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EDITORIAL

Noise and cardiovascular risk: nighttime aircraft noise acutely triggers cardiovascular death

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This editorial refers to 'Does night-time aircraft noise trigger mortality? A case-crossover study on 24 886 cardiovascular deaths'†, by A. Saucy *et al.*, on page 835.

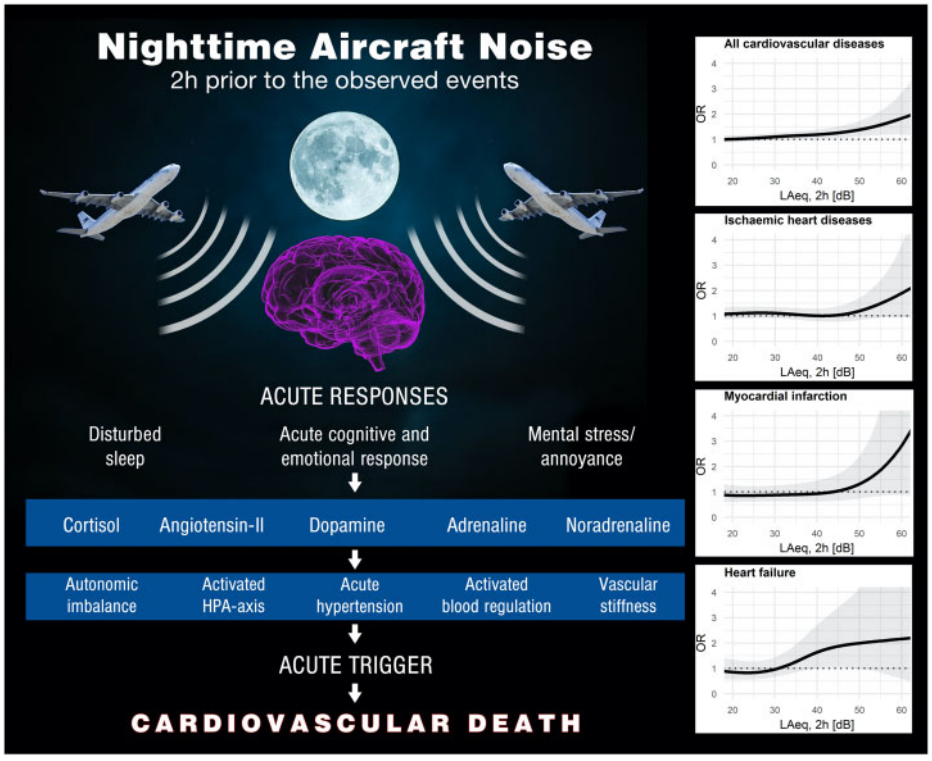

Figure 1 Effects of acute nighttime aircraft noise exposure that lead to cardiovascular death. Inserts (right panel) show substantial odds ratios of nighttime mortality in relation to 2 h-L_{Aeq} levels (energy-equivalent average A-weighted sound pressure level expressed in decibels) as adapted from Saucy *et al.*,[16] with permission.

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Environmental transportation noise as a cardiovascular risk factor

Air pollution is an established risk factor for cardiovascular disease (CVD).[1] Much less attention has been devoted so far to environmental noise, which co-exists with air pollution mainly in urban areas.[2] The World Health Organization (WHO) estimates that in Western Europe alone noise exposure causes up to 1.6 million disability-adjusted life years (DALYs) per year. Also the 'cardiovascular burden' of noise is substantial; for the European Union, transportation noise is estimated to result in 900 000 cases of hypertension, 43 000 hospital admissions, and >10 000 premature deaths per year related to coronary heart disease and stroke.[3] Although a large proportion of the population is exposed to transportation noise levels exceeding the recommended guideline levels, traffic noise is not mentioned or only insufficiently addressed as a risk factor in either the Global Burden of Disease (GBD) Study,[4] 'Health at a Glance: Europe 2018', cardiovascular prevention guidelines by the European Society of Cardiology (ESC),[5] or by the American Heart Association/American College of Cardiology (AHA/ACC).[6]

