Air pollution: outdoor air quality and health

NICE guideline

Draft for consultation, December 2016

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. It recommends taking a number of actions in combination, as multiple interventions, each producing a small benefit, are likely to act cumulatively to produce significant change.

This includes changes to driving style, selection of vehicles by the public sector, and the introduction of cycle lanes, clean air zones and congestion charging.

Who is it for?

- Local authority staff working in:
  - transport
  - planning
  - local air quality management
  - public health, including environmental health.
- Local government elected members

It may also be relevant for:

- Healthcare professionals
- Employers in all sectors (including transport operators), local enterprise partnerships members, and local businesses and developers
- People working in the voluntary sector and non-governmental organisations
- People working in education
- General public

This guideline contains the draft recommendations, information about implementing the guideline, context, the guideline committee's discussions and recommendations for research. Information about how the guideline was developed is on the guideline's page on the NICE website. This includes the evidence reviews, the scope, and details of the committee and any declarations of interest.

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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.

The term consider is used in recommendations if there is less certainty in the strength of the evidence base that underpins them. Please see the committee discussion sections and section 9.1 of Developing NICE guidelines: the manual.

1.1 Planning

Planning new developments

1.1.1 Take air quality issues into account in the Local Plan for new developments. For example:

- Include air pollution in strategic planning across local authority departments and different tiers of local government (including county, district and unitary authorities).
- Assess site plans from an air quality perspective. Consider:
  - Siting new buildings and estates so that the need for motorised travel is minimised.
  - Minimising the exposure of vulnerable groups to air pollution by siting buildings away from busy roads, siting living accommodation away from roadside facades, and ensuring facilities such as schools, nurseries and retirement homes are located in areas where pollution levels will be low.
  - Avoiding the creation of street and building configurations (such as street canyons) that encourage pollution to build up where people spend time.

- Provide an infrastructure to support low- and zero-emission travel. This could include:
  - cycling and walking routes (see recommendation 1.5 and NICE's guideline on walking and cycling)
  - charge points for electric vehicles in residential areas and commercial developments.

1.1.2 If the local plan does not address air pollution, consider developing local guidance (such as Supplementary Planning Documents, see planning practice guidance) on how to design buildings and spaces to improve local air quality.

1.1.3 Consider ways to mitigate road-traffic-related air pollution if the site is likely to generate a significant volume of motorised traffic. For example, think about using:

- travel plans to reduce the number of motorised trips (this could include, parking availability, car clubs and charging facilities for electric vehicles)
- trees and vegetation in open spaces
- vegetation to create 'green' walls or roofs where this does not restrict ventilation.

1.1.4 In consultation with local communities, consider using the Community Infrastructure Levy for air quality monitoring or for infrastructure changes to reduce the risk of poor air quality.

Unintended adverse effects on air pollution

1.1.5 Avoid inadvertently contributing to poor air quality by introducing features on roads and streets that obstruct or alter the way pollutants are dispersed. For instance:

- Where solid barriers are planned alongside major roads (sometimes used to protect local people from noise) consider whether action is needed to mitigate any adverse effects on air quality.

- Take into account the effect that trees can have on street ventilation, based on where they are planted and how they are maintained, to avoid creating areas of poorer air quality.

1.2 Clean air zones

Clean air zones

1.2.1 Consider introducing a clean air zone in line with the draft national air quality framework in areas outside those targeted by the national plan. It could include restrictions for polluting vehicles as well as action to encourage the use of less polluting ways to travel.

1.2.2 Consider including progressive targets to reduce pollutant levels below the EU limits.

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

- encouraging walking and cycling (see NICE's guideline on walking and cycling)
- actions to encourage uptake of low- and zero-emission vehicles, for instance, electric charging points or use of low- or zero-emission vehicles for deliveries to retail, office, residential or other sites in the zone
- specifying emission standards for private hire and other licensed vehicles.

1.2.4 Consider fuel-efficient driving initiatives such as:

- 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 recommendation 1.3)
- actions to smooth traffic flow (see recommendation 1.4).

1.2.5 Consider public awareness initiatives such as car-free days.

1.2.6 Consider working across local authority boundaries to support action on air pollution and to prevent migration of traffic and emissions to other areas.

Congestion charge zones

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

1.2.8 Consider monitoring outside the congestion zone to identify whether its implementation is causing problems. Monitor the effects in terms of traffic composition and flow. Address specific issues, such as increased pollution at the margins of the congestion zone or problems caused by diversion of traffic, for instance, by changing the boundaries of the zone.

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

1.3 Reducing emissions from public sector transport services and vehicle fleets

Driver training for public sector transport services and vehicle fleets

1.3.1 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.

1.3.2 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 when practical and safe when parked by the roadside, and when dropping off people or deliveries.
- Maintaining vehicles, including pumping up tyres to the recommended pressure.
- Emphasising that reducing vehicle emissions will reduce both fuel costs and air pollution.

