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AIRCRAFT NOISE AND CHILD BLOOD PRESSURE

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This thesis is submitted in satisfaction of the requirements for the degree of Doctor of Philosophy, University of Sydney

TABLE OF CONTENTS

PREFACE xvi
I. Note on the author's contribution xvi
II. Institutional Human Ethics Committee Approvals and Consent xviii
III. Acknowledgments xix

ABSTRACT xxi

GLOSSARY OF TERMS AND ABBREVIATIONS xxiii

CHAPTER 1 -- INTRODUCTION 1

1.1 Setting 2

1.2 Review of studies of aircraft noise and non-aural health effects 6
1.2.1 Blood Pressure: historical antecedents, definitions 6
1.2.1.1 Brief historical sketch of blood circulation, pulse and blood pressure 6
1.2.2 Meaning and definitions of blood pressure and blood pressure variability 13
1.2.2.1 Blood pressure regulation 13
1.2.2.2 Haemodynamicity/BP variability 20
1.2.2.3 A candidate mechanism from human studies for noise stimulus to affect resting blood pressure 23
1.2.2.4 Issues of measurement of blood pressure 24

1.3 Determinants of child resting blood pressure 32
1.3.1 Activity and fitness levels 32
1.3.2 Diet and eating habits 33
1.3.3 Ambient temperature 33
1.3.4 Childhood conditioning factors 34
1.3.4.1 Age 34
1.3.4.2 Sex 34
1.3.4.3 Race/Ethnicity 34
1.3.4.4 Body mass, height, adiposity and growth stage 35
1.3.4.5 Hormonal/metabolic factors 36
1.3.4.6 'Tracking' of BP levels 36
1.3.4.7 Pulse rate 37
1.3.5 Effect modifiers 37
1.3.5.1 BP and sodium (Na) intake/excretion/sensitivity 37

1.4 Noise 38
1.4.1 Definitions of noise 38
1.4.2 Human perception of, and reaction to, noise 40
1.4.3 Mechanical measurement of noise 41
1.4.3.1 Development of the dB(A) scale 41
1.4.3.2 The Effective Perceived Noise Level (EPNL) 43

1.4.4 What is aircraft noise? 44
1.4.4.1 Social surveys of community reaction to noise 46
1.4.4.2 Event-based noise metrics 50
1.4.4.3 Energy-averaged noise metrics 50
1.4.4.4 Steps in construction of an ANEI (or ANEC or ANEF) value at a given grid point 53

1.5 Noise and health 55
1.5.1 Definitions of health 55
1.5.2 "Stress" and health 56
1.5.2.1 Development of stress as a determinant of health 56
1.5.2.2 Stress and personality type 59
1.5.2.3 Stress and "locus of control" 61
1.5.2.4 Stress, locus of control and personality type 63
1.5.3 Noise as a stressor 64
1.5.3.1 Cardiovascular effects and noise exposure 67

1.6 Aircraft noise and child BP 79
1.6.1 Los Angeles Airport child BP study 79
1.6.2 The Munich Airport Study (1998) 81

1.7 Conclusions 82

CHAPTER 2 -- OBJECTIVES AND METHODS 84

2.0 Introduction 85

2.1 Hypotheses to be tested 85
2.1.1 Implications and interpretation of hypotheses 87

2.2 Study design and its evolution 89
2.2.1 Evolution of the study 89

2.3 Study sample, design effects, approvals, consent, exposure and outcome measurement 92
2.3.1 Response Rates 97
2.3.2 Data Collection 96
2.3.3 Surveys/questionnaires 97
2.3.3.1 Child activity levels 99
2.3.3.2 Child eating before school and use of salt on food 99
2.3.3.3 Child dietary information 99
2.3.3.4 House structure 100
2.3.3.5 Socio-economic status 100
2.3.4 Physical Measurements 101
2.3.4.1 Blood Pressure 102
2.3.4.2 Skinfold thickness 102
2.3.4.3 Height 102
2.3.4.4 Weight 102
2.3.4.5 Ambient Temperature 103

