Cycling in polluted environments

Evidence briefing

we are cycling UK

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Collection of evidence

Notes:

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Introduction

Understandably, people worry about breathing in exhaust fumes and traffic-related dust when cycling along busy roads.

Although studies consistently find that cycling's health benefits outweigh the risks, not all of them factor in traffic pollution. Of those that have factored this in, however, many conclude that cycling still does more good than harm and, generally speaking, that it is better to exercise (or cycle) in a polluted environment than to remain inactive.

For instance, a study of the benefits of shifting from driving to active travel concluded that "In any case the benefits of bicycling completely overwhelm any concern over pollution exposure of bicyclists."

As other studies suggest, breathing rates influence how much pollution road users inhale, e.g. people travelling by cycle tend to breathe faster than those sitting in cars.

Breathing rates differ among cyclists too, of course – some ride quickly, others slowly, while some routes, or part of routes, involve more physical effort.

Also, how much pollution there is to breath in from any particular surrounds, whatever the breathing rate, depends on various factors. Route choice, proximity to tailpipes, how much stop/start occurs, weather, wind speed, presence of buildings or vegetation etc. may all make a difference to levels of exposure.

As for the influence of infrastructure, there's good evidence to support the case for segregated cycle lanes as a way of minimising the inhalation of exhaust fumes.

Of course, people who cycle are not the only road users who breathe in fumes. Drivers do too because their cars suck in emissions through the engine compartment or via open windows.

So, the more people who cycle instead of driving – and the better the infrastructure that's available for cycling becomes – the cleaner the air will be for everyone.

Notes:

The following collection of evidence on cycling in polluted environments is designed to accompany our briefing on air quality, which covers the subject of pollution more widely.

Cycling UK's health briefing looks in greater depth at benefits v risk studies.

Evidence

The following points to a range of studies that have looked into or touched upon the subject of cycling in polluted environments. They are presented in date order, latest first. If you know of any other sources not mentioned here or cited in the sources themselves, please get in touch: campaigns@cyclinguk.org

2023: a series of wind tunnel experiments replicating a "typical London street canyon" suggested that "… perhaps unsurprisingly – being as far away as possible from polluting vehicles (and other cyclists) is a good mitigation strategy to avoid exposure, therefore one would ideally advise policy makers to construct wider cycle paths, or even better, to completely separate riders from the road traffic." (The reference to "other cyclists" relates to the finding that "the position within the group of riders has a larger influence on the concentration exposure than the relative distance between the source and the vehicle.")[1]

2022: scientists who examined dust from bike paths near main roads in four main cities in Poland discovered it was "highly enriched with heavy metals". The dust, which mainly comes from tyre/brake/clutch wear and even the road surface itself, is easily blown up into the air, where it can be both ingested and inhaled. This is a health hazard, especially for children. Apart from suggesting that cycle infrastructure should be located away from heavily trafficked main roads and stop/start intersections, and separating bike paths with "green belts using specialized plants", the authors also recommended sweeping the dust away. (In Cycling UK's view, high quality, well-maintained infrastructure, and motor traffic demand management, help shift people away from driving, so in itself will reduce the amount of dust accumulating in these environments). [2]

2021: measurements taken before and after the construction of a cycle lane along a mid-sized street in Berlin found that the lane: "led to a reduction in NO_2 exposure for cyclists."[3]

2018: academics, who investigated exposure to coarse and fine particle exposure among commuters using routes in Guildford, Surrey, made the point that there's a distinction between how much pollution commuters are exposed to and how much they actually breathe in.

They found that: "The mean concentrations of coarse particles (PM2.5-10) followed the trend: bus > walk > cycle > car. In contrast, mean concentrations of submicron (PM1) and fine particles (PM2.5) were usually high in the car while lowest for cyclists."

