NICE National Institute for Health and Care Excellence

Public Health England

NICE guideline

Air pollution: outdoor air quality and health

NICE guideline

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Your responsibility

The recommendations in this guideline represent the view of NICE, arrived at after careful consideration of the evidence available. When exercising their judgement, professionals and practitioners are expected to take this guideline fully into account, alongside the individual needs, preferences and values of their patients or the people using their service. It is not mandatory to apply the recommendations, and the guideline does not override the responsibility to make decisions appropriate to the circumstances of the individual, in consultation with them and their families and carers or guardian.

Local commissioners and providers of healthcare have a responsibility to enable the guideline to be applied when individual professionals and people using services wish to use it. They should do so in the context of local and national priorities for funding and developing services, and in light of their duties to have due regard to the need to eliminate unlawful discrimination, to advance equality of opportunity and to reduce health inequalities. Nothing in this guideline should be interpreted in a way that would be inconsistent with complying with those duties.

Commissioners and providers have a responsibility to promote an environmentally sustainable health and care system and should assess and reduce the environmental impact of implementing NICE recommendations wherever possible.

Contents

This guideline is the basis of QS181.

Overview

This guideline covers road-traffic-related air pollution and its links to ill health. It aims to improve air quality and so prevent a range of health conditions and deaths.

Who is it for?

- Local authority staff working in: planning, local air quality management and public health, including environmental health
- Staff working in transport and highways authorities
- Local government elected members
- Employers
- Healthcare professionals, people working in the voluntary sector, non-governmental organisations and education
- Members of the public

NICE worked with Public Health England to develop this guidance.

Recommendations

Making decisions using NICE guidelines explains how we use words to show the strength (or certainty) of our recommendations, and has information about prescribing medicines (including off-label use), professional guidelines, standards and laws (including on consent and mental capacity), and safeguarding.

1.1 Planning

1.1.1 Include air pollution in 'plan making' by all tiers of local government, in line with the Department for Communities and Local Government's National Planning Policy Framework. This includes county, district and unitary authorities, as well as regional bodies and transport authorities. The Local Plan and other strategic planning processes (such as the core strategy, local transport plan, environment and health and wellbeing strategies) should include zero- and low-emission travel, for example cycling and walking (see section 1.6 and NICE's guideline on physical activity: walking and cycling). Other strategies for zero- and low-emission travel could include:

- Providing charge points for electric vehicles in workplaces, commercial developments and residential areas.
- Supporting car sharing schemes or car clubs.

1.1.2 When 'plan making' consider:

- siting and designing new buildings, facilities and estates to reduce the need for motorised travel
- minimising the exposure of vulnerable groups to air pollution by not siting buildings (such as schools, nurseries and care homes) in areas where pollution levels will be high
- siting living accommodation away from roadsides
- avoiding the creation of street and building configurations (such as deep street canyons) that encourage pollution to build up where people spend time

- including landscape features such as trees and vegetation in open spaces or as 'green' walls or roofs where this does not restrict ventilation
- including information in the plan about how structures such as buildings and other physical barriers will affect the distribution of air pollutants.

1.1.3 If the local plan does not address air pollution, consider developing local guidance (such as supplementary planning documents, see the Department for Communities and Local Government information on local plans) on how to design buildings and spaces to improve local air quality until the local plan is amended.

See how the committee made recommendations 1.1.1 to 1.1.3.

1.2 Development management

1.2.1 Consider ways to mitigate road-traffic-related air pollution. This could include:

- Taking action to reduce the number of motorised trips. For instance, by:
  - incorporating air quality outcomes in travel plans
  - developing local parking plans
  - supporting car clubs
  - supporting active travel (see NICE's guideline on physical activity: walking and cycling).
- Supporting the use of zero- and low-emission vehicles for instance, by providing charging facilities for electric vehicles.
- Managing street trees and vegetation to reduce the risk of restricting street ventilation, where this may contribute to poor air quality (for instance, by the choice of species, siting and pruning regimes).

1.2.2 In consultation with local communities, consider including air quality monitoring and measures to reduce road-traffic-related emissions in the Regulation 123 list of funding options for using the Community Infrastructure Levy (see the Planning Portal information on the Community Infrastructure Levy).

See how the committee made recommendations 1.2.1 and 1.2.2.

1.3 Clean air zones

1.3.1 Consider introducing a clean air zone that:

- includes restrictions or charges on certain classes of vehicle
- supports zero- and low-emission travel (including active travel)
- includes targets to progressively reduce pollutant levels below EU limits and aim to meet World Health Organization air quality guidelines
- aims to reduce exposure to air pollution across the whole zone rather than focusing on air pollution hotspots.

1.3.2 Identify which classes of vehicles to restrict or charge in a clean air zone (see recommendation 1.3.1) based on an understanding of local conditions (such as local sources of road-traffic-related pollution and factors influencing dispersion). Use nationally recognised vehicle types (such as the Euro classification for diesel and petrol vehicles).

1.3.3 Work across local authority boundaries to address regional air pollution and prevent migration of traffic and emissions to other communities, resulting in areas of poor air quality.

1.3.4 Consider support for zero- and low-emission travel. This could include:

- Encouraging walking and cycling (see NICE's guideline on physical activity: walking and cycling).
- Encouraging uptake of zero- and low-emission vehicles, for instance:
  - Providing electric charging points.
  - Encouraging public and private sector organisations to use zero- or low-emission vehicles for deliveries to retail, office, residential or other sites in the zone, particularly for the last mile of deliveries in city centres.
- Developing integrated public transport networks (including park and ride schemes) based on low-emission vehicles.

1.3.5 Consider taking action to reduce emissions within the clean air zone. For instance:

- Introducing fuel-efficient driving initiatives including:
  - Bylaws and other action to support 'no vehicle idling' areas, particularly where vulnerable groups congregate (such as outside schools, hospitals and care homes) and in areas where exposure to road-traffic-related air pollution is high.
  - Driver training to reduce emissions (see section 1.4).
  - Actions to smooth traffic flow (see section 1.5).
- Action to minimise congestion caused by delivery schedules.
- Using a fleet recognition scheme (such schemes help fleet operators improve efficiency by reducing fuel consumption and emissions: the system recognises operators who meet best operational standards).
- Addressing emissions from public sector transport activities (see section 1.4).
- Specifying emission standards for private hire and other licensed vehicles.

1.3.6 Where traffic congestion is contributing to poor air quality, consider incorporating a congestion charging zone within the clean air zone.

1.3.7 Consider monitoring outside the zone to identify whether its implementation is causing problems in terms of traffic composition and flow. If so, address any issues identified. For instance, by changing the boundaries to address increased pollution at the margins of the zone or problems caused by diversion of traffic.

1.3.8 Assess the impact of any proposed charges (including exemptions for zero- and low-emission vehicles) on vulnerable groups.

See how the committee made recommendations 1.3.1 to 1.3.8.

1.4 Reducing emissions from public sector transport services and vehicle fleets

Driver training

1.4.1 Consider introducing fuel-efficient driving as part of any test carried out when appointing or re-appraising staff who drive as part of their work.

1.4.2 Consider training staff drivers to reduce their vehicle emissions. This could include:

- reducing rapid accelerations and decelerations, and correct gear selection to improve fuel consumption
- switching off engines, if practical and safe, when parked by the roadside and when dropping off people or deliveries
- vehicle maintenance, including pumping up tyres to the recommended pressure
- emphasising that lower vehicle emissions will reduce both fuel costs and air pollution.

1.4.3 Consider using:

- 'in-vehicle' elements, for instance to ensure vehicles display real-time information about current fuel efficiency, appropriate gear selection and speed
- telematics technology to provide next-day information about driving style.

1.4.4 Consider monitoring fuel efficiency and providing feedback to drivers after training. This could include providing support from colleagues or 'buddies' to improve their driving style and rewards for those who drive efficiently (see NICE's guideline on behaviour change: individual approaches).

1.4.5 Consider monitoring the fleet's fuel consumption and evaluating the local effect on air pollutant emissions to demonstrate the benefits of training on fuel use and air quality.

Procuring public sector vehicles

1.4.6 Consider making low vehicle emissions (nitrogen oxides and particles) one of

the criteria when making routine procurement decisions. This could include selecting low-emission vehicles, including electric vehicles.

See how the committee made recommendations 1.4.1 to 1.4.6.

1.5 Smooth driving and speed reduction

1.5.1 Consider promoting a smooth driving style by using:

- speed limits and average speed technology on the roadside
- real-time information to tell drivers what the current optimum driving speed is
- 20 mph limits without physical measures to reduce speeds in urban areas where average speeds are already low (below around 24 mph) to avoid unnecessary accelerations and decelerations
- signs that display a driver's current speed to reduce unnecessary accelerations.

See also recommendations 1.4.1 and 1.4.2.

1.5.2 Where physical speed reduction measures are used to reduce road danger and injuries (20 mph zones – see NICE's guideline on unintentional injuries on the road), consider using them to encourage drivers to maintain a reduced, steady pace along the whole stretch of road, rather than road humps that may increase acceleration- and braking-related emissions.

See how the committee made recommendations 1.5.1 to 1.5.2.

1.6 Walking and cycling

1.6.1 Provide support for active travel (see NICE's guidelines on physical activity: walking and cycling and physical activity and the environment).

1.6.2 Provide a choice of cycle routes, including routes that avoid highly polluted roads. Ideally use quiet streets or segregated routes.

1.6.3 Where busy roads are used consider:

- Providing as much space as possible between the cyclist and motorised vehicles.

- Using dense foliage to screen cyclists from motor vehicles, without stopping air pollution from dispersing or reducing the visibility or safety of cyclists near junctions. Also take into account concerns about personal safety.
- Reducing the time cyclists spend at highly polluted sites, including some junctions, where this can be done without increasing the time that other groups spend exposed to poor air quality.

See how the committee made recommendations 1.6.1 to 1.6.3.

1.7 Awareness raising

1.7.1 Base actions to raise awareness of road-traffic-related air pollution (and so change people's behaviour) on NICE's:

- guideline on behaviour change (general approaches)
- guideline on behaviour change (individual approaches)
- guideline on community engagement (in particular the section on a local approach to making community engagement an integral part of health and wellbeing initiatives).