2.3.5 Training and assessment of field workers . . . 103
2.3.6 Ethics clearance and approval mechanisms . . . 104
2.3.7 Reporting of measurements to participants . . . 105
2.3.8 Noise Exposure measurement . . . 105
2.3.9 Geocoding address information and aircraft noise exposure data . . . 107
2.3.10 Non-aircraft noise sources . . . 109

2.4 Statistical Analyses . . . 110
2.4.1 Distributions . . . 111
2.4.2 Regression Models . . . 111
2.4.3 The effect of overflights during blood pressure measurement . . . 117
2.4.3.1 The effect of aircraft overflights on blood pressure measurement . . . 120
2.4.4 Within-subject blood pressure and pulse rate variability . . . 123
2.4.4.1 Conclusions on BP and pulse rate variability . . . 129
2.4.5 Discussion of Methods . . . 131

2.5 Preliminary results . . . 132
2.5.1 Response Rates . . . 132
2.5.2 Blood pressure, weight, height and sub-scapular skinfold distributions . . . 134
2.5.2.1 Baseline . . . 134
2.5.2.2 Follow-up . . . 137
2.5.2.3 Distribution of baseline-to-follow-up BP differences . . . 138
2.3.2.4 Distributions of anthropometric measurements . . . 139
2.5.3 Mean values of physical measurements by sub-group: descriptive statistics of physical factors normally associated with BP . . . 141
2.5.3.1 Baseline . . . 141
2.5.3.2 Follow-up . . . 145
2.5.4 Changes and differences in BP and anthropometric measures between baseline and follow-up samples . . . 148
2.5.4.1 Differences between follow-up and lost-to-follow-up at baseline . . . 148
2.5.4.2 Within-subject changes between baseline and follow-up . . . 149
2.5.5 Distributions of school aircraft noise values and children . . . 153

2.6 Summary and conclusions . . . 157

CHAPTER 3 -- RESULTS . . . 160

3.0 Introduction . . . 161

3.1. cross-sectional associations between aircraft noise and blood pressure . . . 161
3.1.1. School aircraft noise exposure -- Pre-baseline, baseline and follow-up . . . 161
3.1.1.1 Systolic blood pressure and school aircraft noise exposure . . . 161

3.1.1.2 Diastolic Blood Pressure and school aircraft noise exposure 166
3.1.2 Total (school + home) aircraft noise exposure, pre-baseline, baseline and follow-up 170
3.1.2.1 Systolic BP and total aircraft noise exposure 170
3.1.2.2 Diastolic BP and total aircraft noise exposure 174
3.1.3 BP and noise measurement artefacts 179
3.1.3.1 BP and aircraft noise exposure as an ordinal variable 179
3.1.3.2 Panel analysis of BP and non-zero aircraft noise exposure 183
3.1.3.3 Summary of unadjusted cross-sectional associations 188

3.2 Regression models of cross-sectional associations between BP and School Aircraft noise exposure -- baseline and follow-up 189
3.2.1 Systolic BP and school aircraft noise exposure 190
3.2.1.1 Baseline systolic BP and pre-baseline noise 190
3.2.1.2 Baseline and follow-up 191
3.2.2. Diastolic BP and school aircraft noise exposure 193
3.2.2.1 Baseline BP and pre-baseline noise 193
3.2.2.2 Baseline and follow-up 193

3.3 Regression models of cross-sectional associations between BP and Total Aircraft noise exposure -- baseline and follow-up 196
3.3.1 Systolic blood pressure and total (home + school) aircraft noise exposure 196
3.3.1.1 Baseline BP and pre-baseline noise 196
3.3.1.2 Baseline and follow-up 196
3.3.2 Diastolic blood pressure and total (home + school) aircraft noise exposure 197
3.3.2.1 Baseline BP and pre-baseline noise 197
3.3.2.2 Baseline and follow-up 197

