***inter.noise 2000***
***The 29th International Congress and Exhibition on Noise Control Engineering***
***27-30 August 2000, Nice, FRANCE***

**I-INCE Classification:** 6.0

# CROSS-SECTIONAL AND LONGITUDINAL RESULTS OF A FOLLOW-UP EXAMINATION OF CHILD BLOOD PRESSURE AND AIRCRAFT NOISE – THE INNER SYDNEY CHILD BLOOD PRESSURE STUDY

**S. Morrell*, R. Taylor*, N. Carter**, P. Peploe***, S. Job******

* University of Sydney, Department of Public Health and Community Medicine, 2006, Sydney, Australia

** formerly National Acoustic Laboratories, 25 Calga St, 2069, Roseville, Australia

*** National Acoustic Laboratories, Greville St, 2067, Chatswood, Australia

**** University of Sydney, Department of Psychology, 2006, Sydney, Australia

Tel.: 61-2-9351-4373 / Fax: 61-2-9351-4179 / Email: stephenm@pub.health.usyd.edu.au

**Keywords:**
AIRCRAFT NOISE, CHILD BLOOD PRESSURE

## ABSTRACT
Results from a follow-up study of domestic jet aircraft noise exposure and child blood pressure (BP) around Sydney (Kingsford-Smith) Airport confirm negative findings of an earlier baseline study of aircraft noise and child BP in Sydney. In relation to changes in BP and changes in aircraft noise exposure experienced by the same individuals at follow-up, no consistent statistically significant association was found between aircraft noise exposure, or its change, and BP or its corresponding change.

## 1 - INTRODUCTION
The scientific basis for relating blood pressure (BP) to aircraft noise rests largely on experimental evidence for various noise sources, including domestic jet aircraft noise, stimulating changes in blood pressure. In particular, abundant laboratory evidence has shown that exposure to noise can produce acute blood pressure reactions which subside soon after cessation of the stimulus [1-4]. Biological mechanisms for an acute BP response to noise include increased peripheral resistance mitigated by reduced cardiac output [5], with more complex cardiovascular responses occurring in the presence of modifying stimuli such as concurrent performance of mental or cognitive tasks [6-8].
While evidence for non-acute or long-term BP effects from exposure to noise is less convincing, there are a number of plausible biological pathways for acute changes in BP manifesting eventually as elevated resting BP. Long-term changes to baroreceptor reflex activity from shorter-term exposure to stressors [9], and thickening of the arterial walls [5], are two biologically plausible mechanisms for the eventual cumulation of acute BP effects into chronically elevated BP. Other mechanisms may also be involved.
Most evidence for aircraft noise affecting child BP beyond the known acute effects is based on two studies of populations, one living near Los Angeles and the other near Munich Airport. In Los Angeles, Cohen et al. [10] found 3 mmHg higher average systolic and diastolic BP in schoolchildren exposed to high aircraft noise levels around the airport, compared to children in schools not so exposed. Evans et al [11] also found an association between child BP and aircraft noise around Munich Airport, although this latter study did not replicate the Cohen et al study. The opening of the new parallel runway at Sydney Airport provided an opportunity to examine child BP, and its changes, in relation to exposure to aircraft noise and changes in the latter, after controlling for confounders of BP.
Accordingly, the Inner Sydney Child Blood Pressure Study comprised a baseline ("Phase I") and follow-up phase ("Phase II") of physical and BP measurements taken on the same individuals 2-3 years apart.

Phase I measurements were conducted in 1994-5, with the follow-up Phase II conducted in 1997. Longitudinal analysis of BP and exposure to aircraft noise in these children enabled within-subject changes in BP to be related to corresponding Phase I-Phase II changes in aircraft noise exposure.

## 2 - OBJECTIVES AND METHODS

The following questions were addressed in Phase II of the study:

1. Is there a cross-sectional correlation between aircraft noise exposure levels (ANEI: Australian Noise Exposure Index) and blood pressures, as measured in Phase II?
2. Is there a correlation between Phase II aircraft noise levels and Phase I-Phase II changes in BP measurements?
3. Is there a correlation between Phase I-Phase II changes in aircraft noise exposure and Phase II BP measurements?
4. Is there a correlation between Phase I-Phase II changes in aircraft noise exposure and corresponding Phase I-Phase II BP changes?

