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REVIEW

Local action on outdoor air pollution to improve public health

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Abstract

Objectives The National Institute for Health and Care Excellence, jointly with Public Health England, have developed a guideline on outdoor air pollution and its links to health. The guideline makes recommendations on local interventions that can help improve air quality and prevent a range of adverse health outcomes associated with road-traffic-related air pollution.

Methods The guideline was based on a rigorous assessment of the scientific evidence by an independent advisory committee, with input from public health professionals and other professional groups. The process included systematics reviews of the literature, expert testimonies and stakeholder consultation.

Results The guideline includes recommendations for local planning, clean air zones, measures to reduce emissions from public sector transport services, smooth driving and speed reduction, active travel, and awareness raising.

Conclusions The guideline recommends taking a number of actions in combination, because multiple interventions, each producing a small benefit, are likely to act cumulatively to produce significant change. These actions are likely to bring multiple public health benefits, in addition to air quality improvements.

Keywords Air pollution · Air quality · Road traffic · Emissions · Interventions · Public health

Introduction

Air pollution has a very significant impact on the public's health, globally accounting for about 4.2 million deaths in 2015 and ranking 5th worldwide among all risks including high blood pressure, smoking, and diet (HEI 2017). In England, 4.7% of adult mortality from all causes in 2015 was attributable to outdoor air pollution measured as human-made particulate matter ($PM_{2.5}$) (PHOF 2017). Although a lot of progress has been made in controlling emissions from industry, power generation and domestic sources in high income countries over the decades following the Great London Smog of 1952, air pollution stubbornly remains one of the main public health problems of the 21st century (Landrigan et al. 2018).

Exposure to air pollution over several years has been found to reduce life-expectancy, mainly due to an increased risk of cardiovascular and respiratory illness and lung cancer, while short-term (day-to-day) exposure can aggravate respiratory and cardiovascular conditions, and trigger asthma attacks and premature deaths (RCP 2016; Di et al. 2017). The World Health Organization's (WHO) International Agency for Research on Cancer (IARC) has classified outdoor air pollution, and diesel engine exhaust in particular, as carcinogenic to humans (Loomis et al. 2013; Benbrahim-Tallaa et al. 2012). There is also emerging evidence of possible links with diabetes, obesity,

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SV was Topic Expert Member, RK Public Health Technical Adviser, and PL Chair of the NICE Public Health Advisory Committee on Outdoor Air Pollution; PC is Medical Director of Public Health England, an Executive Agency of the Department of Health; SH was Chair and JG vice-Chair of the working party on air pollution of the Royal College of Physicians and the Royal College of Paediatrics and Child Health; FK is Chair and JG a Member of the Committee on the Medical Effects of Air Pollutants; SV, SH and FK are Members of a Dyson advisory board; SV is co-Chair of Healthy-Polis (International Consortium for Urban Environmental Health and Sustainability) and has honorary academic appointments with Exeter University Medical School and the London School of Hygiene and Tropical Medicine.

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cognitive decline, dementia, and various adverse birth outcomes (RCP 2016).

Air pollution from traffic may play a role in inducing asthma in some individuals, particularly those who live near busy roads carrying high numbers of heavy goods vehicles (COMEAP 2010). The link between air pollution and reduced lung function growth has been strengthened by a study of children's health in California that reported improvements in lung development in children following a reduction in levels of air pollution (Gauderman et al. 2015). This highlights that taking action to reduce levels of air pollutants could potentially allow more young people to achieve their maximum lung function growth potential (Gilliland et al. 2017).

A significant proportion of outdoor air pollution we experience today, particularly in cities, is associated with road traffic (exhaust emissions, as well as particles from tyre, brake and road surface wear), although emissions from other local and distant sources also make significant contributions. The main traffic-related pollutants of concern in European cities are $PM_{2.5}$ and nitrogen dioxide (NO_2). In the UK, traffic is on average responsible for around 80% of NO_2 concentrations at roadside locations, with diesel vehicles the largest source in the most affected areas. This is due to both the significant growth in vehicle numbers, particularly light passenger and commercial diesel vehicles, and failures of the manufacturers of these vehicles to ensure that they meet emissions limits in real world driving conditions (Defra 2017a).