3.4 Subsidiary BP outcome measures 198
3.4.1 Baseline subsidiary BP measure and pre-baseline noise 198
3.4.2 Baseline subsidiary BP measures and noise 199
3.4.3 Follow-up subsidiary BP measures and noise 199

3.5 Summary of cross-sectional results in relation to hypotheses 199

3.6 Longitudinal associations between aircraft noise and blood pressure 204
3.6.1 Baseline blood pressure and prior changes in aircraft noise exposure 205
3.6.1.1 Recent school aircraft noise exposure change -- pre-baseline to baseline 205
3.6.1.2 Pre-baseline total aircraft noise exposure change and baseline BP 209
3.6.2 Follow-up blood pressure and prior changes in aircraft noise exposure 212
3.6.2.1 Follow-up BP and recent school noise exposure change . . 212

3.6.2.2 Follow-up BP and recent total noise exposure change 213
3.7 Subsidiary BP outcome measures 215

3.8 Baseline-to-follow-up aircraft noise exposure change and follow-up BP 220
3.8.1 Baseline-to-follow-up school aircraft noise exposure change and follow-up BP 220
3.8.2 Baseline-to-follow-up total aircraft noise change and follow-up BP 222

3.9 Baseline-to-follow-up changes in aircraft noise exposure and corresponding longitudinal changes in BP 227
3.9.1 Changes in school aircraft noise exposure and BP change 227
3.9.2 Changes in total aircraft noise exposure and BP change 229
3.9.3 Summary of longitudinal results 232

3.10 Positive and negative confirmation of hypotheses 234

APPENDIX OF RESULTS 235

CHAPTER 4 -- CONCLUSIONS AND DISCUSSION 296

4.1 Introduction 297

4.2 Summary of findings 297

4.3 Los Angeles and Sydney Airport Studies 299

4.4 The Munich Airport study 304

4.5 Biases and measurement issues in the Sydney study 307
4.5.1 Measurement bias 307
4.5.1.1 Inter-BP measurer (inter-rater) bias 307
4.5.1.2 BP machine bias 308
4.5.1.4 Noise measurement variation, “cross-level” and “regression dilution” bias 308
4.5.2 Selection bias 310

4.6 measures of BP and sources of BP variability 310

4.7 Is there a positive relationship between child BP and aircraft noise exposure? 313

4.8 Implications for further research in the health of populations exposed to domestic jet aircraft noise 313

REFERENCES 316

APPENDICES 333
Appendix 1
Parental information sheet, consent form, data recording sheet and questionnaire 334
Appendix 2
Instructions for fieldworkers 340
Appendix 3
Related published work 345

LIST OF TABLES

Table 1.1 Selection of noise sources in domestic aircraft operation, the mechanism for their generation and areas/people affected (reproduced with modification from [Rodda, 1967]). 45
Table 1.2 Summary of selected studies examining the effects of aircraft noise on mental health. 77
Table 2.1 Events surrounding and following construction of new runway, BP study, and changes in flight operations 106
Table 2.2 Variables used in regression models of blood pressure and aircraft noise. 114
Table 2.3 Proportions of positive differences in successive BP measurements (%), by exposure to aircraft overflights, baseline 121
Table 2.4 Proportions of instances of higher third BP readings than second BP reading (%), in those whose second BP reading did not exceed the first, baseline 122
Table 2.5 Means of blood pressures overall and for main sub-groups, baseline . . 142
Table 2.6 Means of anthropometric variables and pulse rate by major sub-group, baseline 144
Table 2.7 Means of blood pressures overall and for main sub-groups, follow-up . 145
Table 2.8 Means of anthropometric variables and pulse rate by major sub-group, follow-up 146
Table 2.9 Group proportions, follow-up and lost-to-follow-up, at baseline 148
Table 2.10 Baseline BP, anthropometric and noise exposure differences between follow-up and lost-to-follow-up 149
Table 2.11 Mean within-subject change in blood pressures between baseline and follow-up, overall and for main sub-groups 150
Table 2.12 Mean within-subject change between baseline and follow-up in anthropometric variables and pulse rate by major sub-group, follow-up . . 151
Table 2.13 Participating schools, numbers of children measured, and mean monthly aircraft noise exposure values for month of measurement occasion, baseline and follow-up 153
Table 3.1 Unadjusted regression estimates of BP (mmHg) versus aircraft noise exposure (ANEI units) 188
Table 3.2 Regression estimates of baseline measures of blood pressure versus pre-runway (pre-baseline) school and total aircraft noise exposures 201
Table 3.3 Regression estimates of measures of baseline blood pressure versus baseline school and total aircraft noise exposure 202

