Speed limits, air quality and health

Improving air quality by lowering vehicle emissions is important for public health. Limiting vehicle speeds on the UK strategic road network can reduce individual vehicle exhaust emissions, however, there are implications for driver behaviour and traffic congestion patterns. This briefing note examines the current evidence for speed limit reduction to benefit air quality and health and provides recommendations for future priority research.

Overview

- Lowering vehicle speeds on the strategic road network has the potential to reduce vehicle fuel consumption and air pollutant emissions.
- Real-world air quality impacts of lowering speed limits are dependent upon whole fleet mobility, driving behaviour and emissions.
- Air quality modelling and use of on-board vehicle GPS monitoring (telematics data) can inform speed limit lowering schemes and help understand how drivers respond to speed limit changes.
- The true air quality impacts of speed limit lowering in the UK are not yet fully understood due to a lack of high quality 'real-world' evaluations.

Background

Poor air quality is the largest environmental risk to public health and is a major cause of premature death.[1-7] In England, approximately 26,000 – 38,000 deaths per year are attributed to air pollution.[8] Long-term exposure to air pollution is not only a risk factor for cardiovascular and respiratory diseases including lung cancer, but also exacerbates these conditions leading to increased risk of hospital admissions and premature death.[7-13] Air pollution is expensive, costing the UK economy an estimated £20 billion each year.[14] Air pollution impacts are not fairly distributed with related deaths and disease disproportionately affecting the poor and vulnerable.[15] Tackling air quality in the UK requires a coordinated approach and it is important to understand the costs, benefits, and unintended consequences of policy options.

The transport sector is the largest contributor to UK greenhouse gas (GHG) emissions, responsible for 24% in 2020 and is a major contributor to air pollutant emissions.[16] Particulate matter (PM), nitrogen oxides (NO_x) and ground-level ozone are the main air pollutants of concern.[17] Fine particulate matter ($PM_{2.5}$) causes the most substantial health impacts.[18] Transport accounts for 13% of UK $PM_{2.5}$ emissions, with non-exhaust emissions (NEEs) from brake, tyre and road wear contributing to over 60% (by mass) of $PM_{2.5}$ and PM_{10} primary emissions from vehicles.[19] Whereas vehicle tail pipe emissions remain a major source of NO_x emissions.[20] The Department for Transport's

Decarbonising Transport strategy lays out the roadmap for achieving the goal of net zero CO_2 emissions by 2050.[21] Decarbonising transport by phasing out internal combustion engine (ICE) vehicles is an opportunity for improving air quality through reduced tailpipe emissions. However, the impact on NEEs may present a public health concern without the introduction of regulatory standards or targeted policies to reduce $PM_{2.5}$ from NEEs.[19,22] This emphasises the need for solutions which tackle both exhaust and non-exhaust emissions.

Existing policies to improve urban air quality include the introduction of low emission (clean air) zones, congestion charging schemes and public investment in active travel (i.e., walking and cycling) and cleaner vehicle fleets (e.g., electric buses). Additional interventions intended to achieve legal air quality compliance can be targeted across the strategic road network (managed by National Highways in England).

Understanding speed limits

Speed limits enhance the safety of all road users by achieving a safe distribution of vehicle speed suitable for the area. In England, there are three national mandatory speed limits for cars* dependent on the road type:[23]

- The 30 mph (default) speed limit in built-up areas,
- The national speed limit of 60 mph on single-carriageway roads, and
- The national speed limit of 70 mph on dual carriageways and motorways

Traffic authorities are permitted to set local speed limits when local needs and conditions suggest a speed limit which is lower than the national speed limit would be beneficial.[23] The key factors to consider when changing the speed limit are shown in box 1.