Effective control of traffic-related air pollution requires national action, supplemented by action by local authorities, as well as public health and healthcare professionals, employers in all sectors, and the public (Wang et al. 2016). To address the need for evidence based measures, the National Institute for Health and Care Excellence (NICE), jointly with Public Health England (PHE), have published a guideline on the effectiveness of local interventions aiming to reduce emissions, ambient concentration levels and personal exposure to road-traffic-related air pollution (NICE 2017a).

Methods

The NICE and PHE guideline on outdoor air pollution was based on a scoping exercise, systematic evidence reviews, stakeholder consultation, and economic analysis, following methods and processes outlined in Developing NICE guidelines: the manual (NICE 2017b).

The systematic evidence reviews included a wide range of studies (observational, modelling, randomised and non-randomised control trials, and cost-effectiveness studies) published from 1995 to 2015, focusing on local interventions. A systematic search of relevant databases and websites was conducted. The following sources were searched: (1) Databases: MEDLINE and MEDLINE in Process (OVID), Embase (OVID), Health Management Information Consortium (HMIC) (OVID), Social Policy and Practice (OVID), CENTRAL (Wiley), Cochrane Database of Systematic Reviews (Wiley), DARE (Wiley), Transport (OVID), Greenfile (EBSCO), NHS EED (legacy database) (Wiley), EconLit (OVID), and Bibliomap; (2) Websites: Google/Google Scholar, Department for Transport, Transport Research Laboratory, Passenger Transport Executive Group, Transport Research & Innovation Portal, National Institute for Public Health and the Environment (RIVM, The Netherlands), and Department for Environment, Food, and Rural Affairs (Defra, UK). A call for evidence from stakeholders was also undertaken to help identify additional relevant evidence.

The detailed protocols outlining the methods for the review, including the search protocols and methods for data screening, quality assessment and synthesis are available online (NICE 2016). All references from the database searches and call for evidence were screened on title and abstract against the criteria set out in the protocols. A random sample of 10% of titles and abstracts was screened by two reviewers independently. Full-text screening was also carried out by two reviewers independently on 10% of papers. Agreement at these two stages was 97 and 93%, respectively. Each included study was data extracted by one reviewer, with all data checked in detail by a second reviewer. Included studies were rated individually to indicate their quality using a checklist (NICE 2017b, Appendix H). Any differences were resolved by discussion.

Included studies were grouped into the following categories: (1) planning and development management, (2) clean air zones, (3) reducing emissions from public sector transport services and vehicle fleets, (4) smooth driving and speed reduction, (5) walking and cycling, and (6) awareness raising. The evidence from these reviews, and additional expert testimonies, were scrutinised by an independent advisory committee, with input from public health professionals and other professional groups via a formal consultation. Whilst the guideline makes recommendations for interventions in England, it was informed by published evidence from around the world, and is thus relevant to other, particularly high income countries. The key areas for action and recommendations (summarised in Table 1) are briefly discussed in this article.

Table 1 National Institute for Health and Care Excellence and Public Health England guideline on outdoor air pollution: key recommendations