Table 3.4 Regression estimates of follow-up measures of BP versus follow-up aircraft noise exposure, school and total 203
Table 3.5 Regression estimates of baseline BP measure versus recent prior (pre-baseline) aircraft noise exposure change, school and total 218
Table 3.6 Regression estimates of follow-up BP measure versus recent prior aircraft noise exposure change, school and total 219
Table 3.7 Regression estimates of follow-up BP measures versus baseline-to-follow-up aircraft noise exposure change, school and total 226
Table 3.8 Regression estimates of baseline-to-follow-up change in BP measure versus follow-up aircraft noise exposure, school and total 233
Table 3.9 Summary of BP variables significantly associated with aircraft noise exposure after adjustment for confounder, effect modifiers, sources of measurement bias and within-subject BP variability 234
Table RA1 Regression estimates of baseline systolic and diastolic blood pressure (mmHg) versus pre-baseline school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 236
Table RA2 Regression estimates of baseline systolic and diastolic blood pressure (mmHg) versus pre-baseline school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, with measures of BP reactivity 237
Table RA3 Regression estimates of systolic blood pressure (mmHg) and school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up 238
Table RA4 Regression estimates of systolic blood pressure (mmHg) and school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, baseline and follow-up 239
Table RA5 Regression estimates of systolic blood pressure (mmHg) versus aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up, school aircraft noise levels ≥15 ANEI 240
Table RA6 Regression estimates of systolic blood pressure (mmHg) versus aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and within-subject BP variability, baseline and follow-up, school aircraft noise levels ≥15 ANEI 241
Table RA7 Regression estimates of diastolic blood pressure (mmHg) versus school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up. 242
Table RA8 Regression estimates of diastolic blood pressure (mmHg) versus school aircraft noise exposure (ANEI), with confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, baseline and follow-up 243

Table RA9 Regression estimates of diastolic blood pressure (mmHg) versus school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up, school aircraft noise 15 ANEI or above. 244

Table RA10 Regression estimates of diastolic blood pressure (mmHg) versus school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, baseline and follow-up, school aircraft noise 15 ANEI or above. 245

Table RA11 Regression estimates of baseline systolic and diastolic blood pressure (mmHg) versus pre-baseline total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 246

Table RA12 Regression estimates of baseline systolic and diastolic blood pressure (mmHg) versus pre-baseline total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 247

Table RA13 Regression estimates of systolic blood pressure (mmHg) versus total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up 248

Table RA14 Regression estimates of systolic blood pressure (mmHg) versus total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, baseline and follow-up 249

Table RA15 Regression estimates of diastolic blood pressure (mmHg) versus total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, baseline and follow-up 250

Table RA16 Regression estimates of diastolic blood pressure (mmHg) versus total aircraft noise exposure (ANEI),controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP reactivity, baseline and follow-up 251

