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Commentary: Post-COVID-19 mobility and traffic noise-induced health effects

Andreas Seidler and Verena Maria Weihofen*

Faculty of Medicine Carl Gustav Carus, Technische Universität Dresden, Institute and Policlinic for Occupational and Social Medicine (IPAS), Dresden, Germany

Corresponding author. Institut und Poliklinik für Arbeits- und Sozialmedizin, Technische Universität Dresden, Medizinische Fakultät Carl Gustav Carus, Fetscherstr. 74, 01307 Dresden, Germany.
E-mail: verena_maria.weihofen@tu-dresden.de

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Before the pandemic is after the pandemic—does this also apply to traffic and traffic-induced noise?

In the early days of the coronavirus pandemic, when lockdowns and home office were enforced, cities suddenly became much quieter. In recent months, however, traffic and associated noise levels have almost returned to pre-pandemic 'normality'.

Is there a lasting COVID-19 learning effect?

Regarding the future impact of business travel, Bill Gates recently noted that we can now ask: 'Do I have to go there physically?'[1] and predicted a 50% decline for the post-COVID-19 world.[2] This is not the only change in mobility behaviours catalysed by post-COVID-19. There are many new initiatives in metropolitan areas, for instance cycling lanes as well as an increase in car-sharing. But we still can only speculate whether these changes will last, and for how long.

Which conditions contribute to the traffic-noise-dependent burden of disease?

In recent years, it has become clear that air pollutants are not the only source of traffic-related health problems, but that traffic noise also has considerable health consequences. Traffic noise can lead to annoyance[3] and sleep disturbance,[4] but more importantly also to serious diseases of the cardiovascular system.[5] Best confirmed is the increased risk of coronary heart disease, including myocardial infarction.[6] However, according to a systematic World Health Organization Review with meta-analysis,[5] previous epidemiological studies of noise and stroke yielded inconclusive results: whereas one included cohort study observed an increased stroke risk, the pooled traffic-noise-related risk estimates of two cross-sectional studies and three cohort studies on stroke-related mortality were not elevated. Pathophysiologically, it would be difficult to explain why road traffic noise should lead to coronary heart disease, including myocardial infarction, but not to stroke, because they share basic pathogenetic processes.[7] This points toward a research gap for road traffic noise and stroke.

In the current issue of the *International Journal of Epidemiology*, Sørensen *et al.*[8] provide an important piece of the puzzle toward a better understanding of noise-induced cardiovascular disease. In a large cohort study, they estimate 10-year time-weighted mean noise exposure for 3.6 million Danes aged >35 years, of whom 184 523 developed incident stroke during follow-up from 2000 to 2017. The authors take into account a large number of potential confounders, including individual and area-level socioeconomic status and air pollutants [particulate matter with a diameter <2.5 µm ($PM_{2.5}$) and NO_2]. As a main result, the authors find a clearly increased stroke risk for individuals exposed to traffic noise at their home address. The authors' description of a levelling off at approximately 62 dB for L_{den}max and 52 dB for L_{den}min is not entirely convincing; against this is the fact that Sørensen *et al.*[8] find the highest risk estimators in the highest road traffic noise categories. Moreover, the finding of considerably decreased stroke risks by railway noise in the study by Sørensen *et al.*[8] is not biologically plausible; here, potential bias should have been discussed as a possible explanation.

While to date burden of disease estimations for traffic noise include ischaemic heart disease, annoyance and sleep disturbance,[9] with some additionally accounting for cognitive impairment of children and tinnitus,[10] stroke is not usually included in such estimates. Based on the study of Sørensen *et al.*[8] together with evidence from other studies

(e.g. Weihofen *et al.*[7] on the association between aircraft noise and strokes), this approach should be re-examined. Another important disease that may also be considered when re-examining these estimates of traffic noise-related burden of disease is depression.[11,12]

What noise 'dose' and what type of traffic noise are hazardous to health?