1.3.3 Consider including an ‘in-vehicle’ element (for instance, ensure vehicles display information about current fuel efficiency, appropriate gear selection and speed in real time), or telematics (to provide next-day information about driving style).

1.3.4 Consider monitoring fuel efficiency and providing feedback to drivers after training. This could include providing practical help from colleagues or 'buddies' and rewards (see NICE's guideline on behaviour change).

1.3.5 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.

Procuring public sector vehicles

1.3.6 Consider making the minimisation of vehicle emissions (NO_2 and particulates) a factor when making routine procurement decisions. This could include selecting low-emission vehicles, including electric vehicles.

1.4 Smooth driving and speed reduction

Smooth driving on motorways and major roads

1.4.1 Consider using variable speed limits and average speed technology on the roadside to promote a smoother driving style. Incorporate real-time information to tell drivers what the current optimum driving speed is.

Reduced speed in urban areas

1.4.2 Where speed reduction is needed to reduce road danger and injuries (see NICE's guideline on preventing road injuries), take account of the potential adverse impact on air pollution. Consider 20-mph zones in residential areas characterised by stop–go traffic where this will reduce accelerations and decelerations. Where physical measures are needed to reduce speed, such as humps and bumps, ensure they are designed to minimise sharp decelerations and consequent accelerations.

1.4.3 Consider using signs that display a driver's current speed to reduce unnecessary accelerations.

1.5 Cycle routes

1.5.1 Avoid siting cycle routes on highly polluted roads. Ideally use off-road routes or quiet streets.

1.5.2 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 reducing street ventilation so that air pollution can disperse.
- Reducing the time cyclists spend at busy sites, including some junctions, where this can be done without increasing the time that other groups spend exposed to poor air quality.

1.6 Awareness raising

1.6.1 Base actions to raise awareness of road-traffic-related air pollution on NICE's guidelines on behaviour change (in particular, recommendations on behaviour change interventions and programmes) and community engagement (in particular, on developing a local approach).

1.6.2 Consider providing information on air quality (using the Daily Air Quality Index) with weather forecasts and the pollen index. Provide this through local, national and social media.

General public and businesses

1.6.3 Consider providing the public with information on how:

- health is affected by exposure to air pollutants
- travel choices contribute to pollution and exposure to levels of local pollution
- engine 'idling' affects air quality in the vehicle as well as outside
- to minimise exposure by altering travel habits or routes (this includes restricting time spent with an engine 'idling', particularly near schools).

1.6.4 Make businesses aware that they can reduce road-traffic-related air pollution and improve fuel efficiency. For example, they could consider:

- ensuring their drivers develop an energy-efficient driving style (see recommendation 1.3)
- scheduling deliveries to minimise congestion
- encouraging employees to cycle to work (see NICE guideline on walking and cycling).

At-risk groups

1.6.5 Consider making healthcare professionals aware of the UK Daily Air Quality Index, and that they understand the health effects of long-term exposure to air pollution.

1.6.6 Healthcare professionals could raise awareness of poor outdoor air quality (see recommendation 1.6.3) and advise high risk groups on how to minimise their exposure and its impact. 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.)

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.

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.

Putting this guideline into practice

[This section will be finalised after consultation]

NICE has produced tools and resources [link to tools and resources tab] 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), 18% of PM_{10} and 19.5% of $PM_{2.5}$ 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 at 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 human-produced $PM_{2.5}$ 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[1] (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 relative concentrations of NO_2 and PM_{10}.
- Urban areas tend to have higher levels regardless of socioeconomic status than rural areas, which often have larger populations in the mid-range of deprivation.

[1] 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.)

So 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, pp953 to 1028).

More information

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.

The committee's discussion

Overview

The points in the overview relate to all the recommendations.

Key pollutants

There are various pollutants related to road transport, including carbon monoxide, benzene and volatile organic compounds. 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 particulates 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 counts 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 high levels of air pollution can lead to:

- exacerbation of asthma
- effects on lung function
- 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].

Studies of interventions related to air pollution are often carried out by disciplines other than public health, so focus on environmental or road-traffic-related effects rather than health outcomes. This means that there is not a lot of high quality evidence on health outcomes.

The committee agreed that metrics related to particulates 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 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 particulates (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 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:

- '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 World Health Organization guideline values, including for $PM_{2.5}$, PM_{10} and NO_2, in 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. Supporting a shift to active transport, like walking or cycling, will also lead to potentially substantial health benefits, mainly associated with increased physical activity.

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.

Changes in the way the environment is viewed and used could mean more people socialise in that environment, so improving their mental wellbeing. 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.

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]. Measurements of traffic will also provide the high quality information needed for planning changes.

The committee noted that there was a risk that drivers may readjust their behaviour over time as they become used to the changes. 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 common approach to localised air pollution has been 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 [EP 3]. 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 pollutants, but they have not led to a corresponding reduction in concentrations of NO_x. 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 latest Euro standard (6/VI) requires manufacturers to adhere to tighter standards of emissions. Although NO_x emissions from Euro 6/VI vehicles in normal use may be higher than the standard might suggest, they will be substantially lower than Euro

5/V vehicles. From 2018, emissions tests will include on-road tests as opposed to the laboratory tests that have been used to date.