Table RA17 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 252

Table RA18 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 253

Table RA19 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys 254

Table RA20 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, girls 255
Table RA21 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys . 256
Table RA22 Regression estimates of baseline systolic and diastolic BP (mmHg) versus prior pre-post runway school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, girls . 257
Table RA23 Regression estimates of baseline systolic and diastolic BP (mmHg) versus pre-baseline change in total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 258
Table RA24 Regression estimates of baseline systolic and diastolic BP (mmHg) versus recent change in total baseline aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 259
Table RA25 Regression estimates of baseline systolic and diastolic BP (mmHg) versus pre-baseline change in total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys 260
Table RA26 Regression estimates of baseline systolic and diastolic BP (mmHg) versus pre-baseline change in total aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, girls 261
Table RA27 Regression estimates of baseline systolic and diastolic BP (mmHg) versus recent change in total baseline aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys . . . 262
Table RA28 Regression estimates of baseline systolic and diastolic BP (mmHg) versus recent change in total baseline aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, girls . . . 263
Table RA29 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 264
Table RA30 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 265
Table RA31 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys 266

Table RA32 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, girls 267
Table RA33 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys . . . 268
Table RA34 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus recent change in school aircraft noise exposure (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, girls 269
Table RA35 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers and sources of measurement bias 270
Table RA36 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 271
Table RA37 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers and sources of measurement bias, boys 272
Table RA38 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers and sources of measurement bias, girls 273
Table RA39 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys 274
Table RA40 Regression estimates of follow-up systolic and diastolic BP (mmHg) and recent change in total aircraft noise, controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, girls 275
Table RA41 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 276
Table RA42 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 277
Table RA43 Regression estimates of follow-up systolic BP (mmHg) and baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 278

Table RA44 Regression estimates of follow-up systolic BP (mmHg) and baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 279
Table RA45 Regression estimates of follow-up diastolic BP (mmHg) and baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, and sources of measurement bias, boys & girls 280
Table RA46 Regression estimates of follow-up diastolic BP (mmHg) and baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 281
Table RA47 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias 282
Table RA48 Regression estimates of follow-up systolic and diastolic BP (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability 283
Table RA49 Regression estimates of follow-up systolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 284
Table RA50 Regression estimates of follow-up systolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 285
Table RA51 Regression estimates of follow-up diastolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 286
Table RA52 Regression estimates of follow-up diastolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 287
Table RA53 Regression estimates of baseline to follow-up systolic BP change (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 288

Table RA54 Regression estimates of baseline to follow-up systolic BP change (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 289
Table RA55 Regression estimates of baseline to follow-up diastolic BP change (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 290
Table RA56 Regression estimates of baseline to follow-up diastolic BP change (mmHg) versus baseline-to-follow-up school aircraft noise exposure change (ANEI),controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 291
Table RA57 Regression estimates of baseline to follow-up systolic BP change (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 292
Table RA58 Regression estimates of baseline to follow-up systolic BP change (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 293
Table RA59 Regression estimates of baseline to follow-up diastolic BP change (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers and sources of measurement bias, boys & girls 294
Table RA60 Regression estimates of baseline to follow-up diastolic BP change (mmHg) versus baseline-to-follow-up total aircraft noise exposure change (ANEI), controlling for confounding factors, effect modifiers, sources of measurement bias and measures of within-subject BP variability, boys & girls 295

LIST OF FIGURES

Figure 1.1. Schema for pathways between childhood stress and raised blood pressure and hypertension in adulthood. Adapted from Cresanta *et al* [1980]. 65
Figure 1.2 Major response mechanisms of the body and their interconnections with the central and autonomic nervous-glandular systems. Source: Kryter [1994] 66
Figure 2.1 Schema for hypotheses tested for association between aircraft noise exposure and blood pressure 86
Figure 2.2 Single flyover scenarios during 3 successive BP measurements 118
Figure 2.3 Double and triple flyover scenarios with 3 successive BP measurements 119