As for "respiratory deposition doses" (RDD): "Car mode experienced both the least concentrations and RDD for coarse particles. It also had the lowest RDD for fine particles

[1] Schmeer, J *et al*. Group riding: Cyclists exposure to road vehicle emissions in urban environments. Journal of Wind Engineering and Industrial Aerodynamics. April 2023.
[2] Adamiec, E *et al.* Adverse health and environmental outcomes of cycling in heavily polluted urban environments. Scientific Reports. 7/1/2022.
[3] Schmitz Seán *et al*. Do new bike lanes impact air pollution exposure for cyclists? – a case study from Berlin. Environmental Research. Open access letter. 28/7/2021.

despite high concentrations. Physical activity of car commuters is modest compared with walking and cycling, which makes the rank ordering of RDD different than those of exposure concentrations. Hence the management of commuting exposures should consider potential dose and not just exposure concentration for curtailing adverse health effects related to commuting. RDD for pedestrian and cycle modes were not the lowest among the measured modes but opportunities such as an increased distance between the heavily trafficked roadways and pedestrians/cyclists should be considered in urban planning to reduce potential doses."[4]

2016: the authors of an academic paper examining the risk v benefits of travelling actively at the same time as being exposed to polluted air concluded that the benefits "outweighed the harm caused by air pollution in all but the most extreme air pollution concentrations." They also said that if cycling replaces driving, the trade-off would be even more beneficial.[5]

2015: despite the fact that exercising in a polluted environment means that the lungs take in more pollutants because of an amplified breathing rate, a study of residents aged 50-65 living in Aarhus and Copenhagen suggested that the long-term benefits outweigh the risks. The researchers focused on NO_2, and looked at various activities, including cycling.[6]

2015: research from the University of Surrey found that although commuting drivers spend just 2% of their journey time passing through junctions with traffic lights, it contributed to about 25% of their total exposure to PM. This is caused by decelerating, stopping and then revving-up to move away. Peak PM concentration proved to be 29 times higher than it is in free-flowing traffic conditions.[7]

2014: monitoring devices fitted to five MPs from the Environmental Audit Committee as they travelled round London showed that their greatest exposure to carbon particles occurred during taxi rides.[8]

2014: a study into the health effects on healthy participants of short-term exposure to traffic-related pollution concluded that: "In a healthy population, intermittent moderate PA [physical activity] has beneficial effects on pulmonary [lung] function even when performed

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[4] Kumar, P *et al*. Dynamics of coarse and fine particle exposure in transport microenvironments. npj Climate and atmospheric science. 3/06/2018.
[5] Tainio M, *et al*. Can air pollution negate the health benefits of cycling and walking? Published in ScienceDirect. 2016.
[6] Andersen, Zorana Jovanovic *et al*. A Study of the Combined Effects of Physical Activity and Air Pollution on Mortality in Elderly Urban Residents: The Danish Diet, Cancer, and Health Cohort. Published in Environmental Health Perspectives. June 2015.
[7] Goel, Anju. Characterisation of nanoparticle emissions and exposure at traffic intersections through fast–response mobile and sequential measurements. *Published in Atmospheric Environment*, Volume 107, April 2015, Pages 374–390.
[8] Environmental Audit Committee. Action on Air Quality: Sixth Report of Session 2014-15. (Para 42, p17). Nov 2014.

in a highly polluted environment." The researchers chose cycling as the physical activity to test.[9]

2011: a study found that: "Use of off-road cycle routes in the city of York led to a significant reduction in the time-weighted concentration of, and exposure to, NO_2 compared to on-road routes. Therefore the provision of additional off-road cycle routes has benefits beyond improved safety."[10]

2011: a Canadian study concluded that: "Short-term exposures to traffic pollution may contribute to altered autonomic modulation of the heart in the hours immediately after cycling." As this is a detrimental effect on heart function, the authors suggested: "it may be prudent to select cycling routes that reduce exposure to traffic and to avoid cycling outdoors or to exercise indoors on days with elevated air pollution levels." The study did not, however, "... observe strong associations between traffic-related air pollution and acute changes in respiratory outcomes."[11]

