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THE SATS STUDY: THE EFFECTS OF AIRCRAFT NOISE EXPOSURE ON STANDARDIZED PERFORMANCE TESTS AROUND HEATHROW AIRPORT

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ABSTRACT

The aim of this multi-level modeling study was to examine the effect of chronic exposure to aircraft noise on a range of school performance outcomes in Mathematics, English (reading, creative writing, spelling and handwriting) and Science in 11 year old children in schools exposed to a range of 8 aircraft noise exposure levels. British National Standardized Scores (SATS) for Key Stage 2 were analyzed in relation to aircraft noise exposure around Heathrow Airport in West London for 11,000 scores of children aged 11 from 128 schools. The analyses were carried out at both the school and individual level, with adjustment made for socio-economic and school quality factors. The results suggest that chronic exposure to aircraft noise is associated with decrements in school performance in reading and mathematics after adjustment for school effects, but that this association is influenced by socio-economic factors.

1 - INTRODUCTION

Previous studies examining the association between chronic noise exposure with standardized reading and school performance tests have found preliminary evidence of a relationship between environmental noise exposure and school performance [1,2,3]. A repeated measures study in schools around Heathrow Airport found that children exposed to high levels of aircraft noise have poorer reading comprehension compared with children in low noise exposed schools [4]. These results raise further questions, two of which were addressed in this study. First, were previously found associations confounded by social class and school quality? Second, does aircraft noise affect school performance uniformly or are impairments more likely to be found in language-based tasks? To address these questions the aim of this study was to examine the effect of aircraft noise on a range of standardized school performance outcomes in Mathematics, English (reading, creative writing, spelling and handwriting) and Science in 11 year old children in schools exposed to a range of 8 aircraft noise exposure levels. It was hypothesized that chronic aircraft noise exposure would be associated with poorer performance in English and Reading in a dose response function after adjustment for school effects. Noise effects would be larger for the reading performance than for spelling, writing and handwriting performance. No effects were expected on the control outcomes of Mathematics and Science.

2 - METHOD

Design: This study is a multi-level modeling study in which the British National Standardized Scores (SATS) for Key Stage 2 were analyzed in relation to aircraft noise exposure around Heathrow Airport in West London for 11,000 scores of children aged 11 from 128 schools. The analyses were at both the school and individual level, with adjustment made for socio-economic and school quality factors.

Database: School performance scores were taken from a sample of all students from 3 local authority areas surrounding Heathrow Airport who did the SATS exams in 1996 and 1997. In the analyses, the following numbers of pupils were included: 10,998 scores for English (10,957 for spelling; 10,957 for handwriting; 10,957 for writing; 10,957 for reading); 11,105 scores for Mathematics; 11,163 for Science. The numbers differ slightly as some test results were missing or invalid for a very small number of pupils. Aircraft Noise Exposure Estimation: Schools were chosen within the published 1994 Civil Aviation Authority dBA Leq, 16hr (92 days) contour maps indicating the average continuous equivalent sound level of aircraft noise within a particular area for 16 hour daily periods during June 15 to September 15 around Heathrow Airport. Each school was classified into one of 8 noise exposure levels depending on which noise contour band the school was sited: 1= >54, 2= 54>57, 3= 57 >60, 4=60>63, 5=63 > 66, 6=66 > 69, 7= 69> 72, 8 = <72.

School Performance and socio-demographic factors: Standardized performance tests (SATs) of national curriculum assessments for Key Stage 2 are taken by all British School children when they are in year 6 and aged approximately 11 years old. These examinations are nationally standardized and marked externally for English (reading, writing, spelling and handwriting), Mathematics and Science. The school and individual level scores were obtained in ASCII format from the Department for Education and Employment (DfEE). Individual final raw scores range from 0 to 100. Sex, year of testing, type of school and percentage of pupils eligible for free school meals were obtained from routinely collected data. Statistical Procedures: To test whether the effects of noise on performance are a dose-response function a multi-level modeling analysis of the performance data was conducted using the noise band contours 1 – 8. These analyses assessed if the impairments in school performance are associated with a monotonic increase in noise exposure. Multilevel modeling was used because the SATS data is hierarchical with pupils clustered within schools. Multilevel modeling makes best (or statistically efficient) use of this data rather than having to choose whether to analyze at the individual or school level neither of which is satisfactory [5]. The multilevel method produces correct standard errors and significance tests as the analysis takes account of the clustered nature of the data adjusting for school differences. If an individual level regression analysis was carried out, the standard errors of the regression coefficients would be underestimated in situations where there is clustering. Another advantage is that both variables at the school level (e.g. type of school) and the pupil level (e.g. age) can be included in the same model. Finally, one can see whether noise effects 'explain' any of the variation in SATS scores between schools. The multilevel models were fitted to the data using the statistical package, Mln, which was written by statisticians from the Institute of Education, University of London.