These questions are addressed in terms of continuous and categorical measures of aircraft noise exposure, and its change, based on comparisons within full-sample, panel sample and extreme exposures to aircraft noise.

### 2.1 - Data

**Child Physical Measurements**

Baseline and follow-up measurements of child blood pressure came from children attending a sample of primary schools within a 20 km radius of Sydney (Kingsford-Smith) Airport. Phase I measurements were conducted in 1994/95, and Phase II measurements carried out in August-November 1997. Of the original 1,230 study participants in Phase I of the study, 628 participated in Phase II. Approximately 300 children from the original Phase I sample were not contactable due to relocation. The remainder did not participate in the study due to parental refusal. Most schools from Phase I of the study participated in Phase II, with the exception of four schools. Two of these schools refused to participate again in the study, and the remainder did not participate due to no pupils participating in Phase II. Two schools not taking part in Phase I, but with some children from Phase I of the study attending, also agreed to co-operate in the follow-up measurements of these children.

**Noise measurements**

Phase I & II aircraft noise measurements were conducted by the National Acoustic Laboratories according to methods based on the Integrated Noise Model [NAL Report No.133, 1996]. The noise metric used in the study was the Australian Noise Exposure Index (ANEI). This unit is an energy-equivalent quantity which takes into account the number of noise events, the noise intensity, and the degree of subjective reaction to the noise type and its source based on social surveys [Hede et al, 1982; Bullen, 1984].

Phase I and Phase II noise levels were assigned to individual home and school street addresses geocoded to absolute latitudes and longitudes (accurate to four decimal places). Noise data produced by the National Acoustic Laboratories were in the form of grid points in ANEI units assigned to approximate 100 metre equidistant points, also geocoded to absolute latitude and longitude co-ordinates. Specialised geographic information system software ("Vertical Mapper") was then used to interpolate noise values for geographic locations (viz, home and school addresses) lying between individual noise grid points.

### 2.2 - Analysis

**Noise**

The following classifications of exposure to aircraft noise were used in univariate and multivariate regression analyses of child BP:

- Aircraft noise at school, home, the difference between school and home noise and the combined school + home total (time-weighted) as a continuous variable, in ANEI units, with exposure levels below 15 ANEI set to zero.
- The same as (i) but with school, home or total noise exposure levels below 15 ANEI excluded from the models (so-called panel design).
- Aircraft noise at the school, home or combined total as a categorical exposed/unexposed variable, with exposure levels below 15 ANEI assigned as unexposed and the remainder assigned to exposed. A similar comparison is made comparing exposures below 20 ANEI (unexposed) with exposures of 20 ANEI or above, and between below 25 ANEI and 25 ANEI or above.

- Aircraft noise at the school, home or combined total as a categorical exposed/unexposed variable, using exposure levels above 25 ANEI to classify the exposed group, and levels below 15 ANEI classified as the unexposed group (ignoring schools with exposures in between 15 and 25 ANEI) – an extremes comparison.

- Differences in Phase I and Phase II aircraft noise measures (ANEI), at school, home or combined, as a continuous variable, with BP comparisons in the full sample, among those experiencing non-zero Phase I-Phase II noise changes only, and among those whose absolute noise change was 5 ANEI or above (ie, < -5 ANEI change group is compared to 5 ANEI noise change group, an extremes comparison).

- Phase I to Phase II transitions from exposed to non-exposed aircraft noise categories (as defined in (iii) and (iv)), with full sample comparisons and comparisons between groups experiencing positive and negative noise exposure changes, using 15 and 20 ANEI as cut points. That is, those whose aircraft noise exposure changed from below 15 or 20 ANEI to 15 or 20 ANEI or above are compared only to those whose noise exposure changed from 15 or 20 ANEI or above to below 15 or 20 ANEI.