Recommendation	Targeted towards	Rationale	Example actions	Key references
1. Planning and development management	Local government Transport authorities Local Health and Wellbeing Boards	The built environment can affect the emission of road traffic related air pollutants Air pollution is not always incorporated into local plans Physical features (buildings, trees, etc.) affect air pollution dispersion Urban vegetation plays an important part in the urban landscape. It provides a number of physical and mental health benefits	Reduce the need for motorised trips through improved planning Charge points for electric vehicles in workplaces, commercial developments and residential areas Support car sharing schemes, such as car clubs Site schools, nurseries and nursing homes away from busy roads Ensure good vegetation canopy design and maintenance	Al-Dabbous and Kumar (2014), Brantley et al. (2013), Baldauf et al. (2016), Hagler et al. (2012), Ning et al. (2010), Pugh et al. (2012), Vos et al. (2013), Vranckx et al. (2015) and Watts and Stephenson (2000)
2. Clean air zones	Local government	Area wide action is needed to reduce the use of polluting vehicles and to encourage a shift to zero- and low-emission travel Clean air zones can support the transition to a low emission economy and sustainable growth People living in deprived areas are more likely to be exposed to higher levels of air pollution and so might gain more from changes that reduce it Targets to progressively reduce pollutant levels below current UK and EU limits, aiming to meet WHO air quality guidelines, will provide additional public health benefits	Access restrictions on certain classes of vehicles Electric charging points Vehicle no idling zones, particularly outside schools, hospitals and care homes Improved road layout and traffic management Improved infrastructure for walking and cycling Low emission park and ride schemes	Chong et al. (2014), Cohen (2005), Cohen et al. (2003), Goncalves et al. (2009a, b), Krutilla and Graham (2012), Soret et al. (2014), Atkinson et al. (2009), Boogaard et al. (2012), Casale et al. (2009), Elliason (2009), Fensterer et al. (2014), Invernizzi et al. (2011), Jones et al. (2012), Kelly et al. (2011), Lee et al. (2005), Levy (2013), Levy et al. (2006), Morfeld et al. (2014), Panteliadis et al. (2014), Qadir et al. (2013), Quiros et al. (2013) and Rotaris et al. (2010)
3. Reducing emissions from public sector transport services and vehicle fleets	National Health Service (NHS) Emergency response (ambulance, police, fire brigade) Local government (e.g. refuse vehicles) Company fleet managers	Public and private sector fleets are a substantial source of air pollution Travel and transport linked to NHS generate around 5% of UK road traffic, contributing to air pollution, accidents and noise Changes to driving style can lead to lower levels of local pollution and fuel consumption Training public sector staff may have the additional benefit of altering their driving habits outside work and helping to make these habits the norm more generally	Assessing employee fuel efficient driving and providing driver feedback and training Making low vehicle emissions one of the criteria when making routine procurement decisions Encouraging NHS staff and patients to walk and cycle	Barth and Boriboonsomsin (2009), Campbell-Hall and Dalziel (2011), Caulfield et al. (2014), Eghbalnia et al. (2013), Rutty et al. (2013) and Ryan et al. (2013)
4. Smooth driving and speed reduction	Local government Transport authorities Businesses and the public	Smoother driving and reduced 'stop–go' reduces emissions of air pollutants Smoother driving also reduces fuel consumption Reduced traffic speed in urban areas reduces road danger which supports a modal shift to walking and cycling	Reduced traffic speed limits in residential areas Use average speed technology on the roadside and real-time information to tell drivers what the current optimum driving speed is 20 mph limits to reduce speeds in urban areas	Atkinson et al. (2009), Invernizzi et al. (2011), Ahn and Rakha (2009), Boulter et al. (2001), Ghafghazi and Hatzopoulou (2014, 2015), Layfield et al. (2003), Kelly et al. (2011), Owen (2005) and Barth and Boriboonsomsin (2009)

Table 1 (continued)

Recommendation	Targeted towards	Rationale	Example actions	Key references
5. Active travel	Local authority	A shift from motor vehicles to more active travel can bring multiple health benefits mainly associated with increased physical activity It reduces carbon emissions from transport, in addition to reducing local air pollution It promotes greater level of social interaction within neighbourhoods Well-designed cycling and walking routes (segregated or sheltered from heavy traffic) can reduce personal exposure to air pollution	Improve urban infrastructure for walking and cycling Provide a choice of cycle routes, ideally quiet streets or segregated routes Use dense foliage to screen cyclists from motor vehicles, without reducing air pollution dispersion or the visibility or safety of cyclists near junctions	Bean et al. (2011), Boogaard et al. (2009), Hatzopoulou et al. (2013), Jarjour et al. (2013), Kendrick et al. (2011), MacNaughton et al. (2014), Al-Dabbous and Kumar (2014), Brantley et al. (2013) and Hagler et al. (2012)
6. Awareness raising	Local government Healthcare and public health professionals	Exposure to air pollution affects health over the life course, not just during poor air quality episodes Changes in daily behavior (e.g. stopping car idling, smoother driving style, and replacing short car journeys with walking and cycling) can reduce emissions and exposure to air pollution Increased awareness can improve the acceptability of policies aiming to reduce emissions from road traffic	Provide information on air quality and related health impacts through traditional and social media Display air quality information in hospitals, bus stops, railway stations, shopping areas etc. Support public awareness initiatives such as car-free days and anti-idling campaigns Advice to business, patients and the public on how to reduce own travel emissions and exposure to air pollution	Casale et al. (2009), Lee et al. (2005), Levy (2013), Levy et al. (2006) and Quiros et al. (2013)

Results

Planning and development management

A key recommendation is that air pollution considerations should be included in planning by all tiers of local government, as well as regional bodies and transport authorities. Local plans (such as core local strategies, local transport plans, and health and wellbeing strategies) should aim to reduce the number of motorised trips and promote zero- and low-emission travel, including support for cycling and walking (NICE 2012). Strategies could include provision of charge points for electric vehicles and support for car sharing schemes such as *car clubs*.