1.7.2 Ensure healthcare professionals are aware that information on air quality is available, what it means for patients and what actions are recommended.

1.7.3 Consider providing information on air quality (using the Department for Environment, Food and Rural Affairs' Daily Air Quality Index) with weather forecasts and the pollen index. This could be provided through local, national and social media.

1.7.4 Consider providing information on:

- How health is affected by exposure to air pollutants in the long term as well as during specific periods of poor air quality.
- The impact of local pollution on air quality inside, as well as outside, a vehicle (levels of pollution are not always lower inside).

- How to reduce air pollutants and people's exposure, including the need to:
  - Reduce the number of motor vehicle journeys, if possible.
  - Drive in a style that minimises emissions by: avoiding rapid accelerations and decelerations, restricting the time spent with an engine 'idling' and ensuring the vehicle is correctly maintained (see the Energy Saving Trust's driving advice).
- Change routes to avoid highly polluted areas and adding to traffic congestion.

1.7.5 Consider public awareness initiatives such as car-free days or National Clean Air Day to raise awareness of air pollution.

1.7.6 Consider giving businesses information on how they can reduce road-traffic-related air pollution and improve fuel efficiency. For example, they could:

- help their drivers develop an energy-efficient driving style (see section 1.4)
- schedule deliveries to minimise congestion
- encourage employees to cycle to work (see NICE's guideline on physical activity: walking and cycling).

Vulnerable groups

1.7.7 Healthcare professionals should be aware of vulnerable groups who are particularly affected by poor outdoor air quality. When notified of poor outdoor air quality, during any contact with vulnerable groups healthcare professionals should give general advice on how to avoid contributing to levels of air pollution and raise awareness of how to minimise exposure. This could include advice to:

- Avoid or reduce strenuous activity outside, especially in highly polluted locations such as busy streets, and particularly if experiencing symptoms such as sore eyes, a cough or sore throat.
- Use an asthma reliever inhaler more often, as necessary.

- Close external doors and windows facing a busy street at times when traffic is heavy or congested to help stop highly polluted air getting in.

  (See also the Department for Environment, Food and Rural Affairs' information about the Daily Air Quality Index.)

See how the committee made recommendations 1.7.1 to 1.7.7.

Terms used in this guideline

This section defines terms that have been used in a specific way for this guideline. For general definitions, please see the glossary.

Electric vehicles

Any vehicle that uses 1 or more electric motors for propulsion. It includes electric bikes and electrically assisted pedal cycles (see the Highway Code information on Electric bikes: licensing, tax and insurance).

Smooth driving

Driving in a way that assesses the road ahead to avoid unnecessary braking and acceleration, which increase the amount of fuel used and emissions.

Street canyons

Streets flanked by buildings on both sides. They can be categorised using the ratio of the height of the buildings to the width of the road, with a deep canyon having taller buildings relative to the width. The geometry of the canyon and its orientation to the prevailing wind influence the flow of air. This can lead to the formation of vortices and the recirculation of air that trap pollutants emitted within the canyon. It can also restrict dispersion, potentially leading to areas of high air pollution.

Vulnerable groups

Children, older people and people with chronic health problems are among the most vulnerable to air pollution. Short-term (for example day-to-day) peaks of elevated air pollution are linked with increased hospital admissions for people with respiratory and cardiovascular conditions. The Royal College of Physician's report on air pollution (Every breath we take: the lifelong impact of air

pollution) noted that it can affect the growth of an unborn baby and may be linked to premature birth.

Putting this guideline into practice

NICE has produced tools and resources to help you put this guideline into practice.

Changes should be implemented as soon as possible, unless there is a good reason for not doing so (for example, if it would be better value for money if a package of recommendations were all implemented at once).

Different organisations may need different approaches to implementation, depending on their size and function. Sometimes individual practitioners may be able to respond to recommendations to improve their practice more quickly than large organisations.

Here are some pointers to help organisations put NICE guidelines into practice:

1. **Raise awareness** through routine communication channels, such as email or newsletters, regular meetings, internal staff briefings and other communications with all relevant partner organisations. Identify things staff can include in their own practice straight away.

2. **Identify a lead** with an interest in the topic to champion the guideline and motivate others to support its use and make service changes, and to find out any significant issues locally.

3. **Carry out a baseline assessment** against the recommendations to find out whether there are gaps in current service provision.

4. **Think about what data you need to measure improvement** and plan how you will collect it. You may want to work with other health and social care organisations and specialist groups to compare current practice with the recommendations. This may also help identify local issues that will slow or prevent implementation.

5. **Develop an action plan**, with the steps needed to put the guideline into practice, and make sure it is ready as soon as possible. Big, complex changes may take longer to implement, but some may be quick and easy to do. An action plan will help in both cases.

6. **For very big changes** include milestones and a business case, which will set out additional costs, savings and possible areas for disinvestment. A small project group could develop the action plan. The group might include the guideline champion, a senior organisational sponsor, staff involved in the associated services, finance and information professionals.

7. **Implement the action plan** with oversight from the lead and the project group. Big projects may also need project management support.

8. **Review and monitor** how well the guideline is being implemented through the project group. Share progress with those involved in making improvements, as well as relevant boards and local partners.

NICE provides a comprehensive programme of support and resources to maximise uptake and use of evidence and guidance. See our into practice pages for more information.

Also see Leng G, Moore V, Abraham S, editors (2014) Achieving high quality care – practical experience from NICE. Chichester: Wiley.

Context

The major human sources of air pollution are the combustion of fuels for heat, electricity and transport. Road transport accounts for 31% of nitrogen oxides (NO_x), 19.5% of $PM_{2.5}$ and 18% of PM_{10}[1] UK emissions. It frequently accounts for more than 64% of air pollution at urban monitoring sites (Road traffic's contribution to air quality in European cities European Topic Centre on Air Pollution and Climate Change Mitigation). This comes from exhausts and other sources such as the wear of tyres, brakes and the road.

Non-exhaust sources account for around 21% of $PM_{2.5}$ from vehicles. As exhaust emissions are reduced, the relative contribution from other sources becomes more significant.

In 2008, the effect of human-produced (anthropogenic) particulate air pollution on mortality in the UK was estimated as equivalent to nearly 29,000 deaths at typical ages, and an associated loss of total life of 340,000 life years (COMEAP: mortality effects of long-term exposure to particulate air pollution in the United Kingdom Public Health England).

In 2010 the total mortality burden of anthropogenic $PM_{2.5}$ in London was 52,630 life years lost and of long-term exposure to NO_2 was up to 88,113 life years lost (Understanding the health impacts of air pollution in London King's College London). This figure assumes the World Health Organization value of up to a 30% overlap between the effects of $PM_{2.5}$ and NO_2. The authors note that the figure for NO_2 is much less certain than that for $PM_{2.5}$.

The health impact of $PM_{2.5}$ pollution from human activities in the UK is estimated to cost between £8.5 billion and £18.6 billion a year (Ambient air quality UK Parliament).

Over recent decades air pollutant emissions have reduced. But in 2013, UK levels of nitrogen dioxide (NO_2) exceeded the EU directive limit in 38 of 43 geographical zones[2] (Directive 2008/50/EC European Commission).

The way air pollution is distributed is not straightforward. Pollutant concentrations vary:

- The most deprived areas tend to have higher concentrations of NO_2 and PM_{10}.
- Regardless of socioeconomic status, urban areas tend to have higher pollutant levels than rural areas, which often have larger populations in the mid-range of deprivation.

The national trend shows high average concentrations in both the most and least deprived areas, and lower concentrations in the (predominantly rural) mid-decile areas.

Children (14 and under) and older people (65 and older) are more susceptible to the effects of air pollution (Air quality and social deprivation in the UK: an environmental inequalities analysis Department of Environment, Food and Rural Affairs).

Addressing air pollution by encouraging people to walk and cycle rather than drive, can help people to become fitter and healthier. Changing the way we travel can also help reduce emissions of greenhouse gases that contribute to climate change. Climate change is linked to increased risk of extreme weather and other events that have an adverse effect on health, such as floods, heatwaves and the spread of some infectious diseases (Climate change 2013: the physical science basis Intergovernmental Panel on Climate Change Working Group I).

More information

You can also see this guideline in the NICE pathway on air pollution.

To find out what NICE has said on topics related to this guideline, see our web page on behaviour change, environment and transport, and on cardiovascular and respiratory conditions.

See also the evidence reviews and information about how the guideline was developed, including details of the committee.

[1] Particulate matter is produced by, among other things, combustion of fossil fuels or abrasion of tyres and brakes. Particles are classified by size, described using the abbreviation PM with a suffix (commonly 2.5 or 10) that gives the maximum particle size in micrometres. The mass concentration of particles is usually expressed in micrograms per m^3 of air.

[2] The UK is divided into 43 zones for assessing air quality and reporting compliance with EU targets. These zones generally include more than 1 local authority (Air quality plan for the achievement of EU air quality limit values for nitrogen dioxide (NO_2) in the UK, 2015 Department for Environment, Food and Rural Affairs.)

The committee's discussion

Evidence statement numbers are given in square brackets. See 'The evidence' at the end of each section for details.

Overview

The committee discussions below relate to all the recommendations.

Key pollutants

Various air pollutants are related to road transport including carbon monoxide, benzene and volatile organic compounds (VOC). This guideline focuses on particulate matter and NO_2 because these have the greatest impact on health at levels currently seen in the UK. The committee heard evidence that both long- and short-term exposure to air pollution adversely affects health and that fine particles and NO_2 are both important contributors [EP1].

Members noted that various metrics are used for particulate pollution including size (such as $PM_{2.5}$, PM_{10} and ultra-fine particles), particle numbers and particle composition (such as black carbon and elemental carbon). They also noted a possible causal relationship between road-traffic-related air pollution and negative health outcomes, and that black carbon is an indicator for such pollution.

Short-term exposure (over hours or days) to elevated levels of air pollution can lead to:

- effects on lung function
- exacerbation of conditions such as asthma
- increases in hospital admissions and mortality.

Epidemiological studies have shown that long-term exposure (over several years) reduces life-expectancy, mainly because of increased risk of mortality from cardiovascular and respiratory causes and from lung cancer [EP1].

