHs) which directly stimulated nerves, while the central carbon particles did not. The researchers say that the small size of the particles helps the chemicals to reach deep into the lungs, and cross membranes, where they can activate the nerves.

Professor Terry Tetley, co-lead author and also from Imperial's National Heart and Lung Institute, said: "This study, which brought together a multidisciplinary team of scientists, helps to address the previously unknown effects of particulate air pollution on respiratory symptoms. The findings further highlight the potential health impacts of urban air pollution on the public, particularly on those with underlying health conditions."

**Uncovering the mechanism**

Working with researchers from King's College London and University of British Columbia, Professor Belvisi's team used commercially available diesel exhaust and generator diesel, which mimics 'real-world' urban environment conditions, to test the effects of exposure on mice in laboratories and animal nerve tissue. The effects were also tested on human tissue, using sections of vagus nerve from donor lung tissue that was surplus to transplant requirement.

The researchers found that when the tissue had been exposed to PAHs, sensory nerves responsible for the reflex events and initiating common respiratory symptoms, such as coughing and wheezing, were stimulated. The evidence suggests that when these organic compounds are inhaled, they interact with receptors in the airways to cause oxidative stress. This stress then cascades and opens ion channels, tipping the electrochemical balance and causing the nerves to 'fire'.

These findings were further supported using nerve tissue from mice lacking the functioning ion channel (called TRPA1), in which this change to the electrochemical balance in the nerves, and subsequent symptoms, was not seen.

"Our work shows that particles from diesel exhaust can activate these ion channels, stimulating the nerves in the lungs. This may be responsible for the respiratory symptoms we see following exposure to urban air pollution," explained Professor Belvisi.

In a previous study in 2013, a group including researchers at Imperial College showed that high levels of air pollution on London's busy Oxford Street had a measurable effect on the lungs of people with asthma, compared with exposure in less polluted areas of the city. The results showed a link between the levels of ultrafine particles (including diesel exhaust particles) at street level and reductions in lung function.

Professor Belvisi explained that the latest work adds to a growing body of evidence demonstrating the direct effects of air pollution on public health.

Combined with previous clinical exposure studies, in which people were exposed to real-world levels of diesel exhaust particles in the lab, the mechanism illustrates the effects of typical exposure for people living and working in an urban environment.

"The main message here is about prevention," said Professor Belvisi. "A significant number of hospital admissions are for people suffering with exacerbations of respiratory disease. If we can prevent these exacerbations which are as a consequence of the increase in symptoms, we're going to have fewer people needing hospital treatment."

Dr Chris Carlsten, from the University of British Columbia and a co-author on the study, said: "Linking traffic-related pollution to cough broadens the scope of those affected by this ongoing public health challenge and this can engage citizens to voice concern so that government responds with appropriate action. This is a great example of top-notch air pollution science once again motivating real-world action."

Dr Ian Mudway, from the Environmental Research Group at King's College London, added: "This study further highlights the adverse impacts diesel exhaust emissions can have on sensitive individuals and strengthens the scientific evidence base supporting moves to improve air quality in the UK."

**Article 3**

**Diesel, children and respiratory disease**

*This is an edited version of an article published by the British Medical Journal (BMJ) in May 2018. The article was written by Norrice M Liu and Jonathan Grigg from the Centre for Genomics and Child Health, Queen Mary University of London.*

What is already known on this topic?

- Air pollution is a global problem with negative health effects on the respiratory, cardiovascular and neurological systems.
- There is robust evidence that the effects of air pollution span over a lifetime, with growing children being particularly vulnerable.
- Diesel vehicles produce disproportionally more air pollution and should be a focus of exposure–mitigation policies.

What this study hopes to add?

- The role of emissions from diesel in contributing to exposure of UK children is reviewed.
- The adverse health effects of diesel emissions on UK children is reviewed.
- Ways of reducing exposure of children to fossil fuel-derived air pollution in the UK, on personal and national levels, are discussed.