The siting and design of new buildings, facilities and estates could reduce the need for motorised travel and minimise the exposure of vulnerable and disadvantaged groups to air pollution, for example by not siting schools, nurseries and care homes in areas where pollution levels are likely to be high. In 2013, 25% of all schools within London were in areas that exceed the annual mean NO_2 EU limit value (Brook and King 2017).

Siting living accommodation away from roadsides and avoiding the creation of street and building configurations, such as deep street canyons, that encourage pollution to build up would also reduce exposure (Vardoulakis et al. 2003). Particular attention needs to be given to those who are subject to other socioeconomic inequalities, as they are particularly susceptible to the adverse effect of air pollution (RCP 2016). There is evidence that populations living in the most deprived areas in London are on average more exposed to poor air quality, particularly NO_2, than those in less deprived areas (Brook and King 2017).

Street trees and green walls or roofs have a mixed effect on air quality: in some cases they restrict street ventilation causing poorer air quality, in others, they improve it. The

effect of street vegetation on air quality depends on several factors including street configuration and canopy design. Managing urban vegetation (e.g. by the choice of species, siting and pruning regimes) to reduce the risk of restricting natural ventilation at street level and maximise the potential benefits related to air quality is important (Salmond et al. 2016). There are additional benefits associated with well-designed and maintained urban green spaces, including urban heat island mitigation (Heaviside et al. 2017), opportunities for physical activity and social interaction, and improved mental health and wellbeing.

Clean air zones

Area-wide action is needed in cities to reduce the use of polluting vehicles and to encourage a shift to low- or zero-emission travel. This action may include access restrictions for motor vehicles, as well as other measures promoting active travel and optimising traffic management.

Existing low-emission zones based on access restrictions for heavy duty vehicles have been marginal in improving air quality in European cities (Holman et al. 2015). While this is partly because of the failure of new technology to reduce individual vehicle emissions under real world driving conditions, it is also due to the limited scope of pollution reduction strategies and current low-emission zones, e.g. in terms of class of vehicles restricted, and the lack of any success in addressing the overall volume of road traffic. The guideline encourages local authorities to consider introducing clean air zones that include restrictions on certain classes of vehicle and support active and low-emission travel. This may include targets to progressively reduce pollutant levels below current UK and EU limits, aiming to meet WHO air quality guidelines (which are more stringent than EU limit values for $PM_{2.5}$) (WHO 2006). Furthermore, clean air zones should aim to reduce ambient concentration of pollutants across the whole zone, rather than focussing on air pollution hotspots.

The guideline recognises the need to work across local authority boundaries to address regional air pollution and prevent migration of traffic and emissions to other areas, and develop integrated public transport networks, including park and ride schemes, based on low-emission vehicles. Local authorities could take action to reduce emissions within clean air zones by introducing fuel-efficient driving initiatives, such as no vehicle idling areas, and minimising congestion caused by delivery schedules. Where traffic congestion is contributing to poor air quality, local authorities could consider incorporating congestion charging zones within clean air zones.

Reducing emissions from public sector transport services and vehicle fleets

Procurement of the right type of vehicles in the public and commercial sectors is important when aiming to reduce traffic-related emissions. In many countries there is a well-developed process for making public sector procurement decisions, but air pollution concerns are rarely a consideration. Therefore, making low vehicle emissions of nitrogen oxides and particles one of the criteria when making routine procurement decisions is encouraged. This can include selecting low-emission and electric vehicles, which will reduce air pollution as well as carbon emissions.

Travel and transport linked to the National Health Service (NHS) in particular generate a significant share (around 5%) of UK road traffic, contributing to air pollution, accidents and noise. The recently released Health Outcomes of Travel Tool (SDU 2017) provides an assessment of these impacts that can help NHS organisations make the business case for sustainable travel and transport strategies. This may include switching to electric vehicles, using technology to reduce patient and staff travel, and encouraging staff and patients to walk and cycle.