The committee agreed that studies of interventions related to air pollutants are important but often carried out by disciplines other than public health and focus on environmental or road-traffic-related effects rather than health outcomes.

The committee agreed that measures of particles and nitrogen oxides (NO_x) were a key indicator of road-traffic-related air pollution so members focused on these as a proxy for health outcomes. The connection between fuel efficiency and emission of air pollutants is well known, so proxy measures such as fuel efficiency are also useful if other metrics are not available.

Limits, guidelines and indicator values

Maximum levels of outdoor air pollutants that affect health, such as particles (PM_{10} and $PM_{2.5}$) and NO_2, are set out in the 2008 Ambient Air Quality Directive (2008/50/EC) [EP2]. This was made law in England through the Air Quality Standards Regulations 2010, which sets targets and mandatory limits for levels of outdoor air pollutants. Equivalent regulations exist in Scotland, Wales and Northern Ireland.

There is also a public health outcomes framework indicator on air pollution. The June 2017 indicator is:

- 'fraction of all-cause adult mortality attributable to anthropogenic particulate air pollution (measured as fine particulate matter, $PM_{2.5}$)'.

In addition, the committee was aware of guideline values, including for $PM_{2.5}$, PM_{10} and NO_2, in the World Health Organization's Ambient (outdoor) air quality and health.

Members noted that there is little evidence to suggest a threshold below which no adverse health effects would be anticipated. So reducing pollution below the EU limits will provide even more health benefits.

Additional impacts

The committee agreed that interventions to address air pollution are also likely to help reduce climate change from emissions of CO_2. Interventions that support a shift to active transport, like walking or cycling, will also lead to potentially substantial health benefits, mainly associated with increased physical activity levels.

The committee noted that a number of recommendations, principally those on planning, might have other impacts on health as a result of changes to, and use of, the built and natural environment. For instance, physical changes (such as changes that alter temperature or provide shade) might help prevent both overexposure to heat and skin cancer.

In addition, changes in the way the environment is viewed and used could mean more people

socialise in that environment. Planning changes can also influence economic activity (and so, in turn, the health) of an area. But these issues were out of scope of the current guideline.

The committee noted that it was important to link information about air pollution to other health advice, such as the benefits of physical activity and the importance of social contact (see NICE's guideline on older people: independence and mental wellbeing).

Multiple interventions

Generally, the evidence gathered for this guideline examined single interventions. The committee felt that single, small scale actions were unlikely to lead to the significant reduction in air pollution needed to protect health. Although there was no evidence to demonstrate the effect, members agreed that multiple interventions, each producing a small benefit, would be likely to act cumulatively to produce significant change.

Monitoring

The committee agreed that although evidence suggests an intervention may produce a particular effect, local factors such as the type of vehicles involved, topography and weather conditions can all have an impact. It also agreed with evidence that air quality monitoring will be an important part of most large-scale changes – before and after implementation [EP2]. The committee noted that traffic data for most roads is currently ad-hoc and of low quality. Measurements of traffic will provide the high quality information needed for planning changes.

The committee noted that there was a risk that intended changes would erode over time as drivers became used to the change and readjust their behaviours. Continual monitoring of the effect of schemes and adjustments to them will probably be needed to ensure that positive, progressive effects are achieved.

Euro standards

A recognised approach to tackling air pollution has been to develop plans and initiatives to encourage cleaner vehicles and to work with transport authorities to discourage high polluting vehicles from entering certain geographical areas. This is based on the assumption that newer vehicles will produce lower emissions.

The committee heard that tail-pipe emissions from vehicles are regulated under a series of European Directives (commonly referred to as Euro standards) for all types of vehicles [EP3]. The standards currently extend from Euro 1 to Euro 6 for cars and vans, and from Euro I to Euro VI for

heavy goods vehicles (HGVs), buses and coaches.

The Euro standards have introduced progressively tighter emission limits for various air pollutants, but they have not led to a corresponding reduction in concentrations of NO_2. The committee heard that this is because of a difference in emissions during test procedures compared with 'real world' driving, combined with an increase in the number of diesel vehicles on the road.

The committee heard that the latest Euro standard (6/VI) requires manufacturers to adhere to tighter standards of emissions. Although NO_x emissions from Euro 6/VI diesel vehicles in normal use may be higher than the standard might suggest, they will be substantially lower than Euro 5/V vehicles. From September 2017, emissions tests for cars will include on-road tests as opposed to the laboratory tests that have been used to date. This is already a requirement for heavy duty vehicles.

Equality issues

The committee heard that children, older people and those with chronic health problems are among the most vulnerable to air pollution [EP1]. In addition, more deprived urban neighbourhoods often experience higher levels than more affluent areas. So any reduction in air pollution is likely to help tackle health inequalities. But at the same time, these vulnerable groups are less likely to be able to afford a new vehicle with low emissions and could be disadvantaged by any changes to restrict older, more polluting vehicles.

Overall, the committee agreed that removing older vehicles from the road would reduce health inequalities, provided these groups could get to the places and services they need.

Cost effectiveness

The economic modelling was based on assessments of specific interventions that had demonstrated effectiveness. It suggests those interventions could be highly cost effective in some settings. But both the effect and cost of any intervention will be highly dependent on factors specific to the local setting, so this may vary considerably from the case studies. A key limitation is that there were no data on pollution dispersal in relation to population for any of the case studies modelled.

Some identified benefits could not be quantified, suggesting that the overall benefits might be greater than the figure given. So the committee concluded that interventions could offer good value for money.

The evidence

The committee looked at evidence in:

- Expert testimony on key issues in the epidemiology of air pollution and health: Expert paper 1 (EP1).
- Expert testimony on national and local frameworks for action: Expert paper 2 (EP2).
- Expert testimony on the use of Euro Standards to control vehicle emissions: Expert paper 3 (EP3).

Planning

The discussion below explains how the committee made recommendations 1.1.1 to 1.1.3.

Rationale and impact

Why the committee made the recommendations

1.1.1

Some evidence suggests that strategic plans can have an important influence on air pollution. Based on the epidemiological evidence on the health impacts of air pollution, particularly for vulnerable groups, and committee consensus, the committee recommended several approaches. This includes action to encourage a move to zero- and low-emission travel (including active travel) by linking to the existing NICE guideline on walking and cycling.

1.1.2

Some expert testimony, supported by the committee's own expertise, suggests that the layout of new developments will affect motorised travel.

The committee agreed that it is important to take account of how air pollution disperses and where people spend time because these factors will influence their exposure.

Some evidence showed that street trees and green walls or roofs have a mixed effect on street air quality – in some cases they restrict street ventilation causing poorer air quality, in others, they improve it.

Because the evidence was uncertain, the committee recommended this as an action to consider.

1.1.3

The committee agreed by consensus that if air pollution is not included in the current local plan, other local policies should be developed until it is updated. Because the evidence was uncertain they recommended this as an action to consider.

Why we need recommendations on this topic

Our built environment can affect the emission of road-traffic-related air pollutants by influencing how, and how much, we travel. It can also affect the way air pollutants are dispersed (through street design and the resulting impact on air flow). Some areas experience poor air quality from motor vehicles passing through (rather than travel within) an area.

Air pollution issues are not always incorporated into local plans, making it difficult to reject a proposal that would have adverse effects.

Physical features (such as buildings, barriers, vegetation and landscape) influence the way air pollution moves and disperses and can sometimes create high pollution levels where people spend time. For instance, trees don't always reduce air pollution: it depends on the street design, species, number and siting of trees, canopy density, time of year and wind direction relative to the street.

Impact of the recommendations on practice

Only a limited amount of new building occurs at a time, but it will have an impact on road-traffic-related air pollution for decades. In addition, relatively small changes in the layout of buildings (such as the siting of air vents away from the roadside or small increases in distance from sources of pollution) might have an important impact on residents' exposure to air pollutants.

Addressing these and other issues at the planning stage may reduce the need for more expensive (and probably less effective) remedial action at a later date.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

The committee agreed that the most important outcomes are health outcomes (for instance, mortality or exacerbations of respiratory conditions). But these are not usually measured directly in studies of air pollution, which rely instead on examining air pollutants. The most important of

these are:

- ambient levels of particles, in particular $PM_{2.5}$
- ambient levels of NO_2.

Other outcomes relating to the need to travel and choice of vehicles are also likely to be relevant to planning interventions.

The quality of the evidence

The committee considered evidence on the impact of air pollution on health, particularly for vulnerable groups. This was from expert paper 1 but was based on the work of the Committee on the Medical Effects of Air Pollutants (COMEAP). Members also considered evidence on the impact of planning on air pollution. This was from expert paper 6 but was based on guidance produced by Environmental Protection UK and the Institute of Air Quality Management. Members agreed that both of these represented good quality evidence that could be used to support recommendations.

The committee considered the evidence of effectiveness of natural and artificial barriers in terms of impact on air pollutants.

- Five studies (4 from the USA, 1 from the UK) looked at barriers alongside major roads. All were rated as poor quality and so at high risk of bias [ES4.1a, ES4.1b].

Two of these studies examined solid noise barriers. They found that although barriers reduced air pollution in the immediate lee of the barrier, levels at some distance away were higher than without the barrier [ES4.1a].

The committee considered 3 modelling studies (2 from Belgium, 1 from the UK) that examined the impact of street trees and vegetation on air pollution [ES4.4]. One study was rated as moderate quality and 2 were rated as poor quality. They found that:

- Vegetation that does not interfere with air flow in a street canyon (such as green roofs or walls, or vegetation not situated within a street canyon) may reduce air pollution.
- Street trees were unlikely to reduce air pollution in most street designs and could worsen it in some cases.

The committee felt that the studies were plausible. No effectiveness studies were found.

Another 3 studies (1 from the UK, 1 from France, 1 from the US), rated as poor quality, agreed with what the committee knew about placing and maintaining trees but did not reduce the uncertainty in the evidence about their effects in any particular direction [ES4.4]. This further supports the need for additional research and the research recommendation developed by the committee.

Members agreed that specific factors in the individual settings were highly important in determining the outcome. However, they felt it was appropriate to recommend caution when using street trees and not to consider them as always being beneficial, because if they are poorly placed or maintained this may affect ventilation at street level and inadvertently create a canopy that traps air pollutants.

