

**ROAD TRAFFIC AND AIRCRAFT NOISE EXPOSURE AND CHILDREN'S COGNITION AND HEALTH:
EXPOSURE-EFFECT RELATIONSHIPS AND COMBINED EFFECTS (RANCH)**

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Executive Summary

Background and Aims

- Research suggests that children may be a high-risk group vulnerable to the effects of noise. Previous studies have found associations between exposure to aircraft noise and children's reading comprehension and long-term memory. Associations have also been found between aircraft noise exposure and annoyance, but evidence of associations with raised blood pressure, mental health and sleep are weaker.
- Most previous studies in children have focussed on aircraft noise rather than road traffic noise and have not examined either exposure-effect relationships or the effects of exposure to more than one source of noise.
- The RANCH project (Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health: Exposure-Effect Relationships and Combined Effects) examined exposure-effect relationships between chronic aircraft noise exposure, chronic road traffic noise exposure and combinations of aircraft noise and road traffic noise exposure and cognitive and health outcomes.
- In addition, the RANCH project has included studies of road traffic noise at home and sleep in Sweden and studies of soundscapes in the UK and Sweden.

Study Design and Methods

Airport Field Studies

- The RANCH project, is the largest cross-sectional study of noise and children's health, examining 9-10 year old children living around three major airports: Schiphol, Amsterdam in the Netherlands, Barajas, Madrid in Spain and London Heathrow in the United Kingdom.
- Cognitive outcomes included reading comprehension, episodic memory, working memory, prospective memory and sustained attention. Health outcomes included noise annoyance, blood pressure, overall mental health and self-reported health. Confounding factors were adjusted for at the school and individual level, across three European countries.
- Children were selected by external aircraft and road traffic noise exposure at school predicted from noise contour maps, modelling and on-site measurements. Schools were selected from a four by four grid of increasing aircraft and road traffic noise exposure. Schools matched for socio-economic position within countries were selected. In the Netherlands one class, and in the UK and Spain two classes were selected from each cell in the grid. No children were excluded from any of the selected classes.
- Standardised paper and pen cognitive tests were developed to measure episodic memory, working memory, prospective memory and sustained attention. For reading comprehension, nationally standardised tests of reading were employed in each country. A children's questionnaire assessed perceptions of noise and annoyance and opportunities for psychological restoration. Parents completed a questionnaire about confounding factors such as socioeconomic position, parental education and ethnicity. Comparable measures were achieved across countries. A sub-sample had their blood pressure measured in the Netherlands and the UK.
- The cognitive tests and questionnaires were group administered, in a fixed order, in the classroom. Written consent was obtained from the children and their parents. Indoor and outdoor noise measurements were made at the schools during testing. Blood pressure measurements were taken during the afternoon.

Sleep & Soundscape Studies

- Epidemiological questionnaire-based studies on the effects of exposure to road traffic noise were carried out on 160 children (9-12 years) and their parents at home in three Swedish residential city areas of varying road traffic noise. Half of the families also completed sleep logs and slept with wrist-actimeters as a measure of sleep quality.
- Children's and adult's 24-hour acoustic soundscapes were mapped by binaural and monaural recordings, at homes and schools, indoors and outdoors. Two psychoacoustical experiments (UK and Sweden) were conducted in which children and adults assessed perceived soundscapes of binaural recordings. The UK study focused on soundscapes dominated by extreme combinations of aircraft and road traffic noise at school, and the Swedish study on soundscapes dominated by road traffic noise at home.
- A psychological test instrument (the Children's Psychological Restoration Scale) was developed in English speaking Swedish children for assessing children's opportunities and abilities for psychological restoration when living in noise contaminated soundscapes. The psychological restoration questionnaire was included in the airport field studies child questionnaire and in the Swedish road traffic noise study.

