



Longitudinal effects of aircraft noise exposure on children's health and cognition: A six-year follow-up of the UK RANCH cohort



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ABSTRACT

Cross-sectional evidence that environmental noise exposure at school shows negative associations with children's cognition and health has increased, yet longitudinal evidence is lacking. This study examined longitudinal associations of aircraft noise exposure at primary school on children's reading comprehension, noise annoyance, and psychological health at secondary school. This six-year follow-up of 461 children aged 15–16 years, who attended primary and secondary schools around London Heathrow airport, used annual average aircraft noise exposure at the schools from noise contour maps. Multilevel regression modelling showed that aircraft noise exposure at primary school was associated with a significant increase in noise annoyance and with a non-significant decrease in reading comprehension at follow-up. Aircraft noise at primary school was not associated with psychological health at follow-up. This is the first longitudinal study of its type, suggesting that aircraft noise exposure at school might impair reading comprehension, as well as increase noise annoyance in children.

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1. Introduction

Exposure to transport noise in the environment is increasingly being seen as an important public health issue. Within Europe it has been estimated that 20% of the population (approximately 80 million people) are exposed to noise levels which scientists and health experts consider unacceptable (European Commission, 1996). The World Health Organisation recently estimated that traffic noise could conservatively account for over 1 million health years of life lost annually in the European Union and Western European countries (WHO, 2011). Evidence for traffic noise effects on human health outcomes such as cardiovascular disease (Jarup et al., 2008; van Kempen & Babisch, 2012), sleep (Basner, Griefahn, & Berg, 2010; Elmenhorst et al., 2012) and noise annoyance (Janssen, Vos, van Kempen, Breugelmans, & Miedema, 2011) has strengthened in recent years.

There is also growing evidence that environmental noise exposure such as aircraft or road traffic noise shows negative associations with children's cognition and health. To date, over 20 studies have shown a negative effect of environmental noise exposure on children's learning outcomes and cognitive

performance (Evans & Hygge, 2007). Studies have demonstrated that children with chronic aircraft, road traffic or rail noise exposure at school have poorer reading ability, memory, and academic performance on nationally standardised tests than children who are not exposed to noise at school (Bronzaft, 1981; Bronzaft & McCarthy, 1975; Clark et al., 2006; Haines, Stansfeld, Brentnall, et al., 2001; Haines, Stansfeld, Head, & Job, 2002; Haines, Stansfeld, Job, Berglund, & Head, 2001a; Hygge, Evans, & Bullinger, 2002; Lercher, Evans, & Meis, 2003; Shield & Dockrell, 2008; Stansfeld et al., 2005). Studies have also demonstrated associations of environmental noise exposure on children's health and quality of life outcomes including noise annoyance and blood pressure (Evans, Hygge, & Bullinger, 1995; Haines et al., 2001; van Kempen et al., 2006; van Kempen et al., 2009; Stansfeld et al., 2005).

Many different mechanisms have been hypothesised to account for environmental noise effects on children's cognition and health including impaired attention (Cohen, Evans, Krantz, & Stokols, 1986; Evans & Lepore, 1993), increased arousal (Yerkes & Dodson, 1908), communication difficulties between teachers and pupils (Evans & Maxwell, 1997), frustration (Evans & Lepore, 1993), learned helplessness and motivation (Evans & Stecker, 2004; Peterson & Seligman, 1984), and sleep disturbance effects on performance the next day (HCN, 2004). Physiological and psychological stress responses have also been posited to account for the

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associations (Babisch, 2003; Evans & Lepore, 1993; Lazarus & Folkman, 1984; Selye, 1976; Stansfeld, Haines, Burr, Berry, & Lercher, 2000): psychologically children are believed to be poorer at appraising threat from environmental stressors and to have fewer well-developed coping strategies.

To date, few studies have examined exposure–effect relationships between noise exposure and children’s cognition and health (Green, Pasternack, & Shore, 1982; Stansfeld et al., 2005). Such studies compare children from schools across a wide range of noise exposures, rather than comparing high exposure with low exposure, in order to be able to identify the exposure level at which noise effects on cognition begin. The European Union funded RANCH project (Road traffic noise and Aircraft Noise exposure and children’s Cognition and Health), the largest study of noise and children’s cognition and health to date, examined the cross-sectional associations of aircraft noise and road traffic noise exposure at primary school on the cognitive performance and health of 2844 9–10 year old children around Heathrow (London), Schiphol (Amsterdam), and Barajas (Madrid) airports. The study found exposure–effect associations between aircraft noise exposure at school and children’s reading comprehension, recognition memory, noise annoyance, and hyperactivity scores after adjusting for a range of socioeconomic factors (Clark et al., 2006; van Kempen et al., 2009; Stansfeld et al., 2005; Stansfeld et al., 2009).