The committee agreed that the limited number of effectiveness studies (and the absence of corroboration of the findings of modelling studies around the effects of street trees) represented a gap in the available evidence base.

Benefits and harms of including air quality in plan making

Benefits include:

- New developments that do not exacerbate poor air quality or expose people to high levels of air pollution and that encourage zero- and low-emission travel (including active travel).
- Reduced risk of inadvertent exposure of people to poor air quality from the redistribution of pollution.
- Use of trees to encourage deposition of air pollutants, to reduce heat stress, provide shade and create a more attractive environment – all of which benefit health without inadvertently creating areas of poor air pollution.

Potential harms include:

- Using trees in areas where they do reduce ventilation.
- Using barriers in a way that creates poorer air quality (see also 'additional impacts' in the overview at the start of the committee discussion).

The evidence reviewed did not focus on the unintended consequence of interventions that may increase allergen levels.

Cost effectiveness and resource use

Taking air pollution issues into account at the plan making stage involves additional cost for training in relevant issues and could have an impact on public consultation. However, this is likely to be relatively small. There will be a cost impact for developers. This may extend beyond the initial site if changes to infrastructure are needed.

The committee did not recommend widespread use of green walls and roofs. The evidence from the reviews (based on modelling studies) suggests that these may improve air quality in some circumstances (where it does not reduce ventilation in the street). However, the committee felt that the very high resource impact for retrofitting green walls and roofs to existing buildings was not likely to be cost effective in terms of air pollution reduction alone. But they may be appropriate for new buildings.

Other factors the committee took into account

The committee agreed that urban trees and greenery play an important part in the urban landscape. They provide a number of positive benefits, including health benefits.

Leaves and branches slow air currents, causing pollutants to settle out. They may also act as 'sinks' for particles and chemicals that may have direct or indirect effects on air quality (in particular, VOCs). The extent to which this is the case depends on factors such as species, time of year and growing conditions.

The impact of trees on ventilation in a street canyon will influence their impact on air quality. Ventilation will vary according to the size, distribution and species of tree and their position within the canyon. For instance, air quality might deteriorate at street level near vehicle sources if ventilation were restricted, while improving near first floor windows above the canopy.

Although it is important to avoid the possible negative effects, it is also important to recognise the positive benefits of properly selected, sited and managed trees.

The committee discussed the dispersion of air pollutants by solid barriers. They agreed this is complex and depends on a range of local factors. There is some evidence to suggest that barriers may result in improved air quality near to the barrier but poorer air quality at a distance. As a result, air quality may be affected downwind from a roadside barrier. The impact on health will depend on the details of this dispersion and on where people live or spend time in relation to the barrier.

The committee noted that there was a concern that some local authorities might adopt the

recommendations but others may not. This could mean that developers focus on areas with fewer controls, resulting in a loss of investment for those aiming for better air quality. It noted that recommendations to all local authorities might lead to a more consistent approach, to the benefit of all. It also noted members' experience of the benefits of a good quality environment in attracting developers.

The evidence

The committee looked at evidence in:

- Evidence review 1 on environmental change and development planning: ES4.1a, ES4.1b, ES4.4.
- Expert testimony on key issues in the epidemiology of air pollution and health: Expert paper 1 (EP1).
- Expert testimony on the role of the local authority planning regime in delivering improvements to ambient air quality and in reducing public exposure to pollution: Expert paper 6 (EP6).

Development management

The discussion below explains how the committee made recommendations 1.2.1 to 1.2.2.

Rationale and impact

Why the committee made the recommendations

1.2.1

Evidence on actions to address road-traffic-related air pollution suggested that travel plans could offer an opportunity to re-evaluate journeys to work and help a more general move away from car travel. Committee members also noted from their experience that these plans could support zero- and low-emission travel and could be implemented as part of the planning approval process.

Evidence indicated that the species, siting and management of trees and vegetation is important in reducing the risk of adversely affecting air quality.

Because the evidence was uncertain the committee recommended this as an action to consider.

1.2.2

Based on their expertise, the committee agreed that it is appropriate to use funds from developers,

via the Community Infrastructure Levy, to pay for work to address air pollution issues. They also agreed that this is best carried out in consultation with local communities. Because the evidence was uncertain the committee recommended this as an action to consider.

Why we need recommendations on this topic

Local development plans do not always address traffic-related air pollution.

Impact of the recommendations on practice

If action to reduce traffic-related air pollution is incorporated in the development plans for new buildings and estates, this will help maintain people's health and wellbeing, both in terms of reducing pollution levels and encouraging physical activity. In turn, this may help reduce the need for NHS treatment and other support in the future.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

The committee agreed that the most important outcomes are health outcomes (for instance, mortality or exacerbations of respiratory conditions). But these are not usually measured directly in studies of air pollution, which rely instead on measuring air pollutant levels. The most important of these are:

- ambient levels of particles, in particular $PM_{2.5}$
- ambient levels of NO_2.

Other outcomes relating to the need to travel and choice of vehicles are also likely to be relevant.

The quality of the evidence

The committee considered evidence on the impact of air pollution on health, including for vulnerable groups. This was from expert paper 1 but was based on the work of the Committee on the Medical Effects of Air Pollutants (COMEAP). Members also considered evidence on the impact of planning on air pollution. This was from expert paper 6 but was based on guidance produced by Environmental Protection UK and the Institute of Air Quality Management. Members agreed that both of these represented good quality evidence that could be used to support recommendations.

Evidence relating to travel plans consisted of 2 poor-quality studies [ES9.1a]. Both were carried out in the UK so the evidence is directly applicable. Both looked at changes in mode of travel, rather than air pollutant emission or air quality data. They focused on travel plans in workplaces. The studies suggest that information on, and the provision of facilities to support, other travel modes could reduce the number of people driving to work alone.

The committee also considered a qualitative study from the UK on factors influencing the uptake of travel plans [ES9.1b]. The committee felt that this evidence was applicable to wider settings.

The committee considered the evidence of effectiveness of natural and artificial barriers (see the discussion of recommendations 1.1.1 and 1.1.2 above) and the management of trees and vegetation.

- Five studies (4 from the USA, 1 from the UK) looked at barriers alongside major roads. All were rated as poor quality and so at high risk of bias [ES4.1a, ES4.1b].

Members agreed that factors such as siting, pruning and species were important in determining the outcome [ES4.4]. So it was appropriate to recommend considering these factors to avoid creating a canopy that traps air pollutants, ensuring air pollution is reduced and ensuring we gain the other benefits from sensitive use of trees and vegetation.

Benefits and harms of including air pollution in development management

Benefits include:

- New developments that do not exacerbate poor air quality or expose people to high levels of air pollution and that encourage zero- and low-emission travel (including active travel).
- Reduced risk of inadvertent exposure of people to poor air quality from the redistribution of air pollutants.
- Use of trees to encourage deposition of air pollutants, reduce heat stress, provide shade and create a more attractive environment – all of which benefit health without inadvertently creating areas of poor air pollution.

Potential harms include:

- Using trees in areas where they do reduce ventilation.

- Using barriers in a way that creates poorer air quality (see also 'additional impacts' in the overview at the start of the committee discussion).

Cost effectiveness and resource use

Taking air pollution issues into account at the development management stage involves additional cost for training in relevant issues, assessment of planning applications and any additional impact on public consultation. However, this is likely to be relatively small. There will be a cost impact for developers. This may extend beyond the initial site if changes to infrastructure are needed.

Other factors the committee took into account

The committee agreed that urban trees and greenery play an important part in the urban landscape. They provide a number of positive benefits, including health benefits.

The committee agreed that local planning and transport officers, in consultation with air quality or pollution control officers, are best placed to ensure that trees and barriers are used effectively in urban areas.

The committee agreed that parking plans (including park and ride plans) are an important way to help reduce motorised trips and avoid the traffic congestion that can be caused when people are having to spend time searching for a parking space.

The evidence

The committee looked at evidence in:

- Evidence review 1 on environmental change and development planning: ES4.1a, ES4.1b, ES4.4.
- Evidence review 3 on travel planning and other initiatives providing information, advice, education and skill development: ES9.1a, ES9.1b, ES10.1.
- Expert testimony on key issues in the epidemiology of air pollution and health: Expert paper 1 (EP1).
- Expert testimony on the role of the local authority planning regime in delivering improvements to ambient air quality and in reducing public exposure to pollution: Expert paper 6 (EP6).

Clean air zones

The discussion below explains how the committee made recommendations 1.3.1 to 1.3.8.

Rationale and impact

Why the committee made the recommendations

1.3.1

Some evidence suggested that area-wide action is needed to reduce the use of polluting vehicles and to encourage a shift to zero- and low-emission travel.

Some of this evidence showed that existing low-emission zones (the current nearest equivalent to a clean air zone) have only slightly improved air quality. This is partly because of the failure of new technology to reduce individual vehicle emissions under real driving conditions. But it is also probably linked to the limited scope of existing low-emission zones, in terms of class of vehicles restricted, and the failure to address the overall volume of traffic.

Some evidence suggested that reducing air pollution below current EU limits would provide more health benefits. The committee agreed that stricter targets should be considered because there is a lack of evidence on how effective a lower threshold would be. They also recognised that there are likely to be greater health benefits if pollution is lower than the legislative limits, so reduction to these limits is a minimum and should not be the maximum target for reducing air pollution. Members agreed that targets should be developed with health goals in mind but that, in practice, these will be expressed as air pollution targets.

Members agreed that the focus should not be limited to taking action to reduce air pollution hotspots alone.

Because the evidence was uncertain the committee recommended this as an action to consider.

1.3.2

Cost effectiveness evidence suggested that low-emission zones could be cost effective. Committee members agreed that it was important to aim for consistency across the country, particularly in relation to the vehicle types that are restricted.

1.3.3

Both air pollutants and their sources are mobile, so actions in one area may affect another. No evidence looked at this empirically, but the committee agreed it would be useful to take a wider geographical approach, involving cooperation across local authority boundaries. The evidence was uncertain (based on committee consensus) but the committee felt it was particularly important not

to simply move the problem to another community so they made a strong recommendation.

1.3.4

The committee noted that active travel (such as walking and cycling) was linked to a range of other health benefits. This is covered by evidence used to develop other NICE guidelines.