**Introduction**

There is strong epidemiological evidence that air pollution is associated with a wide range of adverse health effects on the respiratory, cardiovascular and neurological systems [1–3]. Indeed, in the UK, the combination of new-onset (incident) diseases associated with long-term exposure and exacerbation of diseases, once disease is established, results in approximately 40 000 excess deaths a year that are attributable to air pollution. This has increased health service and social costs by over £20 billion a year [2]. Although deaths associated with air pollution are mainly in adults, there is also increasing concern that air pollution, especially from diesel vehicles, has major adverse effects in children and that this has long-term consequences [4–6]. In this review, we report the evidence that underpins the need for exposure reduction policy to focus on diesel vehicles and the potential beneficial effects of such a policy on children's health. Although this review focuses on the heavily dieselised UK environment, it is also relevant to countries where diesel vehicles remain a major source of emissions.

**Components of air pollution**

The major outdoor pollutants in urban areas are inhalable particulate matter ($PM_{10}$ less than 10 $\mu$m in diameter or the even smaller $PM_{2.5}$), nitrogen oxides ($NO_X$), such as nitrogen dioxide ($NO_2$), ozone ($O_3$), sulfur dioxide ($SO_2$), carbon monoxide (CO) and hydrocarbons (HC). Sources of these include gasoline-powered and diesel-powered engines from vehicles, trains and, in port towns, ships; vehicle tyre and brake wear, power stations and factories from coal combustion and biomass burning [7–9], and wood burning heating that is increasingly popular, contributing up to 9% of PM in London during winter [10]. For diesel engines, an important component of emissions is black carbon, that is, the fraction of PM that most strongly absorbs light—a component that is often called 'diesel soot'. Another pollutant, ozone, is formed by the reaction of $NO_X$ with carbon compounds called volatile organic compounds (VOCs) in the presence of sunlight.

**Why focus on diesel?**

Many parts of the UK breach the EU legal limits and WHO guidelines (**Table 1**) for pollutants on a regular basis [12]. While London often exhibits the biggest breach of pollution limits, other parts of the UK are also affected. Indeed, a recent report from the Department of Environment, Food and Rural Affairs and the Department of Transport showed 37 out of 43 reporting zones across the UK had maximum annual mean $NO_2$ concentrations over the EU legal limit [13].

**Table 1**

EU limits, WHO guidelines and main sources of ambient (outdoor) air pollutants. Adapted from European Commission Air Quality Standards (updated September 2017), WHO Ambient (outdoor) air quality and health fact sheet (updated Sept 2016), and Lethal and Illegal, Solving London's Air Pollution Crisis by Institute for Public Policy Research, November 2016

| **Pollutants** | **EU legal limits (averaging period)** | **WHO guidelines (averaging period)** | **Main sources** |
|---|---|---|---|
| Nitrogen dioxide ($NO_2$) | 200 $\mu g/m^3$ (1 hour)<br>40 $\mu g/m^3$ (1 year) | 200 $\mu g/m^3$ (1 hour)<br>40 $\mu g/m^3$ (1 year) | Transport, combustion |
| Ozone ($O_3$) | 120 $\mu g/m^3$ (8 hours) | 100 $\mu g/m^3$ (8 hours) | Reaction of hydrocarbons, nitrogen oxides and volatile organic compounds in sunlight |
| Particulate matter ($PM_{10}$) | 50 $\mu g/m^3$ (24 hours)<br>40 $\mu g/m^3$ (1 year) | 50 $\mu g/m^3$ (24 hours)<br>20 $\mu g/m^3$ (1 year) | Transport (exhaust, tyre, brake wear), combustion, industrial processes and construction |
| Particulate matter ($PM_{2.5}$) | 25 $\mu g/m^3$ (1 year) | 10 $\mu g/m^3$ (24 hours)<br>25 $\mu g/m^3$ (1 year) | |
| Sulfur dioxide ($SO_2$) | 350 $\mu g/m^3$ (1 hour)<br>125 $\mu g/m^3$ (24 hours) | 500 $\mu g/m^3$ (10 min)<br>20 $\mu g/m^3$ (24 hours) | Coal combustion and road transport |

While there are other sources of outdoor air pollution, the largest contributor to air pollution in urban areas in the UK is road traffic, which has been rising over the last 60 years. By contrast, active forms of transport such as walking and cycling have been declining [2]. In the UK, approximately 50% of $NO_2$ emissions come from the roads [14], with diesel engines powering half the cars and the majority of heavy vehicles [15]. At a global level, diesel vehicles contribute about 20% of $NO_X$ [16].