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 depend on factors specific to the local setting, so this may vary considerably from the case studies.

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.

1.1 Planning

The discussion below explains how the committee made recommendations 1.1.1 to 1.1.5.

Recommendations

Planning new developments

1.1.1 Take air quality issues into account in the Local Plan for new developments. For example:

- Include air pollution in strategic planning across local authority departments and different tiers of local government (including county, district and unitary authorities).
- Assess site plans from an air quality perspective. Consider:
  - Siting new buildings and estates so that the need for motorised travel is minimised.
  - Minimising the exposure of vulnerable groups to air pollution by siting buildings away from busy roads, siting living accommodation away from roadside facades, and ensuring facilities such as schools, nurseries and retirement homes are located in areas where pollution levels will be low.
  - Avoiding the creation of street and building configurations (such as street canyons) that encourage pollution to build up where people spend time.
- Provide an infrastructure to support low- and zero-emission travel. This could include:
  - cycling and walking routes (see recommendation 1.5 and NICE's guideline on walking and cycling)
  - charge points for electric vehicles in residential areas and commercial developments.

1.1.2 If the local plan does not address air pollution, consider developing local guidance (such as Supplementary Planning Documents, see planning practice guidance) on how to design buildings and spaces to improve local air quality.

1.1.3 Consider ways to mitigate road-traffic-related air pollution if the site is likely to generate a significant volume of motorised traffic. For example, think about using:

- travel plans to reduce the number of motorised trips (this could include, parking availability, car clubs and charging facilities for electric vehicles)
- trees and vegetation in open spaces

- vegetation to create 'green' walls or roofs where this does not restrict ventilation.

1.1.4 In consultation with local communities, consider using the Community Infrastructure Levy for air quality monitoring or for infrastructure changes to reduce the risk of poor air quality.

Unintended adverse effects on air pollution

1.1.5 Avoid inadvertently contributing to poor air quality by introducing features on roads and streets that obstruct or alter the way pollutants are dispersed. For instance:

- Where solid barriers are planned alongside major roads (sometimes used to protect local people from noise) consider whether action is needed to mitigate any adverse effects on air quality.
- Take into account the effect that trees can have on street ventilation, based on where they are planted and how they are maintained, to avoid creating areas of poorer air quality.

Rationale and impact

Why the committee made the recommendations

1.1.1 and 1.1.2

The committee agreed that strategic planning can have an important influence on air pollution. This was based on expert testimony [EP6] and committee consensus. Together with the epidemiological evidence on the health impacts of air pollution, particularly for vulnerable groups [EP1], this justified making 1.1.1 a strong recommendation.

The committee acknowledged that the layout of new developments will affect motorised travel and that this should be addressed by incorporating air pollution issues into local documents, in particular local plans and supplementary planning documents. This was based on expert testimony and the committee's expertise.

Suggested approaches to minimising air pollution and its impact included:

- avoiding the creation of buildings and streets that trap pollution (by creating 'street canyons')
- providing the infrastructure to support low- and zero-emission travel modes in areas with a high risk of air pollution.

1.1.3

Evidence on actions to address road-traffic-related air pollution indicated that travel plans could offer an opportunity to re-evaluate journeys to work [ES9.1b] and help a more general move away from car travel [ES9.1a]. Members also noted from their experience that these plans could support low- and zero-emission travel and could be implemented as part of the planning approval process. (Also see 1.1.6 below.)

1.1.4

The committee consensus was that it is appropriate to use funds from developers, via the Community Infrastructure Levy, to address air pollution issues and that this is best carried out in consultation with local communities.

1.1.5

Evidence showed that solid barriers near roads can alter how polluted air is dispersed, changing the air quality for people in other areas [ES4.1a]. So action was recommended to see whether the barriers do have this effect and, if so, to try and mitigate it. But because the evidence was weak this is a 'consider' recommendation.

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 [ES4.4]. The committee noted that planting might add to the attractiveness of an urban environment.

Based on the evidence and committee consensus, a recommendation was made on the need to ensure the planting, siting and maintenance of trees does not restrict street ventilation. Because the evidence was weak, the committee made a 'consider' recommendation.

Why we need recommendations on this topic

Our built environment can affect the emission of road-traffic-related pollutants by influencing how, and how much, we travel. It can also affect the way 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 travelling within) an area.

New building will have an impact on road-traffic-related air pollution for decades, so it is important to ensure the issues are addressed at the planning stage. This may reduce the need for more expensive (and probably less effective) remedial action at a later date.

Solid barriers may reduce some of the adverse effects of major roads, such as noise or visual intrusion. But people regularly travelling or living downwind of a plume of vehicle pollution could experience poorer air quality as a result of a solid barrier. The distance at which this happens is determined by local factors (such as barrier height, wind speed and direction and topography) and this needs to be taken into account.