Further convincing evidence to suggest the existence of noise effects on children’s cognition comes from intervention studies and natural experiments where changes in noise exposure associated with sound insulation or the closure of airports have been accompanied by changes in cognition. However, to date, there have been only three studies examining the effects of noise reduction on children’s cognition (Bronzaft, 1981; Cohen, Evans, Krantz, & Stokols, 1981; Evans, Bullinger, & Hygge, 1998; Evans et al., 1995; Hygge et al., 2002), all of which suggest that noise reduction can eliminate effects on cognition.

However, many children will remain exposed to environmental noise throughout their childhood. Yet, very little is known about the potential long-term consequences of environmental noise exposure persisting throughout a child’s schooling. Most of the evidence for environmental noise effects on children’s cognition and health comes from cross-sectional studies. One follow-up study over a one-year period found that deficits in reading comprehension and noise annoyance responses persisted, suggesting that children did not adapt to noise exposure (Haines, Stansfeld, Job, Berglund, & Head, 2001b). If children do not adapt to their noise exposure, it is possible that associations between environmental noise and cognition and health could increase in terms of their impact over time. Longitudinal studies are much needed in this research field, to evaluate the long-term effects of environmental noise exposure on children’s health and cognitive development; to further understand the causal pathways between noise exposure and cognition and health; to inform the design of preventive interventions; and to further inform policy (European Union, 2002).

2. Aims

This study followed-up the UK cohort from the RANCH project in secondary school, six years after the original primary school-based study. The study had the following aims:

- i. To examine whether aircraft noise exposure at primary school showed longitudinal associations with reading comprehension, noise annoyance, and psychological health at follow-up six years later.

- ii. To examine cross-sectional associations of aircraft noise exposure at secondary school on reading comprehension, noise annoyance, and psychological health, as few studies to date have examined noise associations on the health and cognition of children in this age group.
- iii. To examine associations between cumulative aircraft noise exposure at primary and secondary school and reading comprehension, noise annoyance, and psychological health, to assess the combined effect of aircraft noise exposure across the child’s schooling.

For each type of exposure (aircraft noise at primary school, aircraft noise at secondary school, and cumulative exposure) we hypothesised that children attending aircraft noise exposed schools would have poorer reading comprehension, higher noise annoyance, and higher hyperactivity scores than children attending low aircraft noise exposed schools. No associations were hypothesised between aircraft noise exposure at school and emotional symptom or conduct problem scores.

3. Method

3.1. Sampling and design

A quantitative prospective epidemiological follow-up of the UK RANCH cohort was carried out in 2008, six years after the initial RANCH baseline study which was conducted in 2001–2003. At baseline 9–10 year old children were selected to take part on the basis of aircraft and road traffic noise exposure at their schools around Heathrow airport in West London (Stansfeld et al., 2005). At follow-up participants attended secondary schools in West London with a range of aircraft noise exposure. At baseline, the schools were matched on sociodemographic factors. 29 primary schools participated at baseline and 27 secondary schools participated at follow-up (see Fig. 1).

Ethical approval for the baseline survey in the UK was provided by the East London and the City Local Research Ethics Committee, East Berkshire Local Research Ethics Committee, Hillingdon Local Research Ethics Committee, and the Hounslow District Research Ethics Committee in the United Kingdom. Ethical approval for the follow-up survey was obtained from the Queen Mary Research Ethics Committee [Reference QMREC2007/59].

3.2. Noise exposure assessment

Noise exposure at the child’s school was estimated in dB(A): the A-weighting is used to approximate the typical sensitivity of the human ear. At baseline and follow-up aircraft noise estimates for each school were based on 16-h outdoor dB L_{Aeq} contours available nationally from the UK Civil Aviation Authority. These give the average noise exposure in dB (A) between 7 am and 11 pm for the postcode. Baseline data were from July to September 1999; follow up data were from July to September 2007. At baseline acute noise measurements during testing were taken inside and outside the classroom (see Fig. 2): however, acute noise had no influence on the association between aircraft noise and reading comprehension (Clark et al., 2006) so acute noise was not measured at follow-up. Aircraft noise exposure at baseline and follow-up are analysed as continuous variables in dB L_{Aeq16h} . The mean of the aircraft noise exposure at primary and secondary school variables was used to assess cumulative aircraft noise exposure at school. At baseline L_{Aeq16h} estimates of road traffic noise exposure for the schools based upon a standardised method (H.M.S.O., 1998) and confirmed by noise measurements were also available (Stansfeld et al., 2005). At follow-up no road traffic noise

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