Compliance with European standards is assessed under laboratory conditions only and these are less strict for diesel engines. But even given this leeway, recent measurements under real-life driving conditions have shown that diesel cars produce significantly more toxic emissions than the European standard. Thus, over 2000 education or childcare providers in England and Wales are located close to busy roads with concentrations of $NO_X$ that are regularly higher than legal limits (40 $\mu g/m^3$ annual mean or 200 $\mu g/m^3$ 1 hour mean) [14, 21, 22]. In addition, children attending these schools are exposed to high concentrations of freshly generated diesel pollutants during the commute to and from school and during outdoor activities. (**Figure 1**)

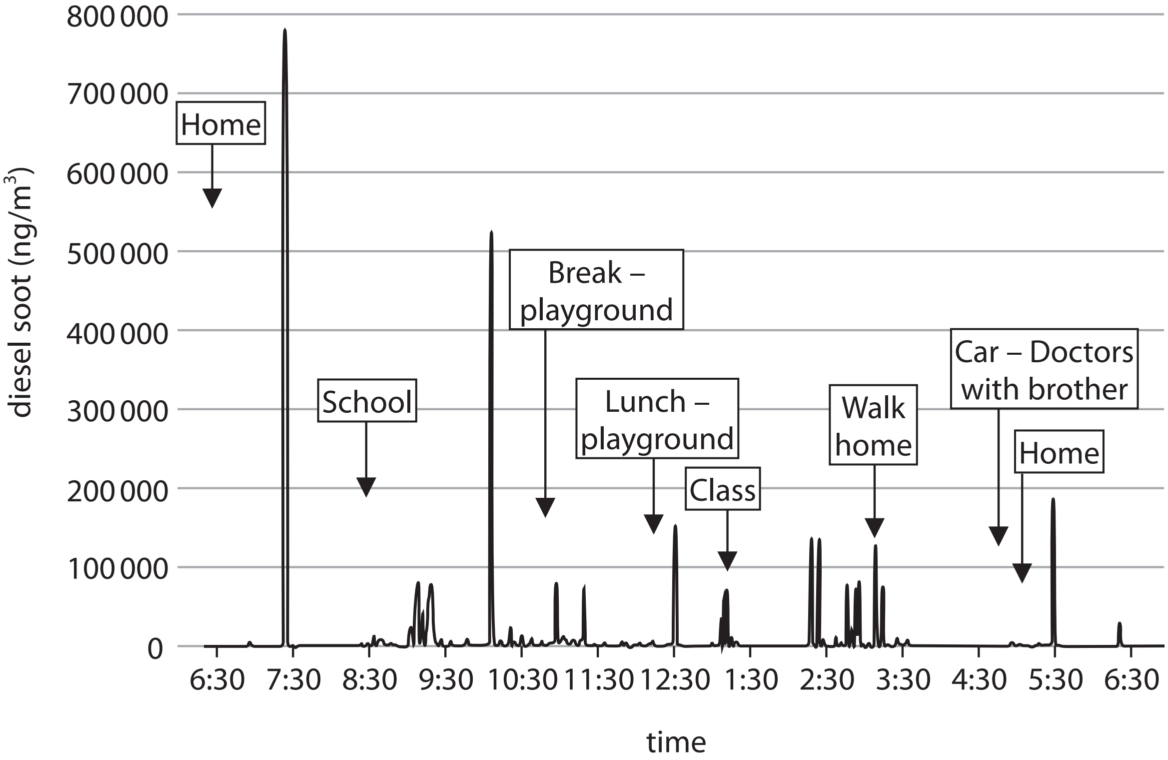


**Figure 1**

Diesel soot levels exposed to children in London on a typical school day.

**Health effects of diesel emissions on children**

Few epidemiological studies address the effects of diesel emissions alone. However, it is reasonable to extrapolate from studies that have assessed exposure to either PM or $NO_X$ since (a) diesel PM is not less toxic than other types of PM and (b) the adverse effects of gases such as $NO_X$ are independent of source. One way of estimating the health burden from diesel emissions alone is to use source data. For example, in London where most taxis, buses, heavy goods vehicles and vans are powered by diesel (**Table 2**), 48% of $NO_X$ and 54% of $PM_{10}$ is from road transport [19, 23]. These vehicles, along with diesel cars, are responsible for 34% of total $PM_{10}$ and 38% of total $NO_X$ emissions [23].