Some people believe that trees reduce air pollution but this is not always true, and it is important to address this misconception. Their effect is dependent on factors including street design, number and siting of trees, species and canopy density, time of year and wind direction relative to the street.

Leaves and branches slow air currents, causing pollutants to settle out. They may also act as 'sinks' for particulates and chemicals that may have direct or indirect effects on air quality (in particular, volatile organic compounds [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 benefits of properly selected, sited and managed trees.

Impact of the recommendations on practice

The committee felt, from its experience, that air pollution issues were not always incorporated into local plans, making it difficult to reject a proposal that would have adverse effects. Incorporation in local guidance documents would support action to address these effects at the planning stage.

The committee's discussion of the evidence

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 pollutants. The most important of these are:

- ambient levels of particulates, 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. This was from expert paper 1 but was based on the work of the Committee on the Medical Effects of Air Pollution (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 in terms of impact on air pollutants.

- Four studies (3 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 that examined the impact of street trees and vegetation on air pollution [ES 4.4]. All 3 were rated as poor quality (2 from Belgium, 1 from the UK). 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.

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 they may create a canopy that traps air pollution.

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 planning new buildings and using solid barriers and street trees

Benefits include:

- New developments that do not exacerbate poor air quality or expose people to high levels of air pollution and that encourage low- or zero-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 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 planning stage involves no additional cost other than training in relevant issues 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.

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.

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

The committee agreed that local planning and transport officers are best placed to ensure that trees and barriers are used effectively in urban areas.

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 in relation to the benefits of a good quality environment in attracting developers.

The evidence

The committee looked at evidence in:

- Evidence review on environmental change and development planning: ES4.1a, ES 4.1b, ES 4.4.
- Evidence review 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: 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: EP6.

1.2 Clean air zones

The discussion below explains how the committee made recommendations 1.2.1 to 1.2.9.

Recommendations

Clean air zones

1.2.1 Consider introducing a clean air zone in line with the draft national air quality framework in areas outside those targeted by the national plan. It could include restrictions for polluting vehicles as well as action to encourage the use of less polluting ways to travel.

1.2.2 Consider including progressive targets to reduce pollutant levels below the EU limits.

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

- encouraging walking and cycling (see NICE's guideline on walking and cycling)
- actions to encourage uptake of low- and zero-emission vehicles, for instance, electric charging points or use of low- or zero-emission vehicles for deliveries to retail, office, residential or other sites in the zone
- specifying emission standards for private hire and other licensed vehicles.

1.2.4 Consider fuel-efficient driving initiatives such as:

- 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 recommendation 1.3)
- actions to smooth traffic flow (see recommendation 1.4).

1.2.5 Consider public awareness initiatives such as car-free days.

1.2.6 Consider working across local authority boundaries to support action on air pollution and to prevent migration of traffic and emissions to other areas.

Congestion charge zones

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

1.2.8 Consider monitoring outside the congestion zone to identify whether its implementation is causing problems. Monitor the effects in terms of traffic composition and flow. Address specific issues, such as increased pollution at the margins of the congestion zone or problems caused by diversion of traffic, for instance, by changing the boundaries of the zone.

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

Rationale and impact

Why the committee made the recommendations

1.2.1 to 1.2.3

The committee agreed that, based on its experience and in line with evidence from expert testimony, action is needed to reduce the use of polluting vehicles and to encourage a shift to low- or zero-emission travel [ES6.3, EP5].

Members agreed that it was important to aim for consistency across the country, particularly in relation to the vehicle types that are restricted. Basing these restrictions on vehicle classes set out in the draft national air quality framework would provide this consistency. Evidence suggested that low-emission zones could be cost effective [ES6.2].

1.2.2

Members agreed that reducing air pollution below current EU limits would provide more health benefits. Based on evidence, they agreed that stricter targets should be considered [EP1]. Public Health England's report Nitrogen dioxide: health effects of exposure recommended that no lower cut-off point should be used when quantifying the impact of NO_2 exposure. This is because there is a lack of evidence for a lower threshold effect at the population level. Members agreed that targets should be developed with health goals in mind but that, in practice, these will be expressed as air pollution targets.

1.2.3

The committee discussed the potential benefits of low-emission vehicles, as suggested by the modelling studies [ES3.3, ES3.4]. Although this was weak evidence, it 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 [EP5]. The committee agreed that infrastructure (in particular, charging points) is needed to achieve significant uptake of zero- or low-emission motor vehicles.

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.

No direct evidence was found on the use of low- or zero-emission vehicles for local deliveries or for private hire. However, based on the committee's experience, recommendations were warranted because of the large polluting effect of delivery and private hire vehicles.