Public sector training programmes to improve energy-efficient driving skills are not widespread. Therefore, the guideline encourages employers to consider introducing fuel-efficient driving tests when they appoint, appraise or train staff drivers to reduce their vehicle emissions. In-vehicle telematics technology could help improve driving style to reduce fuel consumption and air pollution.

Smooth driving and speed reduction

Smooth driving style improves fuel consumption. Ensuring motorists drive steadily at the optimum speed helps reduce stop–go driving and so reduce exhaust emissions as well as particles emitted from brake wear. Furthermore, reducing traffic speed in residential areas can help encourage walking and cycling, and reduce road danger and injuries. The guideline recommends promoting a smoother driving style using speed limits and average speed technology on the roadside, as well as real-time information to tell drivers what the current optimum driving speed is. This may involve 20 mph speed limits in urban areas, without physical measures such as traffic *humps* and *bumps* that may inadvertently cause accelerations and decelerations, as well as signs that display a driver's current speed.

Active travel

A shift from motor vehicles to more active travel can bring multiple health benefits mainly associated with increased

physical activity (NICE 2012). Replacing car journeys with walking and cycling will reduce carbon emissions from transport which will help mitigate climate change, in addition to reducing $PM_{2.5}$ and NO_2, and promote greater level of social interaction within neighbourhoods (Hart and Parkhurst 2011). It is important that this modal shift is done in a way that minimises exposure of cyclists and pedestrians to air pollution by providing support for active transport, including a choice of routes that enable them to avoid highly polluted roads if they choose to. Cycling in quiet streets or segregated routes generally minimises exposure to air pollution. Where busy roads are used, provision of space or dense foliage where possible between cyclists and motor vehicles (without reducing air pollution dispersing or visibility of cyclists near junctions) is recommended. Good cycle route design will improve road safety and help protect cyclists from air pollution, which may encourage more people, including motorists, to cycle.

Awareness raising

There is a broader need to raise awareness of the impact of road-traffic-related air pollution on health to change people's behaviour. It is important to ensure public health and healthcare professionals are aware of the information available on air pollution and health, and on actions recommended, particularly for patients and other sensitive population groups such as young children and pregnant women. Communicating the scale of the health risks and opportunities is important, as it was in effective tobacco smoke-free campaigns. Approaches to raising awareness of air pollution, including information in primary care and hospital settings and more widely in places where people congregate (e.g. bus stops, rail stations, shopping areas, etc.), alerts (using traditional and social media) and smart phone applications, are becoming increasingly popular as a way of warning of the potential health risks. The health information can be linked with the daily air quality index (Defra 2013), weather forecasts and the pollen index.

The challenge for the public health and healthcare community is to communicate how and how much our health is affected by exposure to air pollution over the life course, and to provide advice for reducing people's exposure to, and emissions from their transport choices. The first National Clean Air Day in the UK on 15th June 2017 focused attention on some practical ways to achieve this (GAP 2017). Defra, PHE and the Local Government Association have also published a resource pack for public health teams that can be used to communicate the health effects of air pollution at a local level (Defra 2017b).

Discussion

The NICE and PHE guideline on outdoor air pollution recommends taking several of the actions described in this article in combination, because multiple interventions, each producing a relatively small benefit, are likely to act cumulatively to produce significant change. Some of the interventions, such as support for active travel, can bring multiple public health benefits, including road accident prevention, carbon emissions reduction, improved physical activity levels, enhanced neighbourhood appearance and community cohesion, in addition to air pollution reductions. The economic modelling underpinning the guideline suggests that the recommended interventions could be highly cost effective. The guideline also highlights the importance of including air pollution in strategic planning across local authority boundaries to provide consistency for motorists, developers and businesses. The same potentially applies to other recommendations, e.g. on clean air zones, where national consistency is important for avoiding migration of pollution sources from one zone to another.

We have highlighted local interventions for controlling outdoor air pollution. To achieve significant reductions in air pollution, these interventions need to be implemented alongside national policy and international agreements. Understanding the impact of air pollution on health is important for underpinning support for the recommended action. Public health and healthcare professionals have an important role to play by raising public awareness of the damaging effect of air pollution, advising patients and the public on how to improve their health by minimising exposure, and supporting action within the healthcare sector and more widely to reduce emissions from road traffic. This is an opportunity for the public health and healthcare sectors to be an exemplar and motivator of action to reduce the impact of air pollution.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Research involving human participants and/or animals This review did not involve human participants and/or animals.

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