So far, most epidemiological studies have focused on cardiovascular side effects of long-term exposure to transportation noise (for reviews, see Basner *et al.*[7] and Munzel *et al.*[8]). Importantly, translational studies in humans and animals primarily focused on health side effects of nighttime noise with respect to the cardiovascular system.[9] In humans only one night of aircraft noise triggered endothelial dysfunction, increased stress hormone levels, and deteriorated sleep quality.[10] These effects were even more pronounced in patients with already established CVD.[11] The acute administration of the antioxidant vitamin C improved endothelial dysfunction, suggesting an involvement of reactive oxygen species in the pathophysiology of noise-induced vascular dysfunction.[10] Recent animal studies indicated that aircraft noise applied during the sleeping phase of mice, but not during the awake phase, raises blood pressure, dysregulates genes related to the circadian clock and stress hormone levels, causes endothelial dysfunction, and increases cerebral and vascular oxidative stress.[12] These observations may indicate that the disturbance of sleep (e.g. sleep deprivation or fragmentation) may account at least in part for noise-induced cardiovascular damage.

Acute exposure to nocturnal aircraft noise and cardiovascular death

Whereas the acute effects of noise exposure on neuronal stress responses (e.g. activation of the hypothalamic–pituitary–adrenal axis and the sympathetic nervous system) are well established,[13] the acute effects of noise on cardiovascular events and death have not been studied in detail. Epidemiological and translational studies of humans with and without coronary artery disease revealed that nighttime exposure to different transportation noise patterns for only one night adversely affected blood pressure, diastolic heart function, sympathovagal balance, and the plasma proteome.[10,11,14,15]

With their study, in this issue of the *European Heart Journal*, Saucy *et al.* sought to determine the effects of acute exposure to nighttime aircraft noise on cardiovascular death.[16] On the basis of a case-crossover study design, the authors analysed 24 886 cases of death from CVD from the Swiss National Cohort around Zürich Airport between 2000 and 2015. The authors established that for nighttime deaths, aircraft noise exposure levels 2 h preceding death were significantly associated with mortality for all causes of CVD (*Figure 1*). Most consistent associations were observed for ischaemic heart disease, myocardial infarction, heart failure, and arrhythmia. The associations were more pronounced for females and for people living in areas with low road and railway background noise and in buildings constructed before 1970. The authors also calculated a population-attributable fraction of 3% in their study populaion and finally concluded that nighttime noise may trigger acute cardiovascular mortality.

Strengths and limitations of the study

There are several novel and innovative aspects and strengths of this study. To our knowledge, it is the first study worldwide that has addressed acute effects of noise on cardiovascular mortality indicating for the first time that aircraft noise is a trigger for fatal acute coronary events. The case-crossover design is innovative to analyse acute health effects and has not been used for noise research (but is well established for air pollution research). A particular strength of the study design is that health risks are estimated based on the exposure difference between case and control events for the same person and the same location. This implies that several potential biases, which are of concern in cohort studies, are hardly relevant (e.g. confounding from individual lifestyle factors, selection bias, etc.). In this study, a high precision aircraft noise modelling was used. The researchers used radar records from each flight between 2000 and 2015. Thus, the study accounts for single, specific flight events, yielding individual aircraft noise exposure estimates with high spatial and temporal accuracy for each death and control event. The large sample size and the absence of selection bias as every cardiovascular death within the study area was included is remarkable. The study allowed calculation of the attributable fraction: ~3% of cardiovascular nighttime deaths are attributable to aircraft noise. Furthermore, the study compared the effects for different time windows of exposure, which is scarcely possible in cohort studies due to high correlation. It clearly supports the substantial relevance of nighttime noise as already suggested by epidemiological and animal research.[9]

However, some limitations have to be taken into account. Due to the nighttime flight restriction in place at Zürich Airport, the noise levels were rather low and thus the findings should be reproduced at airports with higher nighttime noise exposure levels. Also, the authors did not consider daytime noise exposure for the analysis of daytime deaths, because they expected substantial exposure misclassification when people are not at home during the day.

What are the societal and political consequences?

Taken together, the present study describes for the first time acute effects of noise on cardiovascular mortality indicating that aircraft noise is a trigger for fatal acute coronary events. If these findings are confirmed by further studies at airports with higher nighttime noise exposure, a complete ban on nighttime flights must be the consequence. There is now substantial evidence that (aircraft) noise is a cardiovascular risk factor that cannot be modified by patients or doctors, but rather by politicians and the cardiovascular societies such as the ESC and AHA/ACC reinforcing, for example, the new noise limits published in the WHO guidelines concerning road, aircraft, and railway noise.[2]

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