1.2.4

The evidence on actions to address driving style and traffic flow was weak. But it supported the committee's knowledge of how air pollution is produced. Training to reduce idling and to change driving style is unlikely to have any negative effects. It may help reduce fuel use, resulting in reduced emissions as well as reduced fuel

consumption. So 'consider' recommendations were made on these issues [ES11.1, ES11.2, ES11.4, EP4].

1.2.5

There was weak evidence relating to partial or occasional traffic restrictions that suggested a limited effect [ES5.1]. But the committee agreed that such restrictions offer the opportunity to demonstrate the positive benefits associated with traffic restriction. So the consensus was that it is reasonable to use them as part of occasional awareness-raising activities.

1.2.6

Both 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. Because the evidence is weak this is a 'consider' recommendation.

1.2.7 to 1.2.9

Evidence, together with the committee's experience, suggested that congestion charging could contribute to a package of measures and incentives to address air pollution [ES6.1, ES6.2]. Because some of the evidence was weak, some of the recommendations are 'consider' recommendations.

Members agreed that it is important to make it clear that charges or fines are not used to generate profits, but rather for other activities to reduce air pollution. However, there was no direct evidence to support this belief. In addition, making a recommendation to restrict the way local government allocates funds was beyond the remit of the guideline.

Members agreed that it was important to monitor outside the zone to identify whether charging restrictions lead to traffic moving elsewhere and resulting in poor air quality in those areas. They also agreed that adjustments should be made in such cases. This was based on weak evidence so this is a 'consider' recommendation.

The committee agreed that the potential impact of charging should be taken into account when developing schemes because charging may affect some groups more than others and so impact on inequalities.

Why we need recommendations on this topic

Wide-ranging action is needed to improve air quality in many cities but the lack of a comprehensive approach may make the situation worse. For example, the use of '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. (For example, it may encourage people to own and use 2 cheaper, older and more polluting vehicles rather than a single, more expensive but cleaner vehicle.)

Action needs to be coordinated across the country. In particular, different vehicle types should be classed in the same way in all clean air zones. The committee agreed that the classes set out in the draft national framework should be used unless, or until, these are amended in a subsequent version.

Moderate evidence shows that existing low-emission zones (the current nearest equivalent to a clean air zone) have only slightly improved air quality [ES6.3]. This is partly because of the failure of new technology to reduce individual vehicle emissions under real driving conditions [EP2]. But it is also probably linked to the limited scope of existing low-emission zones, in terms of the types of vehicles restricted and the failure to address the overall volume of traffic.

Reducing air pollution to levels below the EU limit for NO_2 will lead to a range of health benefits, so the EU limit should not be seen as a threshold below which air pollution is not a health issue.

Congestion charging could help reduce air pollution. Encouraging a move to the use of low- and zero-emission vehicles will also help. But other measures, both to reduce traffic and to encourage a shift to less polluting and zero-emission vehicles, are needed and this is best achieved through a wide-ranging clean air zone.

Reductions in congestion would have a positive effect on air pollution beyond the reduction in total vehicle kilometres travelled. Stop–go driving emits higher levels of pollutants than free-flowing traffic, so increasing the total pollutant load. Vehicle users in congested traffic also spend more time stationary, where air quality is likely to be at its poorest.

Impact of the recommendations on practice

The committee noted that some places are taking concerted action to address air pollution but clean air zones, as such, do not yet exist. Planning, transport and environment departments need to work together across the country to ensure a consistent approach. This is likely to need a change in current practice.

The committee's discussion of the evidence

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 pollutants:

- Particulates, 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 that examined congestion charging zones (from Milan and Stockholm) suggested that they were cost effective, although local factors mean that they are only partially applicable to the UK [ES6.2].
- Four modelling studies of the use of alternative fuels [ES3.3] (3 poor quality from Spain and 1 moderate 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. 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 not to the extent that committee members disagreed with the evidence from their expert perspectives. The study from Italy found some reduction in elements of vehicle-related air pollution.
- Three moderate-quality cost effectiveness studies 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 Canada [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 low- or zero-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 that are limited in terms of class of vehicles restricted or geographical area covered not reducing emissions 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 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 (BCR) 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 BCR 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 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).

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.

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 are required to sign off an air quality management action plan. 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 the schemes risked reducing their effectiveness and antagonising the public. These include the perception that charging 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 on environmental change and development planning: ES3.3, ES3.4.
- Evidence review on traffic management and enforcement, and financial incentives and disincentives: ES5.1, ES6.1, ES6.2, ES6.3.
- Evidence review on travel planning and advice: ES11.1, ES11.2, ES11.4.
- Expert testimony on epidemiology: Expert paper 1.
- Expert testimony on national and local frameworks for action: Expert paper 2.
- Expert testimony on the use of Euro Standards to control vehicle emissions: Expert paper 3.
- Expert testimony on evidence relating to influencing driving behaviours for fleet drivers and others: Expert paper 4.
- Expert testimony on the proposed Clean Air Zones: Expert paper 5.

1.3 Reducing emissions from public sector transport services and vehicle fleets

The discussion below explains how the committee made recommendations 1.3.1 to 1.3.6.