* Includes cars, motorcycles, car-derived vans, and dual-purpose vehicles. Information on other vehicle types can be found at Speed limits - GOV.UK (www.gov.uk)[24]

Box 1. Setting speed limits [23]

- History of accidents (e.g., frequency, severity, types, and causes)
- Road characteristics (e.g., sightlines, bends, and junctions)
- Type of road (e.g,. single carriageway, motorway)
- Types of road users (e.g., pedestrians, cyclists, motorcyclists)
- Current traffic speeds
- Roadside environment and impact on communities (e.g., community severance, noise, and air quality)

Speed limit changes may also be temporary or advisory, for example due to a road traffic incident. Compliance with regulatory limits may be assessed by speed cameras, speed checks or the use of average speed cameras which encourage drivers to stay at a constant speed. Travelling at a constant speed and avoiding harsh braking or acceleration reduces vehicle emissions.[25]

Speed limits and air quality

The relationship between vehicle speeds and air pollutant emissions is influenced by a range of factors – including vehicle weight, engine type, exhaust aftertreatment and its temperature (e.g., Euro Class as a proxy measure for this), driving conditions, road surface material and gradient.[20] Air quality is also influenced by emissions from other sources including industry and agriculture, alongside seasonal and weather effects.[26] Evaluating the relationship between speed limit changes and air quality in 'real-world' conditions is challenging due to the multitude of factors affecting air quality and the interactions between them. Introduction of speed limit changes provides a natural experimental opportunity to better understand this relationship, including impacts on driver behaviour, traffic flow, and potential unintended consequences – including displacement to alternative routes. Existing evidence comparing modelled and natural experimental data suggests mixed conclusions, highlighting the need to evaluate speed limit impacts in the context of wider factors influencing exhaust emissions.[27]

Case study 1: 50 mph speed restrictions on motorways in Wales

In Wales, 50 mph speed restrictions on motorway and trunk roads were introduced in 2018 at five locations where NO_2 levels exceeded legal limit values. Data collected from roadside diffusion tubes showed that NO_2 concentrations fell below the annual mean limit at all locations in 2020 and 2021 (after applying national bias adjustment factors).[28] It is acknowledged that during the pandemic, vehicle usage would have decreased and thus the 2022 data should provide further insight into the impact of speed limits on air quality under post-COVID-19 conditions. Data collected from average speed cameras indicate high compliance with speed limits for air quality, with an average speed below 50 mph at all sites and exceedance of the speed limit ranging from 4.0–9.8% in 2022.[28]

Case study 2: Motorway speed limit reduction in the West Midlands

The West Midlands region (population ~2.9 million) has recognised air quality challenges with all areas exceeding 2021 World Health Organisation (WHO) health-based guidelines for NO_2 and $PM_{2.5}$ concentrations.[29,30] WM-Air researchers at the University of Birmingham have undertaken high-resolution ADMS-urban air quality dispersion modelling to assess air quality impacts of speed limit reduction from 70 mph to 60 mph between two junctions on the M6 and M5, reflecting speed limit trials by National Highways.[30, 31] The modelling scenario assumes that all vehicles travel at an average speed of the prespecified speed limits. The modelling results (Fig. 1 and Fig. 2) show that the greatest reduction in air pollution was observed in the roadside environment with an estimated 5.1–7.5 $\mu g\ m^{-3}$ (7.1–11.6%) reduction in NO_2 and 0.11–0.16 $\mu g\ m^{-3}$ (0.69–1.00%) reduction in $PM_{2.5}$ compared with the 2019 annual average (for the 70-mph baseline case). Lesser improvements in air quality are observed up to one kilometre away from the motorway due to the dispersion of air pollutants. This modelled data suggests that in urban environments with dense motorway networks, speed limit reduction could result in widespread improvements in air pollutant exposure, particularly for those living near busy urban roads. However, this modelled data does not assess the wider impacts of lowering speed limits including real-world compliance, changes in driving behaviour (altered patterns of acceleration and braking), and traffic congestion. Further, there are potential displacement effects as drivers may choose alternative journey routes. Therefore, real-world scheme evaluation is vital.