Some evidence suggested potential benefits could be gained from using zero- and low-emission vehicles. This supported expert testimony on the actions of the Department for Environment Food and Rural Affairs to speed up the transition to a low-emission economy. The committee agreed that infrastructure (in particular, charging points) is needed to achieve significant uptake of zero- or low-emission motor vehicles.

Because the evidence for all these actions was uncertain, the committee recommended these as actions to consider.

1.3.5

There was some evidence on addressing driving style and traffic flow and this supported the committee's knowledge of how air pollution is produced. They agreed that training to reduce idling and to encourage people to change their driving style is unlikely to have any negative effects.

No direct evidence was found on local deliveries or private hire vehicles. However, based on the committee's experience, they suggested action to combat the large contribution that they can both make to air pollution.

They agreed that air pollution from congestion related to deliveries might be addressed by thinking about delivery schedules and by training and accreditation of fleets using a fleet recognition scheme. In addition, it may help reduce fuel use resulting in reduced emissions. Because the evidence was uncertain, they recommended this as an action to consider.

1.3.6

Some evidence, together with the committee's experience, suggested that congestion charging could contribute to a package of measures and incentives to address air pollution where congestion was identified as a significant cause. Because the evidence was uncertain, the committee recommended this as an action to consider.

1.3.7

Members agreed that it was important to monitor outside the zone to identify whether traffic is moving elsewhere and resulting in poor air quality in those areas. They also agreed that adjustments should be made in such cases. Because the evidence was uncertain (committee consensus), the committee recommended this as an action to consider.

1.3.8

The committee agreed that people living in deprived areas are more likely to be exposed to higher levels of air pollution and so might gain more from changes that reduce it. But at the same time, they may be less likely to be able to afford new vehicles and so might be disadvantaged by a charging scheme. The committee agreed that the potential impact that charging may have on inequalities should be taken into account. This was based on uncertain evidence (committee consensus) but the committee felt it was particularly important so they made a strong recommendation.

Why we need recommendations on this topic

Piecemeal, uncoordinated actions to tackle air pollution may make the situation worse. For example, the use of single interventions such as 'alternate car days', in which half the vehicle fleet is banned from an area on alternate days, may inadvertently encourage the use of older, poor performing vehicles.

Similarly, if different vehicle types are not classed in the same way in all clean air zones, then the overall impact will be diminished.

Impact of the recommendations on practice

Planning, transport and environment departments will need to work together across the country to ensure a consistent approach. More consistent, concerted action to change current practice will, in turn, improve people's health, by:

- reducing the ill effects of air pollution
- encouraging more people to become more active, by adopting active travel as a lifestyle choice.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

The committee agreed that the most important outcomes in the absence of measured health outcomes are a reduction in the following air pollutants:

- Particles, especially $PM_{2.5}$ and the vehicle-related components of $PM_{2.5}$ (such as black carbon)
- NO_2.

Ideally these outcomes should be measured in the ambient air (the air that we breathe). But for many outcomes, changes in total emission levels or vehicle kilometres driven suffice and have been used to determine the effect of interventions.

The committee noted that ambient NO_2 concentrations are more sensitive to changes in local transport than total $PM_{2.5}$.

Other relevant outcomes include changes in number and type of vehicles in the zone.

The quality of the evidence

The committee considered the evidence of effectiveness for various elements of clean air zones:

- Six studies of low-emission zones (2 from the Netherlands, 3 from Germany and 1 from the UK) found some evidence of reductions in pollution, particularly with more stringent restrictions on vehicle classes [ES6.3]. Four studies were rated as moderate quality and 2 as poor quality. All were at some risk of bias but overall the committee considered the evidence sufficient to support the recommendations.
- Two cost effectiveness studies (1 from Italy and 1 from Sweden) that examined congestion charging zones in Milan and Stockholm, suggested that they were cost effective, although local factors mean that they are only partially applicable to the UK [ES6.2]. Both studies were rated as moderate quality.

- Four modelling studies of the use of alternative fuels (3 poor quality from Spain and 1 poor quality from the UK) showed the potential for considerable improvements in air quality from fuel changes if the penetration of the technologies is large enough [ES3.3]. As modelling studies, they involve greater uncertainty. However, the committee agreed that that they support the recommendations.

- Five studies of traffic restrictions (1 each from Italy, Korea and Israel, 2 from the US) suggested that vehicle restrictions or bans have little impact unless they restrict the volume of traffic substantially [ES5.1]. All were at some risk of bias, 3 were rated as poor quality and 2 as moderate quality.

- Three studies (2 from the UK, 1 from Italy) looked at congestion charging schemes [ES6.1]. All were at risk of bias (rated as poor quality) but committee members agreed with the evidence from their expert perspectives. The study from Italy found some reduction in elements of road-traffic-related air pollution.

- Three moderate-quality cost-effectiveness studies (from the US) looked at changes to vehicle fleets [ES3.4]. These suggested that changes to emission-controlled diesel or compressed natural gas were not cost effective when viewed against medical interventions. However, they were within the range normally considered cost effective for interventions to address mobile or stationary air pollution.

- One poor-quality study from the US found that a 10% to 20% reduction in fuel consumption could be obtained by using wireless technology to inform drivers of the appropriate speed on major roads [ES11.1].

- Two studies (1 from Canada and 1 from the Netherlands) looked at the impact of information and training on driver behaviour [ES11.2]. Both were rated as poor quality. They suggested that information and training might help reduce fuel consumption and time spent idling.

- The effect of anti-idling information campaigns for bus drivers was considered in 2 linked studies from the US [ES11.4]. Both were rated as poor quality and so at risk of bias. They suggested that such campaigns could reduce the time school buses spent idling.

The committee considered the evidence of effectiveness of charging zones on air quality.

- Three studies (2 from the UK, 1 from Italy) looked at charging schemes [ES6.1]. All were rated as poor quality. The studies from the UK failed to find clear evidence of reductions in air pollution. This may in part be because of the failure of Euro standards to produce the modelled benefits. The study from Italy suggested that there were some reductions in particulate air pollution most heavily linked to vehicle use. However, it is possible that there are differences in the vehicle fleet between Italy and the UK, meaning that this is only partially applicable. The committee agreed that this evidence supported the recommendations.
- Two cost effectiveness studies (1 from Sweden rated as moderate quality and 1 from Italy rated as moderate quality) looked at the costs and benefits of congestion charging schemes [ES6.2]. Both were at some risk of bias. Both suggested greater benefits than costs. However, the main benefits came from changes to traffic flow, travel time savings and reductions in road injuries, rather than from air pollution savings. Local factors (such as the limited number of access points to the islands of Stockholm and differences in the vehicle fleet) mean that the evidence is partially applicable. The committee agreed that this evidence supported the recommendations.

Benefits and harms of clean air zones

Benefits include:

- Discouraging use of the most polluting vehicles, by restricting their access to some areas or by encouraging zero- or low-emission travel, will improve local air quality.
- Increased levels of physical activity from encouraging 'active' travel.
- A reduction in health inequalities by reducing vulnerable groups' exposure to poor air quality.

Potential harms arise from:

- Approaches covering only limited classes of vehicles or geographical areas not reducing emissions sufficiently, or moving the pollution elsewhere.
- People who depend on highly polluting vehicles or older vehicles that do not meet current emission standards not being able to afford to replace them.

Cost effectiveness and resource use

Large-scale schemes such as city-wide clean air zones (that can include low-emission zones) can be expensive to set up – but they can deliver substantial benefits. They also target a large population, meaning that the cost per head of population is likely to be relatively low.

Much of the cost relates to setting up. Running costs are likely to be substantially lower (and potentially covered by charges or fines). Ongoing income can then be used for other activities to reduce air pollution. Demonstrating a link between income raised and funding activities to reduce air pollution is likely to encourage public support for the actions.

Evidence in the economic modelling suggested an annual cost of around £2 per head for the Amsterdam low-emission zone. Although a clean air zone involving a range of interventions might be more expensive, the committee felt this was likely to have an additive positive effect.

There are no data for clean air zones so the economic model considered 1 component – low-emission zones. It estimated a cost per quality-adjusted life year (QALY) of around £2,240. The committee noted this is likely to decrease as vehicle fleets progressively improve because of regulation, unless restrictions evolve to take into account improving vehicle standards. Nevertheless, because they have a benefit–cost ratio of around 29 (that is, £29 of benefit for every £1 spent) the committee considered the impact of these zones is unlikely to stop representing good value for money.

Interventions to encourage reductions in vehicle idling were included in the economic modelling. Using a study that assessed the impact of a campaign to tackle bus idling at 4 schools in Cincinnati the model estimated a cost per QALY of £157 and a benefit–cost ratio of 44. The committee noted the benefit was based on the best-performing school, some schools showed no improvement The committee felt that it was reasonable to extrapolate from this to interventions aimed at reducing idling more widely.

Other factors the committee took into account

The committee heard about the draft national clean air zone framework (Air quality plan for nitrogen dioxide in UK Department for Environment, Food and Rural Affairs) that aims to achieve compliance with the EU NO_2 limit values and the implementation of clean air zones [EP5]. Members noted that evidence about the effectiveness of clean air zones does not exist because they have yet to be implemented. However, they heard evidence about actions that might constitute a clean air zone (in particular low-emission zones) [EP2]. The committee heard expert testimony on influencing drivers' behaviour [EP4] which noted that better driving can reduce emissions and fuel consumptions.

The committee noted that the contribution of diesel cars to NO_2 pollution was substantial [EP3]. Which vehicle types need to be restricted in a particular area to protect health would need to be assessed in light of local conditions. This would include assessing the timetable to implement changes and amending restrictions if modelled targets for health goals are not achieved, including

the possibility of an introductory advisory-only restriction.

Members discussed providing parking concessions for lower-emission vehicles, such as electric vehicles, as an incentive for people to buy them. But they felt that such subsidies would be going to people who can afford expensive vehicles. In addition, in areas of high housing density, off-street space for charging electric vehicles is rare. So support for on-street charging would be necessary to alleviate any potential inequalities this may cause.

The committee agreed that the bulk of the actions would need to be taken by transport authorities. These are located in county council and unitary authorities. Environmental issues may be located in other authorities such as district councils. Directors of public health should sign off annual status reports and air quality management action plans. The committee felt that it was appropriate to target recommendations at these groups.