Recommendations

Driver training for public sector transport services and vehicle fleets

1.3.1 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.

1.3.2 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 when practical and safe when parked by the roadside, and when dropping off people or deliveries.
- Maintaining vehicles, including pumping up tyres to the recommended pressure.
- Emphasising that reducing vehicle emissions will reduce both fuel costs and air pollution.

1.3.3 Consider including an ‘in-vehicle’ element (for instance, ensure vehicles display information about current fuel efficiency, appropriate gear selection and speed in real time), or telematics (to provide next-day information about driving style).

1.3.4 Consider monitoring fuel efficiency and providing feedback to drivers after training. This could include providing practical help from colleagues or 'buddies' and rewards (see NICE's guideline on behaviour change).

1.3.5 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.

Procuring public sector vehicles

1.3.6 Consider making the minimisation of vehicle emissions (NO_2 and particulates) a factor when making routine procurement decisions. This could include selecting low-emission vehicles, including electric vehicles.

Rationale and impact

Why the committee made the recommendations

1.3.1 to 1.3.5

Weak evidence showed that 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 [ES11.1 ES11.2, ES11.3, ES11.4, EP4].

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 [ES11.1, ES11.2, ES11.4]. The committee heard expert testimony 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% [EP4].

Based on members' own experience, the committee agreed that providing support to help people change their driving style was justified because the recommendation was likely to be cost neutral (based on fuel efficiency savings). The evidence was not strong so the committee made a 'consider' recommendation.

1.3.6

The committee agreed that procurement of the right type of vehicles is important when aiming to reduce road-traffic-related emissions. Members noted that this could be done as older vehicles are replaced. Because the evidence was weak, the committee made a 'consider' recommendation.

Why we need recommendations on this topic

Only around 20% of people employed as drivers have been provided with training on efficient driving by their employer [EP4]. The extent of training in the public sector is not known. To reduce air pollution we need to increase the numbers providing this type of training.

The public sector transport fleet is targeted because this sector has a duty to address its environmental impact, reduce emissions and promote the public’s health and wellbeing. In addition, its fleet is substantial. It includes many vehicle types and many are highly polluting (from local authority refuse vehicles and goods vehicles to lease cars and patient transport vehicles).

Encouraging procurement of low- or zero-emission vehicles will further reduce the impact on air quality from the public sector vehicle fleet.

It is important to give drivers information about the impact of their driving on air pollution, and about practical ways to reduce their contribution.

Impact of the recommendations on practice

Public sector training programmes to improve energy-efficient driving skills already exist. For instance, the Bart's Health cleaner fleets, healthier streets campaign notes a 63% improvement in 4 behaviours (harsh acceleration, over-revving the engine, harsh cornering and harsh breaking) in the first month of the campaign.

But because these programmes are not universal or widespread, a recommendation was needed to reduce variability. There is a well-developed process for making public sector procurement decisions. But air pollution concerns are not always a part of this.

The committee's discussion of the evidence

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 Canada [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 feed back 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. 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 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.

1.4 Smooth driving and speed reduction

The discussion below explains how the committee made recommendations 1.4.1 to 1.4.3.

Recommendations

Smooth driving on motorways and major roads

1.4.1 Consider using variable speed limits and average speed technology on the roadside to promote a smoother driving style. Incorporate real-time information to tell drivers what the current optimum driving speed is.

Reduced speed in urban areas

1.4.2 Where speed reduction is needed to reduce road danger and injuries (see NICE's guideline on preventing road injuries), take account of the potential adverse impact on air pollution. Consider 20-mph zones in residential areas characterised by stop–go traffic where this will reduce accelerations and decelerations. Where physical measures are needed to reduce speed, such as humps and bumps, ensure they are designed to minimise sharp decelerations and consequent accelerations.

1.4.3 Consider using signs that display a driver's current speed to reduce unnecessary accelerations.

Rationale and impact

Why the committee made the recommendations

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 pollutants [ES6.4, ES11.1]. This was supported by the committee's understanding of air pollution and the effect of accelerations and deceleration. The evidence was weak so this was a 'consider' recommendation.

Evidence on traffic-calming measures such as speed bumps suggested that these may increase emissions by adding to decelerations and accelerations [ES5.2]. Evidence from area-wide schemes does not show increases [ES5.3]. So where physical measures are needed to reduce road injuries they should be designed to

minimise their impact on air pollution. The evidence was weak so this was a 'consider' recommendation.

Why we need recommendations on this topic

Ensuring motorists drive steadily at the optimum speed can help reduce stop–go driving and so improve fuel consumption and reduce emissions.

Reducing speed in residential areas can help encourage walking and cycling (see NICE's guideline on walking and cycling), rather than using motor vehicles. This in turn will reduce emission of pollutants.