Measures of total aircraft noise exposure were derived from school and home aircraft noise measures combined as a weighted sum, reelecting the time spent at school and at home exposed to aircraft noise and the jet aircraft operating curfew at Sydney Airport (11 pm − 6 am):
Total aircraft noise = (6/17*school aircraft noise) + (11/17* home aircraft noise level).
The measure of noise related to blood pressure was a mean level for the month in which the BP measurement was taken. This was done in order to minimise the day-to-day variability (measurement error) in the noise exposure measure used.

**Blood Pressure**

The blood pressure outcomes of interest were systolic and diastolic blood pressure, and Phase I − Phase II changes in systolic and diastolic BP. The mean of the second and third BP readings was used as the outcome variable. BP outcomes were related to aircraft noise in regression models controlling for measured individual potential confounders of a blood pressure/aircraft noise relationship, including height, weight, family history of high BP, BP measured at baseline (Phase I), physical activity levels and ambient temperature at the time of BP measurement. Changes in Phase I-Phase II BPs were related to corresponding changes in aircraft noise levels, after controlling for corresponding changes in physical measures such as weight, height and skinfold thickness.

**Sample design Effect**

Sampling design effect estimates, due to sampling by school rather than individual, were used to adjust accepted levels of statistical significance to account for the effect of cluster sampling. The extent of clustering and the design effect was recalculated for each of the main outcomes: Phase II systolic and diastolic BPs and the Phase I-Phase II differences in systolic and diastolic BPs. For Phase II systolic BP the standard statistical significance level of 0.05 equated to a statistical significance of 0.028; for Phase II diastolic BP the equivalent level of statistical significance was 0.026. For the Phase I-Phase II systolic pressure change, the equivalent level of statistical significance was 0.028; and for the Phase I-Phase II change in diastolic BP, the equivalent level of statistical significance was 0.025.

**Confounding**

Confounding variables controlled for in all regression models of aircraft noise and BP were as follows:

- **Noise abatement**: School insulated for noise, Domestic residence insulated for heat or noise;

- **Child BP characteristics**: Phase I BP, Heart rate (beats/min.), BP reaction measure, Pulse reaction measure, Family history of high BP, Parental history of high BP, Child history of high BP;

- **Anthropometric measures**: Weight, Height, Total skinfold thickness (bicep+tricep+subscapular);

- **Eating habits**: Did not eat before school and prior to BP measurement, Child adds salt to food;

- **Demographics**: Sex (female), Non-English speaking background, Index of socioeconomic status of child's postcode;

- **Child activity levels**: Child plays actively during recess/lunch breaks, Child participates in organised sport, Child considered less active than average by parent;

- **Measurement conditions**: Ambient temperature at time of BP measurement, BP measurer

In addition, regression models of BP change from Phase I to Phase II of the study took into account Phase I BP (ie, baseline BP) and Phase I-Phase II differences in weight, skinfold thickness and ambient temperature [Jenner et al, 1987] at the time of physical measurement.

## 3 - RESULTS

### 3.1 - Participation

The Phase II sample comprised 628 children, from an original Phase I sample of 1,230 children. In Phase II, 314 were males and 314 females; 157 children came from a non-English speaking background (25%); 311 children (50%) had a reported family history of high blood pressure (where a parent reports high BP in themselves or one of their own parents); 103 children had a history of elevated BP in a biological parent (16%), and 4 children reported having a history of elevated BP themselves (<1%). Thirty three children were judged by a parent as being less active than average (5%), and 387 children were reported as regularly using salt on their food (62%).

The corresponding proportions in the Phase I sample were very similar: boys–50.2%; children from a Non-English Speaking Background –27%; children with a family history of high BP– 46%; children with history of high BP in a biological parent–15%; children with a history of high BP themselves–<1%; child regarded by a parent as less active than average–6%; and children reported as using salt on their food–61 percent [Carter et al 1997].

### 3.2 - Aircraft noise levels and BP

The results of the various analyses are summarised in the Table below. Overall, all effect sizes of noise and BP were small and, with few exceptions, statistically non-significant. This occurred with unadjusted regression models and in models adjusted for the confounding factors listed above.