The committee agreed that although road traffic was a key contributor to poor air quality, other sources would need to be tackled as well. These would depend on local circumstances but would be likely to include gas-powered domestic boilers, domestic biomass use and combined heat and power stations.

The committee noted that perceptions about charging schemes risked reducing their effectiveness and antagonising the public. These include the perception that schemes are aimed at income generation rather than reducing air pollution, or that restrictions would inevitably damage economic growth and activity. It felt that emphasising the public health benefit of the schemes and adopting a consistent national approach would be important in limiting these misperceptions.

The evidence

The committee looked at evidence in:

- Evidence review 1 on environmental change and development planning: ES3.3, ES3.4.
- Evidence review 2 on traffic management and enforcement, and financial incentives and disincentives: ES5.1, ES6.1, ES6.2, ES6.3.
- Evidence review 3 on travel planning and advice: ES11.1, ES11.2, ES11.4.
- Expert testimony on epidemiology: Expert paper 1 (EP1).
- Expert testimony on national and local frameworks for action: Expert paper 2 (EP2).

- Expert testimony on the use of Euro Standards to control vehicle emissions: Expert paper 3 (EP3).
- Expert testimony on evidence relating to influencing driving behaviours for fleet drivers and others: Expert paper 4 (EP4).
- Expert testimony on the proposed clean air zones: Expert paper 5 (EP5).

Reducing emissions from public sector transport services and vehicle fleets

The discussion below explains how the committee made recommendations 1.4.1 to 1.4.6.

Rationale and impact

Why the committee made the recommendations

1.4.1 to 1.4.5

Some evidence showed that changes to driving style may be used to lower levels of local pollution, as well as reducing fuel use. It also showed that people can be encouraged to make these changes.

Some evidence suggests that if large numbers of people change their driving style this, combined with other measures to reduce traffic, could have a positive effect on the environment. An expert also told the committee that fuel consumption could be reduced by around 20% to 25% by adopting efficient driving techniques, with a realistic long-term reduction of between 5% and 10%.

Based on this evidence and their own experience, the committee felt that providing support to help people change their driving style was justified. They also noted that this would be cost neutral because of the savings generated by better fuel efficiency. Because the evidence was uncertain, the committee recommended these as actions to consider. The committee was aware of NICE's guideline on behaviour change: individual approaches and added a link to this in recommendation 1.4.4 but did not specify the type of rewards for those who drive efficiently.

1.4.6

The committee agreed by consensus that procurement of less polluting vehicles will help public sector organisations to reduce road-traffic-related air pollution. Members noted that this could be done as older vehicles are replaced. Because the evidence was uncertain, they recommended this as an action to consider.

Why we need recommendations on this topic

The public sector fleet is substantial. It includes various vehicle types (from local authority refuse vehicles and goods vehicles to lease cars and patient transport vehicles) many of which are highly polluting.

Public sector decisions about vehicle procurement don't always take air pollution into account. In addition, many drivers are unaware of the impact their driving has on air pollution, and about practical changes they could make to reduce this. Currently only around 20% of people employed as drivers have been trained in efficient driving by their employer.

Impact of the recommendations on practice

Making changes will help the public sector fleet to meet its duty to address its environmental impact, reduce emissions and promote the public's health and wellbeing.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

The committee agreed that although outcomes relating to ambient air quality are important for health it would be unlikely to find studies that reported these in relation to changes to driving style.

Other more likely outcomes are:

- length of time a vehicle is left idling
- overall fuel consumption.

The quality of the evidence

The committee considered modelling evidence from 1 poor-quality US study [ES11.1]. This suggested that information on an appropriate speed could reduce emissions on major roads. The study was modelling only and rated as poor quality so the results were treated with caution. But the committee felt that it, together with other evidence, supported the recommendation.

The committee considered evidence of effectiveness from 2 studies (1 from Canada and 1 from the Netherlands) that looked at the impact of information and training on driver behaviour [ES11.2]. Both studies were rated as poor quality and so at risk of bias. They suggested that information and

training might help reduce fuel consumption and time spent idling.

The committee considered the effect of anti-idling information campaigns for bus drivers in 2 linked studies from the US [ES11.4]. Both were rated as poor quality and so at risk of bias. It suggested that educating drivers about the importance of reducing the time they spend idling could be effective.

The committee considered qualitative evidence that looked at factors that influence the likelihood of people changing their driving style. One moderate-quality study from the UK suggested several factors likely to support the uptake of 'eco driving' [ES11.3]. The authors felt that a focus on cost savings, in-vehicle information and systems to feedback progress were key.

Key elements in reducing fuel consumption were vehicle maintenance (in particular ensuring correct tyre pressure), gear selection and avoiding aggressive acceleration.

Although in general the evidence was of poor quality, committee members felt that it was consistent with what they would expect from their own experience and so supported the recommendations.

Benefits and harms of driver training and public sector procurement

Benefits include:

- Increased knowledge about factors associated with fuel economy. Putting this knowledge into practice will result in lower fuel use and improved air quality.
- Energy-efficient driving with fewer rapid accelerations and decelerations. This will improve fuel consumption and reduce wear and tear on vehicles, leading to financial benefits.
- Energy-efficient driving with fewer rapid accelerations and decelerations may reduce road danger and encourage others to walk or cycle, resulting in lower total emissions.
- Training public sector staff may have the additional benefit of altering their driving habits outside work. It may also help to make these habits the norm more generally.

Cost effectiveness and resource use

Evidence from expert testimony suggested that efficient driving training is likely to be cost saving [EP4]. Training costs are estimated at a one-off cost of £25 to £30 per driver, with an annual fuel saving of around £96. If training is provided as part of existing programmes for staff, the marginal

cost is likely to be small.

Use of telematics would be likely to have an additional cost. However, the committee felt these costs were likely to be small.

It would be most logical to make changes to the vehicle fleet as part of the usual turnover of vehicles. Any resource impact would depend on the extent of changes and the relative cost of vehicles. This would need to be managed within available resources.

Other factors the committee took into account

The committee noted that the potential for financial savings and health benefits meant that these recommendations were highly relevant to the public sector. But the committee also felt that adoption of the recommendations by the public sector would act as an example of good practice that might be taken up in other sectors. In addition, it noted the potential for a positive knock-on effect if energy-efficient driving habits developed at work were carried over into people's personal lives.

Members noted that the views of those receiving training are important in determining the potential for success. They noted that there is a perception that air pollution levels inside a vehicle are lower than outside but this may not be the case.

The evidence

The committee looked at evidence in:

- Evidence review 3 on travel planning and advice: ES11.1, ES11.2, ES11.3, ES11.4.
- Expert testimony on influencing driving behaviours for fleet drivers and others: Expert paper 4 (EP4).

Smooth driving and speed reduction

The discussion below explains how the committee made recommendations 1.5.1 to 1.5.2.

Rationale and impact

Why the committee made the recommendations

1.5.1

Evidence on using lower speed limits, encouraging smoother driving and providing real-time information showed that reducing 'stop–go' driving could help reduce emissions of air pollutants. This was supported by the committee's understanding of air pollution and the effect of accelerations and decelerations.

The committee agreed that signs displaying drivers' current speed would encourage a smoother driving style.

Because the evidence was uncertain they recommended these as actions to consider.

1.5.2

Some evidence on physical speed reduction measures like humps and bumps suggested that individual measures may increase motor vehicle emissions by encouraging decelerations and accelerations. But evidence from area-wide schemes does not back this up.

So where physical measures are needed to reduce road injuries, the committee agreed that area-wide schemes should be designed to minimise the impact on air pollution. Because the evidence was uncertain, the committee recommended this as an action to consider.

Why we need recommendations on this topic

Speeding motor vehicles in residential areas discourages people from walking and cycling, increases the risk of injury and increases traffic-related air pollution.

Impact of the recommendations on practice

Ensuring motorists drive steadily at the optimum speed can help reduce stop–go driving and so improve fuel consumption as well as reducing congestion and air pollution. Reducing the speed limit in residential areas, while making sure that it does not result in an increase in vehicle emissions, will reduce road danger, injuries and air pollution.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

The committee agreed that the most important outcomes are:

- Ambient levels of air pollutants, in particular NO_2 and $PM_{2.5}$.
- Individual vehicle emissions of these pollutants.

The quality of the evidence

The committee considered the evidence relating to the impact of motorway speed.

- Two studies examined the effect of schemes to reduce speed on urban motorways [ES6.4]. Both were from the Netherlands; 1 was rated poor quality and 1 moderate quality. They showed that speed limits and enforcement on urban motorways have a small positive effect on PM_{10} and NO_2. The emission reduction depends on the impact of speed management on traffic dynamics, so the larger the reduction in traffic congestion the larger the emission reduction. Although this evidence is poor quality, it supports the understanding of traffic flow dynamics and air pollution production. Although the studies are from the Netherlands they are applicable to the UK.
- One modelling study from the US noted savings in fuel consumption using wireless technology to inform drivers of the optimum speed on a major road [ES11.1].

The committee agreed that these studies were in line with expectations about the effect of smoothing traffic flow by reducing speed [ES6.4]. Members noted that where flow was not improved by changes to the speed limit (generally in less congested conditions) it would be unlikely that air quality would improve.

The committee discussed the modelling study [ES11.1]. This suggested substantial benefits were possible from changes to the behaviour of relatively small numbers of drivers. This had been achieved using wireless technology to identify the optimum speed. Although this was plausible, it would not be implementable at the moment because of lack of the necessary technology in vehicles to receive information about the current optimum speed. However, a similar effect might be obtained by the expansion of variable limit speed control using signs outside the vehicle.

The committee considered the evidence on the effect on air pollution of traffic-calming schemes.

- Two poor-quality studies from the UK suggested that there was no significant impact on ambient NO_2 concentrations from the construction of an area-wide traffic-calming scheme [ES5.2].
- Four modelling studies examined the emissions from individual vehicles [ES5.3]. Two moderate-quality studies were from Canada and 1 each, both poor quality, were from the US and UK.

Two poor-quality studies of area-wide traffic calming from the UK did not show significant changes in area-wide air quality. The changes seen were within the margin of error of the measurement techniques used.