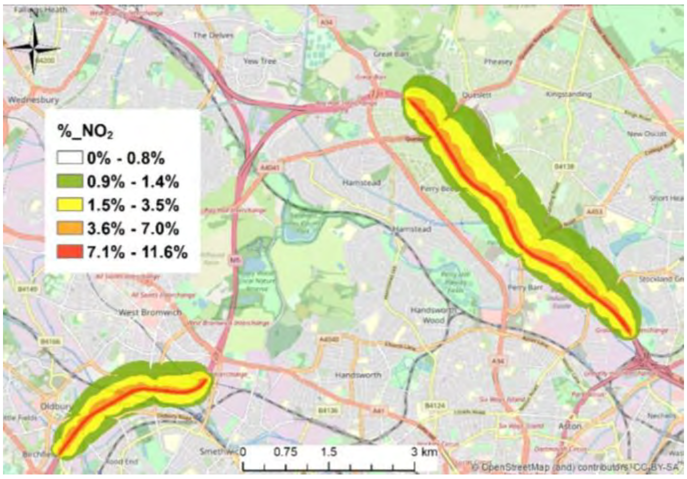

Figure 1. % Change in NO_2 when speed limit reduced from 70 mph to 60 mph (M6 junctions 6 to 7, M5 junctions 1-2)

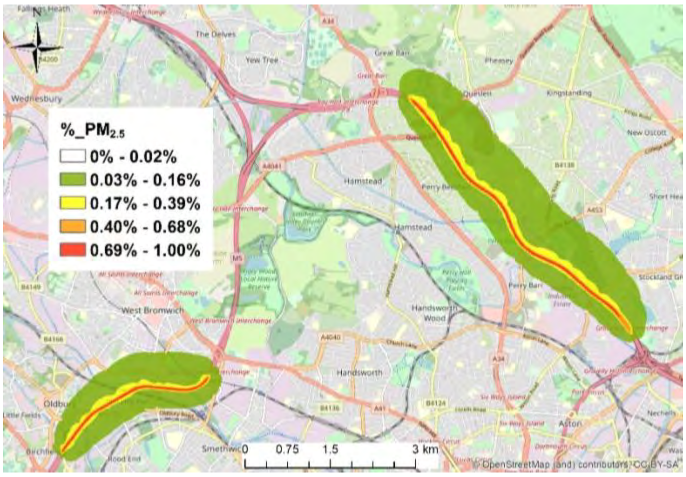

Figure 2. % Change in $PM_{2.5}$ when speed limit reduced from 70 mph to 60 mph (M6 junctions 6 to 7, M5 junctions 1-2)

Speed limits and driver behaviour

Driver behaviour – the intentional and unintentional actions performed when operating a motor vehicle - has a significant contribution to ICE emissions and NEEs. Key characteristics include acceleration, deceleration and braking patterns, and time spent cruising or idling.[32] Whilst speed limits determine the maximum speed for safe travel, individual driver compliance with the speed limit is determined by a range of factors, including speed limit credibility and subjective perception of risk.[33] Public attitudes towards speeding are another important consideration.[34] UK-based data shows that under free-flowing traffic conditions, 51% and 48% of car drivers exceed the speed limit on 30 mph roads and motorways, respectively.[35] Responses from the National Travel Attitudes Study indicate that 40% of people think it is safe to travel slightly over the speed limit on motorways.[36]

Information on driver behaviour can be captured by use of 'telematics'. On-board vehicle GPS systems can be used to gather information on vehicle location, speed, driver behaviour and engine diagnostics (vehicle telematics data). Telematics data has principally been used to support fleet management and by insurers, however, its role in understanding driver behaviour following the implementation of traffic interventions (e.g. clean air zones) is increasingly recognised.[32] In the West Midlands, telematics data from a sample of passenger cars have been used in speed limit analysis to understand urban mobility.[37] The data show there is more variability in travel speed on motorways compared with other road types, and the highest average speeds travelled on motorways occur at late night and early morning, whereas the slowest average speed peaked below 60 mph during rush hours. Fewer drivers exceeded the speed limit on motorways compared to primary and secondary roads, which may reflect the higher number of speed cameras or the inclusion of 'smart' motorways in which the speed limit varies based on real-time traffic conditions. Across all road types, vehicles on average exceeded the speed limit 30.4% more at weekends compared with weekdays.[37]