2010: a review of various studies comparing cyclists with car drivers concluded that, overall, "air pollution exposures experienced by car drivers were modestly higher than those experienced by cyclists." However, assuming cyclists' breathing rate per minute is just over twice that of car drivers, the authors concluded that cyclists inhale larger doses of PM2.5. They also pointed out that exposure for both types of road user depends on many factors, e.g. route, car speed, trip duration, car type, whether the window is open or not, the street, weather, etc. Nevertheless, the authors still concluded that: "On average, the estimated health benefits of cycling were substantially larger than the risks relative to car driving for individuals shifting their mode of transport."[12]

2010: a study carried out in Belgium concluded that previous research had underestimated cyclists' ventilation rate and that it was 4.3 higher than that of car drivers (i.e. not just above twice as much). They found, for instance, that in Brussels and Louvain-la-Neuve, concentration of PM2.5 and PM10 "was significantly higher for the bicycle compared to the car". The authors also said that concentrations are heavily dependent on location. (In their trials, however, they examined the effects of cycling and driving along identical routes, whereas in practice cyclists may well choose routes with less traffic and better air quality – maybe particularly so if they're less confident and ride relatively slowly).[13]

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[9] Kubesch, N., de Nazelle, A., Westerdahl, D. *et al*. Respiratory and inflammatory responses to short-term exposure to traffic-related air pollution with and without moderate physical activity. Published in Occupational and Environmental Medicine,4/12/2014.
[10] Bean, T *et al*. How does exposure to nitrogen dioxide compare between on-road and off-road cycle routes? Published in the Journal of Environmental Monitoring. 18/2/2011.
[11] Weichenthal,Scott. Traffic-Related Air Pollution and Acute Changes in Heart Rate Variability and Respiratory Function in Urban Cyclists. Published in Environmental Health Perspectives. 14/6/2014.
[12] de Hartog, Jeroen Johan *et al.* Do the Health Benefits of Cycling Outweigh the Risks? Published in Environmental Health Perspectives, 30/6/2010.
[13] Int Panis, Luc *et al*. Exposure to particulate matter in traffic: A comparison of cyclists and car passengers. Published in Atmospheric Environment, Volume 44, Issue 19, June 2010, Pages 2263–2270

2009: a Dutch study looking specifically at ultra-fine particles, found that in the Netherlands car drivers' exposure to "particulate number concentration" and PM2.5 was slightly higher than that of cyclists. The authors also said that cyclists are confronted with mainly short, but very high peaks, yet could take more direct routes avoiding busy roads. Car drivers, on the other hand, encounter lower peaks for a longer time. For cyclists, peaks were caused by passing vehicles, waiting for traffic lights, passing different types of (large) intersections, and cycle lanes/paths close to motorised traffic.[14]

2009: an experiment which tested the heart rate and "minute ventilation" of 34 people during trips by bicycle, bus and car, found that "Minute ventilation during bicycle rides were on average 2.1 times higher than in the car (individual range from 1.3 to 5.3) and 2.0 times higher than in the bus (individual range from 1.3 to 5.1)." The authors therefore concluded that it was important to include ventilation data in comparing air pollution between different type of transport. [15]

2001: a study from Copenhagen concluded that "… even after taking the increased respiration rate of cyclists into consideration, car drivers seem to be more exposed to airborne pollution than cyclists."[16]

[14] Boogaard, Hanna *et al*. Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities. Volume 43, Issue 27, September 2009, Pages 4234–4242
[15] Zuurbier, M et al. Minute ventilation of cyclists, car and bus passengers: an experimental study. Environmental Health. 2009.
[16] Rank J *et al*. Differences in cyclists and car drivers exposure to air pollution from traffic in the city of Copenhagen. Published in Science of the Total Environment, vol 279, p 131-136, 2001.