Impact of the recommendations on practice

Variable speed limits are in use. But they could be used more widely to promote a steady flow of traffic. Actions to reduce speed in residential areas are increasingly common and are important for reducing road danger and injuries. But they do not always take into account the impact on air pollution. It is important that effective methods to slow traffic are used, that do not result in hard decelerations.

The committee's discussion of the evidence

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 levels of 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 may support a modal shift to walking and cycling. This will reduce emissions of air pollutants.
- Reduced speeds may reduce 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, BCR 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 1.3.1 to 1.3.6. Recommendations 1.4.1 to 1.4.4 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 on traffic management and enforcement, and financial incentives and disincentives: ES5.2, ES5.3, ES6.4.
- Evidence review on travel planning and advice: ES11.1.

1.5 Cycle routes

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

Recommendations

1.5.1 Avoid siting cycle routes on highly polluted roads. Ideally use off-road routes or quiet streets.

1.5.2 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 reducing street ventilation so that air pollution can disperse.
- Reducing the time cyclists spend at busy sites, including some junctions, where this can be done without increasing the time that other groups spend exposed to poor air quality.

Rationale and impact

Why the committee made the recommendations

Evidence suggested that increasing the space between cyclists and motor traffic helps protect cyclists from air pollution [ES3.1]. This evidence agrees with the

committee's understanding of the sources and dispersal of air pollutants, so this is a strong recommendation.

Where it is not possible to create cycle routes off-road or using quiet streets, the evidence showed that separating cycle routes from motor traffic and reducing the time spent in areas of high pollution helps protect cyclists.

Committee consensus was that providing as much space as possible between the cyclist and motorised vehicles was important to reduce their exposure to air pollution, as was reducing the time they are made to spend at busy sites.

Using hedges as barriers may sometimes help protect cyclists, but the impact on the distribution of pollutants needs to be taken into account [ES3.1, ES4.1b]. The committee agreed that the evidence supported its understanding of the dispersal of pollutants.

The evidence for these actions was weak so this is a 'consider' recommendation.

Why we need recommendations on this topic

Good route design will help protect cyclists from road-traffic-related air pollution. It may also encourage more people, including motorists, to cycle. A shift to low- and zero-emission modes of transport is key to addressing road-transport-related air pollution.

Impact of the recommendations on practice

The resource impact on the public sector is likely to be negligible if the recommendations are implemented at the design stage of new cycle routes. Although many areas have taken action to support cycling, members noted that this was not universal and that exposure to air pollution was often not considered in design.

The committee's discussion of the evidence

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. So the evidence supported a weak recommendation.

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 BCR 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 on environmental change and development planning: ES 3.1, ES4.1b.

1.6 Awareness raising

The discussion below explains how the committee made recommendations 1.6.1 to 1.6.6.

Recommendations

1.6.1 Base actions to raise awareness of road-traffic-related air pollution on NICE's guidelines on behaviour change (in particular, recommendations on behaviour change interventions and programmes) and community engagement (in particular, on developing a local approach).

1.6.2 Consider providing information on air quality (using the Daily Air Quality Index) with weather forecasts and the pollen index. Provide this through local, national and social media.

General public and businesses

1.6.3 Consider providing the public with information on how:

- health is affected by exposure to air pollutants
- travel choices contribute to pollution and exposure to levels of local pollution
- engine 'idling' affects air quality in the vehicle as well as outside
- to minimise exposure by altering travel habits or routes (this includes restricting time spent with an engine 'idling', particularly near schools).

1.6.4 Make businesses aware that they can reduce road-traffic-related air pollution and improve fuel efficiency. For example, they could consider:

- ensuring their drivers develop an energy-efficient driving style (see recommendation 1.3)
- scheduling deliveries to minimise congestion
- encouraging employees to cycle to work (see NICE guideline on walking and cycling).

At-risk groups

1.6.5 Consider making healthcare professionals aware of the UK Daily Air Quality Index, and that they understand the health effects of long-term exposure to air pollution.

1.6.6 Healthcare professionals could raise awareness of poor outdoor air quality (see recommendation 1.6.3) and advise high risk groups on how to minimise their exposure and its impact. 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.)

Rationale and impact

Why the committee made the recommendations

Evidence on the extent of the impact of air pollution on health justified action to raise awareness of its impact and ways to reduce it [EP1].

The committee agreed that community support is always important when aiming for sustainable changes in behaviour. This supported the evidence on interventions to change behaviour related to air pollution [EP4]. Achieving wide-scale change also involves raising awareness among professionals and decision makers. Members noted that this is in line with other NICE guidelines and so supports a stronger recommendation.

The committee felt that it was reasonable to make businesses aware of the need to reduce air pollution. Members noted that better scheduling to avoid delivery vehicles being used when streets are congested might help to reduce pollution.

The committee consensus was that social marketing techniques were important and that texting and patient forums were useful ways to disseminate information about daily levels of air pollution (from the Daily Air Quality Index), particularly to vulnerable groups. Because the evidence was weak the committee made 'consider' recommendations.