West Midlands vehicle telematics data in combination with real-world emission factor datasets has been used to study fuel consumption and exhaust emissions.[38] It has also been used to understand the impact of changing fleet composition and traffic conditions on vehicle emissions. For example, modelled emissions data show that NO_x emissions have decreased by 14% from 2016 to 2018, which can be attributed to the increase in Euro 6 vehicles and the decrease in diesel vehicles on the road. Time of travel has a significant impact on fuel consumption and vehicle emissions. In non 'rush hour' periods where traffic is more free-flowing, estimated NO_x emissions are higher due to higher travel speed and accelerations, and this effect is most notable for motorways. In the future, telematics data could be used "in-vehicle" to support drivers to drive at speeds appropriate for current road conditions, avoid congestion and ultimately reduce vehicle emissions to improve air quality.[37]

Public health implications

The public health benefits of lowering speed limits are not solely achieved through improving air quality. There is strong evidence that lowering speed limits reduces casualties and fatalities from road traffic accidents.[34,39,40] A meta-analysis conducted in 2019 showed that for every 1km/hr increase in speed, the likelihood of a pedestrian fatality increased by 11%.[41] Implementing city-wide 20 mph speed limits in Edinburgh led to a 23% reduction in road fatalities over a one-year period.[39] Noise pollution is the second largest environmental driver of poor health after air pollution linked to nuisance, sleep disturbance, cognitive impairment, and cardiovascular disease. It is estimated that noise pollution contributes towards 12,000 premature deaths and 48,000 new cases of heart disease in Europe each year.[42] Lowering speed limits in residential areas may also improve public perception of road safety which is frequently cited as a barrier to active travel,[43] and is one of the main parent-reported reasons for not allowing their children to walk or cycle to school.[44]

Poor air quality contributes towards health inequalities. In London, there is a clear relationship between air pollution and area-level deprivation, whereby the most deprived areas have the highest air pollutant concentrations.[45] Deprived communities are more likely to be situated in urban areas near busy roads and industrial areas. Further, individuals living in deprived areas are more likely to have reduced access to public transport and safe infrastructure for active travel compared with those living in more affluent areas.[45] These impacts are compounded by the fact that those experiencing the highest levels of social deprivation are more likely to experience existing poor health which further increases their vulnerability to poor air quality.[46,47]

The economic implications of lowering speed limits on journey time should be considered. However, in congested urban areas the impact of lowering the legal speed limit on journey time may be less than expected.[48] Cost-benefit analyses of speed limit interventions should also consider the wider societal benefits as described previously, and not just the impact on journey time.[49]

Transport policies require a systems-based approach as changes made to one part of the transport system will likely impact another. Multi-agency working to identify the likely co-benefits and unintended negative consequences of speed limit reduction schemes would ensure that positive outcomes are maximised, and negative outcomes are minimised.[50]

Future research priorities

- Lowering vehicle speeds principally influences NO_X emissions and has a limited effect on $PM_{2.5}$. Understanding the impacts of speed limit changes on NEEs is a key priority as vehicle fleets transition towards EV alternatives.
- High quality robust studies are needed to evaluate real-world impacts of lowering speed limits on air quality, including the impact of reducing the speed limit from 30 mph to 20 mph in residential areas.
- Telematics data offers the potential to better understand how speed limit changes influence traffic conditions and driver

behaviour. This information may be used to inform effective speed limit interventions.

- Speed limit lowering programmes should also consider and evaluate the wider health benefits of speed reduction, such as fewer road traffic injuries, reduced noise pollution, and implications for health inequalities.

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