Results

Airport Field Studies

- 2844 children, from 89 schools around Schiphol, Barajas and Heathrow participated in the study. The data was pooled across the three countries and analysed using multilevel modelling, adjusting for confounding factors at the school and the individual level.
- Aircraft noise exposure was associated in a linear exposure-effect association with reading comprehension, episodic memory and working memory. It was estimated that a 5dB (A) increase in noise was associated with a 2-month impairment in reading age in the UK and a 1-month impairment in reading age in the Netherlands.
- Aircraft noise exposure was not associated with impairment of either prospective memory or sustained attention.
- Road traffic noise exposure was not associated with either reading comprehension, episodic memory, working memory, prospective memory or sustained attention.
- There was a strong non-linear exposure-response relationship between aircraft noise exposure at school and at home and children's annoyance. Annoyance was greater at higher levels of exposure. For road traffic noise at school and annoyance the exposure-response relationship was linear. Reported annoyance was lower for road traffic noise than for aircraft noise.
- The relationship between noise exposure and blood pressure was inconsistent. Aircraft noise exposure at school was not associated with children's blood pressure. Aircraft noise exposure at home was significantly related to systolic blood pressure but not to diastolic blood pressure or heart rate. For road traffic noise, there was an inverse relationship for systolic blood pressure and no association for diastolic blood pressure or heart rate.
- There was no association between aircraft noise or road traffic noise and overall mental health or self-reported health.
- Combined effects and cognition: High road traffic noise exposure reduced the effect of high aircraft noise on reading comprehension. There were no other combined effects of aircraft and road traffic noise exposure on cognitive outcomes.
- Combined effects and annoyance: Children exposed to aircraft noise experienced greater annoyance from aircraft noise when also exposed to road traffic noise and vice versa, children

exposed to road traffic noise who are also exposed to aircraft noise report higher annoyance from road traffic.

- Combined effects and health: There was no association between combined noise exposure and overall mental health, self-reported health or blood pressure.

Sleep and Soundscape Studies

- Weak exposure-effect relationships between exposure to road traffic noise and sleep quality and alertness in the morning were found in the Swedish sleep studies. No exposure-effect relationships were found between road traffic noise exposure and difficulties falling asleep and awakenings in children but there was some evidence of daytime sleepiness among children exposed to noise levels above 55 dB $L_{Aeq, 24h}$.
- In the soundscape experiments children were able to assess the magnitude and quality of sounds as reliably as adults. Children exposed to high aircraft noise and children from schools with low or no aircraft noise exposure did not differ in their perceptual scaling of soundscapes. This means that children can judge and respond to noise in a consistent manner.
- A health evaluation model for children was developed and tested at a pan-European level. An analysis of this model demonstrated that children's psychological restoration combined with adults' social support may serve as protective factors for reducing children's self-reported annoyance at school and at home as well as reducing their self-reported symptoms and sleep disturbance.

Conclusions

- Similar effects of noise on cognitive performance and health were found across Spain, the Netherlands and the United Kingdom.
- High levels of chronic aircraft noise exposure impair children's reading and their ability to perform complex cognitive tasks.
- Road traffic noise did not show exposure-effect relationships with children's cognition and low levels of road traffic noise would probably not interfere with children's school work. In this study, the highest noise levels for schools were 71 $L_{Aeq, 16hr}$ dB which is lower than previous studies where cognitive impairments were found, therefore an effect of road traffic noise at high levels cannot be ruled out.
- The results for noise annoyance both confirm previous findings that children experience annoyance and extend knowledge on exposure-effects for aircraft and road traffic noise exposure. This implies an impaired quality of life for children.
- There is no evidence for exposure-effect relationships between noise exposure and children's self-reported health or overall mental health and inconclusive evidence for blood pressure and sleep disturbance.
- Effects of combined exposure to aircraft and road traffic noise were only observed for reading comprehension and annoyance: high levels of road traffic noise moderated the effects of high aircraft noise on reading comprehension; high road traffic noise augmented children's annoyance response to aircraft noise and high aircraft noise augmented children's annoyance response to road traffic noise.
- Opportunities for psychological restoration may potentially protect against adverse reactions to noise and improve children's well-being.

Policy recommendations and future research

- The results of the RANCH project, adding to previous research, provide evidence that aircraft noise exposure impairs child development, education and quality of life. The implications for policy are as follows:
- Since similar effects were found in the RANCH project across Europe, this implies that similar health-based guidelines on daytime aircraft noise limits for children can be applied in European countries.
- In the planning process noise exposure should be considered with other environmental aspects. It is recommended that new schools should not be planned close to existing airports, where noise exposure exceeds the WHO (2000) recommended levels for school playgrounds. It is advised that measures need to be taken to reduce noise in existing schools, where noise exposure is excessive.
- Children exposed to adverse environmental conditions, such as aircraft and road traffic noise should have quiet relaxing areas at or near home for psychological restoration.
- Further research should examine (i) whether sound insulation at school can protect against cognitive impairments related to chronic aircraft noise exposure and (ii) examine the role of classroom acoustics and teacher communication in the causation of noise effects on children's cognitive performance.