All regression models of BP and aircraft noise when analysed as a continuous exposure variable produced no statistically significant associations, either in full or panel samples, or in comparisons of extreme exposure differences or changes. Where a statistically significant association between aircraft noise exposure and BP was found, it was either in the opposite direction to that hypothesised, as with diastolic BP and its Phase I-Phase II change versus aircraft noise and its corresponding change analysed as a categorical variable above or below the two cut points of 15 or 20 ANEI; or the relationship was not confirmed by a dose-response consistency. This was the case with Phase II systolic BP, and with Phase I-Phase II change in systolic BP, and Phase I-Phase II aircraft noise change when analysed as a categorical variable above or below 15 or 20 ANEI.

The various regression models of BP used in the analysis accounted for about 20%-50% of the variance found in BP.

| | **Statistically significant association with Phase II BP (after adjustment)**[1] | | **Statistically significant association with Phase I-Phase II BP change (after adjustment)**[1] | |
|---|---|---|---|---|
| **Noise exposure measure** | **Phase II Systolic BP** | **Phase II Diastolic BP** | **Phase I-Phase II Systolic BP change** | **Phase I-Phase II Diastolic BP change** |
| Phase II noise exposure as a continuous variable | No association | No association | No association | No association |
| Phase II noise exposure as a categorical variable | Inconsistent association[2] | No association | Inconsistent association[2] | No association |
| Phase II noise exposure as difference between school and home noise exposure | No association | No association | No association | No association |
| Phase I-Phase II noise exposure change as a continuous variable | No association | No association | No association | No association |
| Phase I-Phase II noise exposure change as a categorical variable | No association | Opposite association[3] | No association | Opposite association[4] |

**Table 1:** Summary of relationships found between child blood pressure and changes and exposure to aircraft noise and changes ([1.] adjustment is for factors which confound the relationship between aircraft noise and blood pressure (eg, weight, height, etc, as listed above); [2.] 20 ANEI at school positive, but 20 ANEI at home negative; [3.] Total noise increase to 15 ANEI versus remainder, or versus decrease to <15 ANEI, both negative; [4.] total noise increase to 20 ANEI vs. decrease to <20 ANEI, negative).

## 4 - CONCLUSION

Studies of child BP and aircraft noise in naturalistic settings so far have not produced replicable results. Where statistically significant associations between child BP and aircraft noise exposure in naturalistic settings have been found, these have been small and only when BP has been related to noise exposure as a categorical (class) variable. Using accurate, individual-based noise exposure measurements which allow BP to be related to aircraft noise exposure as a continuous variable, along with greater controlling of potentially confounding factors of a BP-aircraft noise relationship, the findings of Cohen et al, or Evans et al, could not be replicated in this study.

## REFERENCES


1. **LB Cartwright et al**, The effects of broadband noise on the cardiovascular system on normal resting adults.

2. **L Andren et al.**, Hemodynamic and hormonal changes induced by noise.

3. **L Andren et al.**, Noise as a contributory factor in the development of elevated arterial pressure. A study of the mechanisms by which noise may raise blood pressure in man.

4. **K Yamamura et al.**, Physiological responses induced by 555-min exposure to intermittent noise.

5. **D Hattis et al.**, *Noise, general stress responses, and cardiovascular disease processes: Review and reassessment of hypothesised relationships.*

6. **RL Ray et al.**, Cardiovascular effects of noise during complex task performance.

7. **TN Wu et al.**, Effects of noise exposure and task demand on cardiovascular function.

8. **NL Carter et al**, The effect of intermittent noise on cardiovascular functioning during vigilance task performance.

9. **MJ Kenny et al.**, Ustained increases in aortic depressor nerve activity after acute elevation of arterial pressure.

10. **S Cohen et al.**, Physiological, motivational, and cognitive effects of aircraft noise on children: moving from the laboratory to the field.

11. **GW Evans et al.**, Chronic noise exposure and physiological response: A prospective study of children living under environmental stress.