Most research finds that a linear model adequately describes the relationship between road traffic noise and cardiovascular diseases—with more noise leading to higher disease risks. Whereas the WHO Guidelines—based on the systematic review of van Kempen *et al.*[5]—find a risk increase of 8% per 10 dB for the association between road traffic noise and the incidence of ischaemic heart disease (pooling of seven cohort studies), Sørensen *et al.*[8] reveal a 4% (95% confidence interval 3% to 5%) increase of the stroke risk per 10 dB road traffic noise. In both studies, risk increase starts at noise pressure levels around 50 dB. According to the NORAH (Noise Related Annoyance, Cognition and Health) study on disease risks, cardiovascular risks might already be increased from noise levels of about 43 dB L_{DEN} onwards.[12–15] For railway noise, Sørensen *et al.*[8] cannot find elevated stroke risks, and our own research group could only determine very small stroke risk increases for aircraft noise in a recently published systematic review.[7] That does not necessarily mean that railroad noise and aircraft noise do not cause strokes. Instead, this may point toward an inadequate reflection of railroad noise and aircraft noise by average sound pressure levels. Whereas road traffic noise is usually fairly constant, railway and air traffic noise are characterized by fluctuations through recurring noise events. Maximum sound levels may be more appropriate.

What noise-related research is needed?

Future research should take maximum sound pressure levels into account (particularly when analysing the health effects of railway and aircraft noise). In addition, railway-induced vibration has an effect on annoyance independent of noise.[16] Future research should therefore examine a potential impact of these aspects on cardiovascular diseases.

'Classic' approaches to noise assessment based solely on the loudest façade fall short when it comes to the best possible assessment of individual noise exposure. Sørensen *et al.*[8] go one step further by additionally using risk estimators for the estimation of noise at the least exposed façade, which might better represent night-time noise as often the bedroom would be located at the quiet side of the home. Beyond this, future research should consider indoor noise, ideally in combination with noise exposure outside the home, as well as occupational noise exposure. In a recently published systematic review, Bolm-Audorff *et al.*[17] could demonstrate a positive dose-response relationship between occupational noise and the development of hypertension. The implementation of individual person-worn 24-h noise dosimeters in epidemiological studies seems worth considering for future research.

Another finding of Sørensen *et al.*[8] appears noteworthy: the authors report a considerably higher risk increase for fatal than for non-fatal strokes (8% vs. 3% per 10 dB increase in road traffic noise). We found a similar result for myocardial infarction due to road, train and aircraft noise.[13] As a potential explanation, traffic noise may affect not just the onset, but also the course of cardiovascular diseases. This also appears to be an area requiring more research.

What are the consequences for future mobility and its health impact?

The current trend in conversion of private motorised transport to e-vehicles is good for health by reducing air pollutants from engine exhaust. On the other hand, air quality is also affected by particles generated from tyres and brakes as well as dust—and this is independent of how the engine is powered. E-cars also hardly reduce the relevant health effects of traffic noise, because from a speed of about 30 km/h, tyre-road noise starts dominating the sound emission whether the vehicle is electric-powered or driven by combustion engine.[18] Thus even if we switch to e-vehicles, one could still expect negative health effects from road traffic noise including coronary heart disease, depression, and—as Sørensen's latest study in this issue finds—also stroke.

Future mobility concepts may lead to quieter and healthier cities

To overcome the problematic effects of road traffic, future urban mobility should therefore not rely on individual car traffic, regardless of the propulsion system. The pandemic has caused urban planners and policy makers to rethink future transport frameworks. Policy makers should nurture the momentum gained to further transform the traffic landscape towards bike-friendly cities. Several international metropolises have initiated respective conversions, and this certainly would not have happened as fast without the pandemic. Movement to bike transport may have a greater impact on inner-city noise levels than the e-car trend, and the potential health benefits (exercise, weight

reduction[19,20]) go beyond avoiding traffic noise-related health damage.

Conflict of interest

None declared.

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