Multi-Level Models: Results from two models will be reported. The first model, referred to as the 'unadjusted model', examined the association between noise and SATs scores after adjustment for sex, year of testing and type of school. These analyses are fully reported in Table 1. The second model adjusted additionally for the percentage of pupils eligible for a free school meal, a measure of social deprivation. Family on social security benefit is the criteria for entitlement for free school meal and is a reliable indicator of social disadvantage. These results will be reported in the text of the results section with the noise coefficient for reading and mathematics after adjustment for percent eligible for free school meals.

3 - RESULTS

School Sample: 61 schools were exposed to low levels of aircraft noise (>57 dBA Leq); 48 schools were exposed to moderate levels of aircraft noise (57>63 dBA Leq); 19 schools were exposed to high levels of aircraft noise (63>72 dBA Leq).

Science: Noise level is not associated with performance in Science (Table 1).

Fixed Coefficients	English	Spelling	Hand-writing	Creative Writing	Reading	Maths	Science
	n=10998	n=10957	n=10957	n=10957	n=10957	n=11105	n=11163
Intercept	56.88 (1.07)	6.07 (0.15)	3.6 (0.06)	19.72 (0.3)	27.64 (0.6)	45.29 (1.03)	49 (1.0)
Noise Level	-0.54 (0.31)	-0.02 (0.04)	-0.01 (0.02)	-0.09 (0.10)	0.42 (0.19)*	0.73 (0.30)**	-0.44 (0.30)
Sex (F vs M)	5.84 (0.28)	0.7 (0.05)	0.3 (0.02)	2 (0.08)	2.81 (0.18)	-1.28 (0.27)	0.03 (0.22)
Year (97v96)	1.24 (2.19)	-0.09 (0.04)	-0.2 (0.02)	1.0 (0.09)	-2.43 (0.18)	2.49 (0.27)	-0.11 (0.23)
Type of School (Church vs Gov)	6.77 (1.15)	0.8 (0.16)	0.13 (0.07)	1.6 (0.4)	4.2 (0.7)	5.55 (1.11)	4.21 (1.08)
Type of School (Grant Maintained vs Gov)	1.24 (2.19)	0.06 (0.31)	0.04 (0.12)	0.4 (0.6)	0.7 (1.3)	-0.67 (2.11)	-1.97 (2.08)
%eligfsm	-	-	-	-	-	-	-
Random Parameters							
Level 2: (school)	26.95 (3.84)	0.52 (0.08)	0.09 (0.01)	2.63 (0.37)	9.54 (1.4)	25.10 (3.57)	24.94 (3.44)
Level 1: (pupil)	218.2 (2.96)	6.6 (0.09)	0.64 (0.000)	20.35 (0.28)	83.61 (1.2)	203.6 (2.75)	140.9 (1.90)

Table 1: The multi-level models for English, Spelling, Handwriting, Creative Writing, Reading Mathematics and Science unadjusted: estimates and standard errors (* p=0.025, ** p=0.014).

English, Reading, Spelling, Handwriting and Writing: Noise level was not associated with performance in English (Table 1). An analysis of the four subscales of the English test show that aircraft noise exposure affects performance on the reading test more than the other sub-tests: spelling, handwriting, creative writing (Table 1). As noise levels increase by contour band, performance drops by 0.42 of a mark (p=0.025). After adjustment for percentage of pupils eligible for free school meals the effect is no longer significant on the reading test (noise level=0.03(0.16)).

Mathematics: Noise level was significantly related to mathematical performance after adjustment for school effects (Table 1). As noise levels increase by contour band, performance drops by 0.73 of a mark (p=0.014). After adjustment for percentage of pupils eligible for free school meals the association becomes statistically insignificant (noise level = -0.44 (0.30)).

4 - DISCUSSION

There were three main findings in this study. First chronic exposure to aircraft noise was significantly related to poorer reading performance and was not associated with the control English performance outcomes, spelling, writing and handwriting. Second, chronic exposure to aircraft noise at school was significantly related to poorer performance on a nationally standardized test of Mathematics after adjustment for school effects. Third, after adjustment for socio-economic status, measured by free school meal ratio, the association between high noise exposure and poorer reading and mathematical performance on the SATS tests was reduced and was no longer statistically significant.

Given the complex and unexpected nature of the results, it is difficult to draw definitive conclusions from this study. Taken together, these results suggest that chronic exposure to aircraft noise is associated with impairment of school performance in reading and mathematics in a dose-response function after adjustment for school effects, but that this association is influenced by socio-economic factors. These results suggest that it is still an open issue as to whether chronic aircraft noise exposure affects language-based tasks exclusively because aircraft noise had the strongest effect on mathematical performance. The models fully adjusted for socio-economic status provide limited information about the interrelationship between noise exposure, school performance and socio-economic status. The results from both the unadjusted and fully adjusted models suggest that both noise exposure and socio-economic status are interrelated and combine to influence performance. Future research should be conducted concurrently

with detailed theoretical consideration of the nature of the pathways between socio-economic status, noise exposure and performance.

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