The committee noted that the modelling evidence suggested that individual traffic-calming measures tended to increase emissions from vehicles because of the increase in accelerations and decelerations. The UK modelling study cited 9 measures including road humps, pinch points, raised junctions, chicanes and mini-roundabouts. Although there are uncertainties associated with the modelling, these studies supported an increase in emissions associated with individual traffic-calming measures.

One study was carried out in the UK on existing measures and so is applicable; others were carried out elsewhere and so differences in the design of measures and the make-up of the vehicle fleet mean that they are partially applicable.

Benefits and harms of traffic calming and speed reduction

Benefits include:

- Reducing stop–go driving will lower emissions of air pollutants from accelerations and decelerations, lowering exposure of the population to poor air quality.
- Reduced speeds in urban areas supports a modal shift to walking and cycling. This will reduce emissions of air pollutants.
- Reduced speeds reduces the number and severity of road injuries.

Cost effectiveness and resource use

The economic modelling included examination of speed restrictions around Amsterdam. This suggested that the reduction in the speed limit on a section of motorway from 100 kph to 80 kph was highly cost effective at reducing air pollution (cost per QALY approximately £1,290, benefit–cost ratio 51). However, the committee noted costs will vary depending on the existing

enforcement infrastructure already in place and whether additional speed cameras are needed.

Other factors the committee took into account

The committee noted that altering driving behaviour to reduce emissions has 2 elements: education and restriction. The committee felt that these complementary elements should both be included in the guideline separately. Education is addressed in recommendations 1.4.1 to 1.4.5. Recommendations 1.5.1 to 1.5.2 address restriction.

The committee discussed the possibility of using average speed technology to reduce this risk in various areas. It noted that on major roads where there are very few (or no) route choices the cost is likely to be small because only a limited number of speed cameras would be needed. However, in other areas (such as residential streets) there were possible benefits, but implementation would be difficult or impossible because of the number of route options. Other measures (such as signs indicating current speed) were more likely to be useful in these areas.

The evidence

The committee looked at evidence in:

- Evidence review 2 on traffic management and enforcement, and financial incentives and disincentives: ES5.2, ES5.3, ES6.4.
- Evidence review 3 on travel planning and advice: ES11.1.

Walking and cycling

The discussion below explains how the committee made recommendations 1.6.1 to 1.6.3.

Rationale and impact

Why the committee made the recommendations

1.6.1 and 1.6.2

The committee agreed that it was important to support a general shift from motor vehicles to more active travel. They also agreed that this needed doing in a way that minimises cyclists' exposure to air pollution for example, by providing a choice of cycle routes.

In addition, evidence suggested that increasing the space between cyclists and motor traffic helps

protect cyclists from air pollution. Although this evidence was uncertain, it agrees with the committee's understanding of the sources and dispersal of air pollutants.

1.6.3

Some evidence suggested that where it is not possible to create cycle routes using quiet streets, separating cycle routes from motor traffic and reducing the time spent by cyclists in areas of high pollution, including busy sites, helps protect them from air pollution.

Some evidence suggested that using dense foliage as a barrier may sometimes help protect cyclists from motor vehicle emissions, but the impact on the distribution of air pollutants needs to be taken into account. The committee agreed that the evidence supported its understanding of the dispersal of air pollutants. They also noted that it was important to take account of the need for cyclists to be visible to reduce the risk of collisions and to help normalise cycling.

Because the evidence was uncertain the committee recommended this as an action to consider.

Why we need recommendations on this topic

Cyclists and pedestrians are vulnerable to road-traffic-related air pollution as well as other injuries on the road. Both factors discourage people from taking up these zero-emission modes of transport.

Impact of the recommendations on practice

Encouraging active travel such as walking and cycling will help reduce traffic-related air pollution and help people to be more physically active. Incorporating the rest of the recommendations at the design stage of new cycle routes will help improve the currently patchy provision across the country. It will also encourage planners to consider exposure to air pollution, which currently is not always taken into account.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

Ambient levels of air pollutants, in particular NO_2 and $PM_{2.5}$.

The quality of the evidence

The committee considered the evidence of the impact of cycle route design on exposure to air pollution [ES3.1]. This included 6 studies that examined the siting and design of cycle routes: 3 from the US, 1 each from the Netherlands, Canada and the UK. All were rated as poor quality:

- All 6 found exposure to $PM_{2.5}$ was lower in low traffic routes and air pollution levels were reduced by increasing separation.
- Shelter provided by vegetation reduced levels of exposure to air pollutants; conversely, peak levels of exposure were seen in conjunction with junctions and waiting at signals.
- One study suggested exposure for drivers was as high as for cyclists.

There is considerable variation in measurement techniques used, which introduces uncertainty. However, the results are in line with what is known about dispersion of air pollutants in general.

The committee felt that although the evidence was of poor quality it was plausible. The reduction in air pollution with distance from the source is well understood and follows a simple mathematical relationship.

ES4.1b examined natural barriers. One UK study found a positive effect from a dense hedge adjoining a major road. Although this was a poor-quality study the committee felt it was plausible, based on its understanding of the deposition of air pollutants. Because the evidence was uncertain, the committee recommended this as an action to consider.

Benefits and harms of cycle routes

Benefits include:

- Positioning cycle routes away from areas of poor air quality will reduce the exposure of cyclists to air pollution.
- Perceptions of poor air quality put some people off cycling. Improving air quality will encourage more people to cycle and so further reduce air pollution.
- Those encouraged to cycle will also benefit from being more physically active.

Potential harms could arise from collisions as a result of poorly designed cycle routes.

Cost effectiveness and resource use

Construction and maintenance of dedicated and separated cycle routes may entail additional costs, but it is not as expensive as constructing and maintaining vehicular roads.

Modelling of the cost effectiveness of off-road cycle routes suggested that they were good value for money. The cost per QALY was estimated at around £5,080, with a benefit–cost ratio of 14. This analysis included additional monetised benefits of £64,000 resulting from increased take up of cycling. The committee noted the intervention costs and benefits calculated assume several routes are developed. Developing a single route would cost less, but may also be less effective because it is likely to reach less of the population.

Other factors the committee took into account

The committee noted that a variety of terms are used in the studies. The definitions are often not clear and may vary between studies (for example: cycle routes, paths and lanes). Members agreed that, other factors being equal, the significant factor in terms of exposure was the distance between the source (motor vehicles) and the cyclist. They also agreed to use the term 'cycle route'.

The committee was aware from members' own experience that air pollution concerns were among the factors putting some people off cycling. Taking action to address this would support the overall goal of achieving a shift in transport choices and so an overall reduction in air pollution.

The committee noted there was considerable uncertainty in this modelling. However, it agreed that off-road cycle paths could be cost effective in some circumstances.

The evidence

The committee looked at evidence in:

- Evidence review 1 on environmental change and development planning: ES 3.1, ES4.1b.

Awareness raising

The discussion below explains how the committee made recommendations 1.7.1 to 1.7.7.

Rationale and impact

Why the committee made the recommendations

1.7.1 and 1.7.2

Evidence on the impact of air pollution on health provided justification for action to raise awareness of the issues and ways to mitigate the problems. The committee agreed that community support is always important when aiming for sustainable changes in behaviour. This supported the evidence on interventions to change behaviours related to air pollution. Members noted that this is in line with other NICE guidelines.

1.7.3

The committee agreed that local, national and social media techniques are useful ways to disseminate information about the Daily Air Quality Index, particularly to vulnerable groups. Because the evidence was uncertain the committee recommended this as an action to consider.

1.7.4

The committee agreed that it is important to give the public information on how road-traffic-related air pollution affects their health and on how their transport choices (such as driving during episodes of high pollution) contribute to this. Because the evidence was uncertain the committee recommended this as an action to consider.

1.7.5

Some evidence relating to partial or occasional traffic restrictions suggested a limited effect. But the committee agreed that such restrictions offer the opportunity to demonstrate the positive benefits. So the consensus was that it is reasonable to use them as part of occasional awareness-raising activities. Because the evidence was uncertain the committee recommended this as an action to consider.

1.7.6

The committee agreed that it is reasonable to make businesses aware of the need to reduce air pollution, by encouraging active travel and more energy-efficient driving. Members noted that scheduling deliveries to avoid times when streets are congested might also reduce the contribution businesses make to congestion and the resulting pollution. Because the evidence was uncertain the committee recommended this as an action to consider.

1.7.7

The committee agreed that information provided by healthcare professionals is likely to be important in highlighting the effect of air pollution on health. So it is important to ensure health professionals are aware of the facts and can communicate them to vulnerable groups. Because the evidence was uncertain the committee recommended this as an action to consider.

Why we need recommendations on this topic

Many people do not understand the link between health and road-traffic-related air pollution. For example, they do not realise that long-term exposure to typical levels of air pollution causes far more health problems than short-term exposure to higher levels. In addition, they do not realise that they can help reduce this pollution, as well as their exposure to it, if they change their behaviour.

Without this understanding it will be difficult to get public support for the changes needed. Without such support changes are unlikely to be sustainable and implementing them would be unethical.

Impact of the recommendations on practice

If healthcare professionals routinely raise air pollution as an issue affecting health, this could help prevent health conditions escalating, particularly among the most vulnerable groups. If local authorities raise awareness about air pollution with businesses and the public, this could help reduce air pollution and resulting ill health, so meeting their duty to protect people's health and wellbeing.

In both cases this would also reduce the need for potentially more expensive and less effective remedial action later.

Evidence discussion

Interpreting the evidence

The outcomes that matter most

Reduced exposure to air pollution (NO_2 and particles) is the main outcome in determining health effects. Changes in knowledge and behaviours that may to lead to reduced exposure (either for the person or the wider community) are important.

The quality of the evidence

The committee heard expert testimony on the extent of the impact of air pollution on health [EP1]. It noted that some groups are more likely to be at risk from air pollution.

The committee heard expert testimony on influencing drivers' behaviour [EP4].

The committee felt that members' experience of working on air pollution, together with the wider public health evidence (including NICE guidance on behaviour change and community engagement), justified these recommendations.

The committee considered the evidence of effectiveness of traffic restrictions on air pollution from 5 studies of traffic restrictions (1 each from Italy, Korea and Israel, 2 from the US). The evidence suggested that vehicle restrictions or bans have little impact unless they restrict the volume of traffic substantially [ES5.1]. All were at some risk of bias, 3 were rated as poor quality and 2 as moderate quality.