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**Table 2**

Fuel sources of vehicles in London, 2015 (adapted from Lethal and Illegal, Solving London's Air Pollution Crisis by Institute for Public Policy Research, September 2016)

| Vehicles | Petrol (%) | Diesel (%) | Other (%) |
|---|---|---|---|
| Buses | 0 | 89 | 11 |
| Taxis | 0 | 100 | 0 |
| Private vehicles | 42 | 57 | 1 |
| Light goods vehicles | 2 | 97 | 1 |
| Heavy goods vehicles | 0 | 100 | 0 |

**Antenatal exposure**

When considering effects measured in later childhood, it is difficult to separate the effect of maternal exposure to air pollution from postnatal effects—since there is a strong correlation between exposure to traffic-derived air pollutants (TRAPs) of pregnant women and their children. But independent associations between antenatal exposure to $NO_2$ and reduced forced expiratory reserve volume ($FEV_1$) later in childhood are reported. By contrast, effects on the fetus or on the newborn infant must be due to maternal exposure. These epidemiological studies report that maternal exposure to TRAP has adverse effects on the fetus leading to increased infant mortality, reduced fetal growth, low birth weight at term and premature birth [25, 26]. It is likely that these antenatal effects, coupled with postnatal pollution exposures increase susceptibility to common respiratory conditions such as wheeze, bronchiolitis and asthma [28–30].

**Childhood exposure**

Air pollutants, particularly $NO_X$ (reflecting exposure to both $NO_X$ and PM), are associated with reduced lung function in children—for both forced vital capacity (FVC) and $FEV_1$ [5]. Both FVC and $FEV_1$ are measures of lung function. Urman et al [5] showed that an increase in $NO_X$ exposure was associated with a decrease in both FVC and $FEV_1$, and similar findings were seen in children with or without asthma. Residing in areas with high concentrations of PM and $NO_2$ can also lead to suppression of lung function growth in school children [4, 31]. This reduction can potentially be halted and reversed with better air quality. For example, Gauderman et al [32] showed that reducing the levels of $NO_2$, $PM_{10}$ and $PM_{2.5}$ were associated with improvements in $FEV_1$ and FVC growth in adolescents. Children with existing chronic illnesses, particularly respiratory conditions, are most vulnerable. Air pollution can predispose individuals to new-onset asthma; preschool children are more prone to new-onset of wheeze. A meta-analysis (an examination of many studies) concluded that exposure to $NO_2$ is linked to new-onset asthma, while exposure to PM is linked to new-onset wheeze [33]. An effect of diesel PM on reactivity to inhaled allergens is supported by the association between long-term traffic pollution exposure and allergies [34–36]. Asthma exacerbations are also closely associated with short-term variations in $PM_{2.5}$ [37]. Although increasing inhaled corticosteroids (asthma inhalers that reduce inflammation and help prevent an attack) prior to high pollution days may seem logical [38], it is unclear whether this strategy is effective.

There is emerging evidence that air pollution impacts on children's neurological systems and development. For example, associations between exposure to air pollutants and reduced IQ and neurocognitive ability such as working memory, autism and reduced brain-derived neurotrophic factor are widely reported [39–41]. In particular, Basagaña et al [39] reported that traffic-related $PM_{2.5}$ was more strongly associated with reduction in cognitive function compared with fine particulates from other sources such as mineral, heavy oil combustion or road dust. In addition, exposure to high levels of traffic-induced pollutants may delay maturation of the brain [42]. An additional emerging link is between air pollution and the endocrine system. For example, Thiering et al [43] reported an association between insulin resistance and either $NO_2$ or PM exposure in healthy children.

**Implications for adult life**

It is increasingly recognised that impaired fetal wellbeing is a substrate for adult-onset cardiovascular disease such as atherosclerosis [44]. Prolonged exposure to air pollutants may increase mean pulmonary arterial pressure and diastolic blood pressure [45, 46], predisposing to cardiovascular events and premature death in adulthood. The effect on cognition lingers onto adulthood, where associations with dementia and Parkinson's disease have been found [47, 48].