Why we need recommendations on this topic

Technological and planning changes are needed to reduce emissions of pollutants from motor vehicles. But changes to individual behaviour are also needed to reduce both emissions and exposure. To achieve this we need to ensure that everyone understands why the changes are needed and the benefits that they will bring.

Public support for changes is important, both to ensure the changes themselves are successful and to help develop a positive working relationship with the community. Without such support changes are unlikely to be unsustainable, and implementing them would be unethical.

It is also important to address misperceptions about the impact of short-term high levels of air pollution compared with that of chronic exposure (over years) to typical levels of air pollution. The latter causes most of the long-term public health problems.

Understanding the links between health and air pollution is also important to underpin support for the other changes recommended in the guideline.

Information provided by healthcare professionals is likely to be important in highlighting the health impacts of air pollution. So it is important to ensure they are aware of the facts and can communicate them to vulnerable groups.

Impact of the recommendations on practice

Healthcare professionals are unlikely to routinely raise air pollution as an issue affecting health. This will probably be a change in practice, as will local authorities raising awareness about air pollution with businesses and the public.

The committee's discussion of the evidence

Interpreting the evidence

The outcomes that matter most

Reduced exposure to air pollution (NO_2 and particulates) 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.

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 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:

- Expert testimony on epidemiology: EP1.
- Expert testimony on influencing driving behaviours for fleet drivers and others: 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. It 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. It felt that the results would be unlikely to be replicated in the UK because of differences in climate. It 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, it 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 on road transport-related air pollution identified a number of gaps. These gaps are set out below.

1. 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 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.)

4. Effectiveness of advice and warnings on air pollution for the general public and people at particular risk:

a) Air pollution forecasts and real-time data.

b) Air pollution early warning alerts by text or email.

c) Air pollution early warning or monitoring information using web- or app-based geographical systems.

(Source: Evidence review on travel planning and other initiatives providing information, advice, education and skill development.)

Recommendations for research

The guideline committee has made the following recommendations for research.

1 Barriers and street trees

What factors influence how barriers and street trees impact on urban air quality?

Why this is important

There is limited evidence on how barriers and street trees influence urban air quality. Information is needed because they are often used – either to address air pollution or for other purposes.

Research is needed into how barriers and trees in an urban setting influence the distribution of air pollutants. Factors should include:

- size and position of barriers
- impact of different species of tree
- where trees are sited and how they are maintained.

2 Promoting a shift in travel modes

What methods are effective at promoting a modal shift to low and zero-emission modes of travel?

Why this is important

Achieving a shift to low- and zero-emission modes of travel is key to reducing air pollution. This includes identifying approaches that encourage more efficient, less polluting driving behaviour.

Studies are needed to identify the most effective and cost effective approaches and messages for different population groups and in different settings.

3 Clean air zones

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

Why this is important

Clean air zones are new developments to address air quality and are likely to vary across the country. It is important to use this opportunity to identify which elements are most effective at reducing air pollution and supporting a modal shift to low- or zero-emission travel.

Studies will evaluate complex interventions. Research should also examine segmentation of travel behaviours relating to clean air zones to inform how public awareness and social marketing approaches.

4 Telematics

How effective is it to gather information about driving style using telematics devices and other technological changes (such as apps or in-car global positioning system [GPS]) at reducing individual fuel consumption and vehicle emissions?

Why this is important

Evidence suggested that information and training can help drivers change their driving style. New developments in telematics mean driving style (and so, fuel consumption) can be evaluated. 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.

5 Air alerts

Are air quality alerts effective in changing people's exposure to poor air quality?

Why this is important

Air quality alerts (using several approaches, including traditional and social media) 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 either to stop any strenuous physical exertion, particularly outdoors, when air quality is poor, or to avoid other activities (such as driving polluting vehicles) that may make air quality worse. There is also little information on whether alerts affect people’s ability to avoid negative health outcomes.

Research on the absolute and relative effect of different approaches could be used to develop effective and cost effective systems. Studies could also consider the risk of adverse effects (such as raising unnecessary worries or increasing the level of vehicular travel after an alert).

6 Exposure to air pollution using different modes of transport

How does altering the 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 reduces emissions of air pollutants. But walking and cycling 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.

Glossary

Average speed zones

Areas where video systems with automatic number plate reading (ANPR) digital technology are used. Cameras are 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 along it.

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 standard

Standards produced by EU Directives specifying maximum permitted emissions of various 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 quantity of particulates 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 pollution reacts with the atmosphere. $PM_{2.5}$ particles are sometimes referred to as 'fine particulates', and $PM_{2.5–10}$ as 'coarse particles'. Fine particles can penetrate deep into the lungs.

Street canyons

Street canyons are generally defined as narrow streets where the buildings on both sides of the road are taller than the road width. This leads to the formation of vortices and recirculation of air that can trap pollutants and restrict dispersion.

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 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 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 negative transport impacts of development to promote sustainable development. They are needed for all developments that generate significant amounts of traffic.

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

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