Benefits and harms of engaging the public

Raising awareness of air pollution will:

- Help people, particularly those who are most vulnerable, to reduce their exposure – especially when levels of pollution are high.
- Help people understand how to change their behaviour to reduce emissions, thereby further reducing population-level exposure.
- Support the development of social networks (social capital), which can be built on for benefits in other areas.

Actions to reduce the amount of polluted air from entering a home (such as closing windows) might increase indoor levels of air pollutants, if there are other sources of pollution in the house. Potential harm may also be caused if unfounded concerns are raised about the possible health effects of air pollution.

Cost effectiveness and resource use

No cost effectiveness evidence or modelling was identified for this recommendation. The committee noted that local agencies were likely to have resources capable of addressing these issues by developing effective local communications strategies. Developing an effective strategy would involve a cost but this would be more likely to be successful.

The committee noted that training healthcare workers about air pollution would have a cost. However, this could form part of continuing professional development so would be cost neutral. There was also the potential for cost savings if exacerbations of ill health (such as asthma), and so hospital attendances, were reduced.

The evidence

The committee looked at evidence in:

- Evidence review 2 on traffic management and enforcement, and financial incentives and disincentives: ES5.1.
- Expert testimony on epidemiology: Expert paper1 (EP1).
- Expert testimony on influencing driving behaviours for fleet drivers and others: Expert paper 4 (EP4).

Evidence statements not used to make recommendations

- ES2.1 – bus operations. The committee felt that this evidence (2 poor-quality modelling studies, 1 from Canada and 1 from Greece) was too uncertain to support a general recommendation. Local factors would be particularly significant in this context, and would involve considerable potential disruption.
- ES3.2 – alterations to bus services and technology. The committee felt that the uncertainties in both studies (2 poor-quality studies, 1 from Chile and 1 from the US) meant that this evidence was unsuitable to support a general recommendation. In particular, differences in vehicle fleets in Chile and the UK and lack of appropriate control fleets in the US study made the evidence of limited applicability. Emission standards are also addressed by recommendations relating to clean air zones.
- ES3.5 – bypass construction. The committee felt that this evidence (1 poor-quality UK study) did not justify a recommendation. Bypass construction is likely to be extremely expensive and only applicable in very specific circumstances. The committee felt that the reductions noted were possibly due to other factors. The age of the study (carried out in 1998) also meant that vehicle technology would be very different.

- ES4.2 – dust suppressants. The committee felt that this evidence (2 poor-quality studies, 1 from Spain and 1 from the USA) did not justify a recommendation. They felt that the results seen in the Spanish study would be unlikely to be replicated in the UK, partly from differences in climate. The study from the USA looked at unsealed roads so is not relevant to the UK generally.
- ES4.3 – street washing. The committee felt that this evidence (1 poor-quality study from Spain) did not justify a recommendation. They felt that the results would be unlikely to be replicated in the UK because of differences in climate. They felt that street washing was unlikely to have a significant effect on smaller particles most closely linked to health impacts.
- ES10.1 – personalised travel planning. This consisted of 1 poor-quality study of students in Japan, which suggested that vehicle mileage could be reduced substantially by using personalised approaches. Although the committee agreed that these interventions could be feasible in the UK, they felt the evidence was insufficient to base a recommendation on. The committee also noted that the linked walking and cycling guideline contains recommendations on these approaches based on evidence to promote physical activity (rather than to reduce air pollution).

Gaps in the evidence

The committee's assessment of the evidence and expert testimony identified a number of gaps. These gaps are set out below. Where a gap in the evidence was identified and prioritised as a research recommendation it is included in the 'Recommendations for research' section.

1. Effectiveness and cost effectiveness of environmental change and development planning at reducing road-transport-related air pollution:

a) Planning and land allocations, development control and planning decisions, urban space and building design: siting, layout and design of developments; and applying planning conditions or obligations.

b) Developing public transport routes and services, including bus lanes, and improving bus quality.

(Source: Evidence review on environmental change and development planning.)

2. Effectiveness and cost effectiveness of traffic management and enforcement, and financial incentives and disincentives to reduce road-transport-related air pollution:

a) Traffic management systems and signal coordination:

- road signs, traffic signals and road markings
- lane control
- elements of routes (such as positioning of traffic lights)
- roadside emission testing.

b) Parking restrictions and charges:

- restricted parking zones (including low-emission vehicles, car clubs and electric vehicle recharging points)
- higher parking charges.

c) Vehicle 'idling' restrictions and charges, including waiting and loading restrictions.

(Source: Evidence review on traffic management and enforcement, and financial incentives and disincentives.)

Recommendations for research

The guideline committee has prioritised the following gaps in the evidence as recommendations for research.

1 Vegetation and street trees

What factors influence how vegetation and street trees affect urban air quality?

Why this is important

There is limited evidence on how vegetation and trees influence urban air quality and health outcomes. Information is needed because they are often used to address air pollution or for other purposes.

Research is needed on a range of factors including:

- impact of different species of vegetation and tree types
- impact of trees depending on where they are sited and how they are maintained
- impacts across the course of a year
- impact on health inequalities
- other potential health benefits.

2 Promoting a shift to zero- and low-emission travel

What methods are effective and cost effective at promoting a shift to zero- and low-emission modes of travel, including active travel?

Why this is important

Achieving a shift to zero- and low-emission modes of travel (including active travel) is key to reducing air pollution. We also need to identify approaches that encourage more efficient, less polluting driving behaviour.

Studies based on behaviour change theories are needed to identify the most effective and cost effective approaches and messages for different groups and in different settings. Useful outcomes include: travel mode and driver behaviour.

3 Clean air zones

How do different elements of a clean air zone interact to improve air quality and what is the overall effect on people's health?

Why this is important

At publication of this guideline, clean air zones were being introduced. These zones are likely to vary across the country and it is important to use this opportunity to identify which elements are most effective and cost effective at reducing air pollution and supporting a shift to zero- and low-emission travel. Studies are needed to evaluate:

- exposure to air pollution
- acute and chronic health outcomes
- impact on health inequalities.

Research is also needed to look at travel behaviour in relation to different groups, to inform public awareness and social marketing approaches.

4 Telematics

How can information about driving style gathered from telematics devices and other technologies (such as apps or in-car global positioning systems) be used to reduce individual fuel consumption and vehicle emissions?

Why this is important

Evidence suggests that information and training can help drivers change their driving style.

Research is needed to evaluate how telematics devices can be most effectively used with different groups to influence driving style and so, in turn, reduce emissions and improve air quality. Specific gaps in current research include the impact on individual drivers and those driving as part of a fleet including costs, health and other benefits, and value for money.

5 Awareness raising

What is the effectiveness and cost effectiveness of different methods of awareness raising about air pollution (including air pollution alerts) on people's behaviour and on acute and chronic health outcomes?

Why this is important

Activities to raise awareness of air pollution, including air pollution alerts (using traditional, social media and other methods) are becoming increasingly popular as a way of warning of the potential risk from episodes of poor air quality. But little is known about whether these alerts help encourage people to change their behaviour. Research on the absolute and relative effect of different approaches could be used to develop effective and cost effective systems.

Research is needed on the impact of, for example, air pollution alerts on:

- different groups (such as those vulnerable to air pollution and the general population)
- behaviours related to the production of pollution (such as changes in mode of transport)
- acute and chronic health.

Studies are also needed on:

- the risk of adverse effects (such as making people worry unnecessarily, or increasing the level of motor vehicle travel after an alert)
- the ability of health services to respond to concerns raised by issuing alerts.

6 Exposure to air pollution using different modes of transport

How does altering a person's mode of transport and route affect their personal exposure to air pollution?

Why this is important

Mode of transport (such as walking, cycling, using public transport or driving) influences personal exposure to air pollution. Overall, 'active' travel (such as walking or cycling) reduces emissions of air pollutants. But it could potentially increase someone's personal exposure, depending on the route

they take. Research is needed to clarify the health impact of making such changes, including on health-related quality of life.

Glossary

Average speed technology

Cameras with automatic number plate reading (ANPR) digital technology, placed in multiple locations (at least 2, at a minimum of 200 m apart) along a stretch of road to monitor a vehicle's average speed.

Daily Air Quality Index

A number used by government agencies to tell the public how polluted the air is or will be. The number is provided with recommended actions and health advice. The index is numbered 1 to 10 and divided into 4 bands: low (1 to 3), moderate (4 to 6), high (7 to 9) and very high (10).

Euro standards

Standards produced by EU Directives specifying maximum permitted emissions of various air pollutants. Light duty vehicle standards are referred to using Arabic numerals (Euro 1 to 6); standards for heavy duty vehicles use Roman numerals (Euro I to VI).

$PM_{2.5}$, PM_{10}

Particulate matter is produced by, among other things, combustion of fossil fuels or abrasion of tyres and brakes. Particles are classified by size, described using the abbreviation PM with a suffix (commonly 2.5 or 10) that gives the maximum particle size in micrometres. The mass concentration of particles is usually expressed in micrograms per m^3 of air.

Airborne PM_{10} and $PM_{2.5}$ come from both primary emissions (including combustion of fossil fuels, tyre and brake wear) and secondary particles (for example, nitrates and sulphates) formed when pollutants react in the atmosphere. $PM_{2.5}$ particles are sometimes referred to as 'fine particles', and $PM_{2.5–10}$ as 'coarse particles'. Fine particles can penetrate deep into the lungs.

Street ventilation

Air in a street flows in a pattern determined by many factors, including the shape and design of buildings. It mixes with air from outside the street. If there are sources of pollution in the street

(primarily motor vehicles) the air flow is restricted.

Telematics

Technologies that store and send information on the speed, position, acceleration and deceleration of road vehicles. This, together with global positioning system (GPS) data, can be used to compare driving styles and estimate the impact on fuel consumption, emissions or wear and tear.

Travel plans

Travel plans are a way of assessing and then mitigating the potential negative effects that new developments could have on air pollution by generating significant amounts of motor traffic.

For other public health and social care terms see the Think Local, Act Personal Care and Support Jargon Buster.

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Accreditation