Although the epidemiological evidence for the health effect of fossil fuel-derived pollution is very strong, there are important confounders (other factors) that must be considered. For example, in England, increased exposure to mean annual $NO_2$ concentrations is higher in areas of increased social deprivation and reduced access to healthcare [49]. Furthermore, children from more deprived areas are also more likely to be exposed to other sources of pollution such as second-hand cigarette smoking [50].

**Mechanisms**

Many of the mechanisms underlying the robust epidemiological associations between air pollution and health across the lifetime remain to be defined. Effects on organs distant from the lungs are likely to be aided by substances released into the systemic blood circulation and organs [51]. A key type of cell for releasing these substances is alveolar macrophage (AM) since phagocytosis of PM by AM stimulates release of cytokines (cell signalling molecules) [52, 53]. PM that reaches the most distant airways is phagocytosed by airway macrophages [54, 55]. Indeed, Kulkarni et al [56] reported that in healthy children, the amount of carbon in AM is inversely associated with lung function. Phagocytosis of inhaled diesel PM by AM is also essential for normal removal of PM from the lungs, which minimises exposure of other airway cells. Conditions that impair AM phagocytosis will increase the proportion of PM impacting on and penetrating airway epithelial cells, further worsening inflammation [57–59].

**What can we do about diesel pollution?**

**National level**

In London, air pollution is mostly caused by road traffic, of which diesel vehicles are a major contributor, as discussed above. With an estimated 9400 premature deaths attributable to air pollution, it has the second biggest impact on public health [19]. These highly polluting vehicles should therefore be phased out to comply with legal limits of pollutants—and cleaner alternatives encouraged. Tougher national regulations on traffic emissions such as the expansion of Ultra Low Emission Zones and scrappage schemes for older generations of diesel vehicles should be considered. Indeed, the 2016 report from the Institute for Public Policy Research [23] estimated that phasing out diesel-powered vehicles in London would lead to large reductions in $NO_X$ and $NO_2$ levels, ultimately lowering $NO_2$ levels to comply with EU standards. This report estimated that with a 45% reduction in $NO_X$ and 56% reduction in $NO_2$, 1.4 million life-years would be gained along with a financial benefit of up to £800 million.

Planting trees can reduce air pollution by acting as a physical barrier to intercept PM and absorbing gaseous pollutants such as $O_3$ [62], although the effect on pollution concentrations at schools is, to date, unclear. However, the amount of pollutants removed by these organic barriers will be proportional to the extent of plantation. Therefore, vast tall hedges around nurseries and schools should be encouraged, but this does not provide protection against pollution exposure during travel to and from schools.

**Individual level**

Various measures such as walking along less busy roads, cycling, use of public transport and carpooling may reduce exposure to air pollution [63], but the evidence base for whether this is achievable over the long term, and is sufficient to improve health, is limited. The Department for Environment, Food and Rural Affairs website provides information and forecast on UK air quality, while the British Lung Foundation provides information on various measures to take according to air pollution levels. These include avoiding spending time near busy roads, reducing strenuous activities outdoors, avoiding rush hours and using an inhaler to prevent triggering asthma.

Air cleaning systems are available commercially claiming to reduce indoor pollution—these can either remove particles and gaseous pollutants or have ultraviolet light technology to destroy indoor pollutants [64]. All have their limitations, for example large particles tend to settle before reaching filters, while gaseous pollutant filters may have short lifespans [64]. These systems also use electricity—which may not be from sustainable sources. Improvement in our air quality will benefit the whole population with lasting health and economic advantages. We should aim to build cities that promote and improve the health of the population.

In conclusion, in the UK, the phasing out of the current diesel car, van and taxi fleet, and replacing this fleet with greener alternatives must be central to the exposure-reduction strategy. Changes that would support such an initiative are:

- more active travel supported by better public transport infrastructure
- providing electric charging points on residential streets
- providing clinicians with the tools to discuss personal exposure reduction strategies with their patients.

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*This article has been edited and some references have been removed from the list.*

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