Figure 2.4 Systolic BP (mmHg) and pulse rate (beats per minute), baseline and follow-up 124
Figure 2.5 Diastolic BP (mmHg) and pulse rate (beats per minute), baseline and follow-up 125
Figure 2.6 Longitudinal changes in systolic and diastolic BP (mmHg), versus longitudinal change in pulse rate (beats per minute) 126
Figure 2.7 Systolic BP (mmHg) and systolic BP variability (mmHg of systolic BP standard deviation), baseline and follow-up 127
Figure 2.8 Diastolic BP (mmHg) and diastolic BP variability (mmHg), baseline and follow-up 128
Figure 2.9 Longitudinal change in BP (mmHg) and longitudinal change in BP variability (standard deviation, mmHg), systolic and diastolic BP 129
Figure 2.10 Distribution of mean of 2nd & 3rd systolic BP readings (mmHg), boys & girls, baseline 134
Figure 2.11 Distribution of mean of 2nd & 3rd diastolic BP readings (mmHg), boys & girls, baseline 135
Figure 2.12 Distribution of weights (kg), boys & girls, baseline 135
Figure 2.13 Distribution of heights (cm), boys & girls, baseline 136

Figure 2.14 Distribution of sub-scapular skinfold thicknesses (mm), boys & girls, baseline 136
Figure 2.15 Distribution of systolic BP (mmHg), boys & girls, follow-up 137
Figure 2.16 Distribution of follow-up diastolic BP reading (mmHg), boys & girls, follow-up 138
Figure 2.17 Distribution of longitudinal change in systolic BP (mmHg), boys & girls 138
Figure 2.18 Distribution of baseline-to-follow-up change in mean of 2nd & 3rd diastolic BP reading (mmHg), boys & girls 139
Figure 2.19 Distributions of weight (kg), boys & girls, follow-up 139
Figure 2.20 Distribution of height (cm), boys & girls, follow-up 140
Figure 2.21 Distributions of subscapular skinfold thickness (mm), boys & girls, follow-up 140
Figure 2.22 Aircraft noise contours from Sydney Airport, in ANEI units, and schools (stars), August 1997 156
Figure 3.1 Baseline systolic BP (mmHg) versus pre-baseline school aircraft noise exposure (ANEI units) 162
Figure 3.2 Systolic blood pressure (mmHg) versus school aircraft noise exposure (ANEI units), baseline and follow-up 163
Figure 3.3 Systolic blood pressure (mmHg) and school aircraft noise exposure (ANEI units), baseline and follow-up, boys 164
Figure 3.4 Systolic blood pressure (mmHg) and school aircraft noise exposure (ANEI units), baseline and follow-up, girls 165
Figure 3.5 Baseline diastolic BP (mmHg) versus pre-baseline school aircraft noise exposure (ANEI units) 166
Figure 3.6 Diastolic BP (mmHg) and school aircraft noise exposure (ANEI units), baseline and follow-up 167
Figure 3.7 Diastolic blood pressure (mmHg) and school aircraft noise exposure (ANEI units), baseline and follow-up, boys 168

Figure 3.8 Diastolic blood pressure (mmHg) and school aircraft noise exposure (ANEI units), baseline and follow-up, girls 169
Figure 3.9 Baseline systolic BP (mmHg) versus pre-baseline total (home + school) aircraft noise exposure (ANEI units) 171
Figure 3.10 Systolic BP (mmHg) versus total aircraft noise exposure (ANEI units), baseline and follow-up 172
Figure 3.11 Systolic BP (mmHg) and total aircraft noise exposure (in ANEI units), baseline and follow-up, boys 173
Figure 3.12 Systolic BP (mmHg) and total aircraft noise exposure (in ANEI units), baseline and follow-up, girls 174
Figure 3.13 Baseline diastolic BP (mmHg) versus pre-baseline total aircraft noise exposure (ANEI units) 175
Figure 3.14 Diastolic BP (mmHg) versus total (school + home) aircraft noise exposure (ANEI units), baseline 175-176
Figure 3.15 Diastolic BP (mmHg) versus total (school + home) aircraft noise exposure (ANEI units), baseline, boys 176-177
Figure 3.16 Diastolic BP (mmHg) and total aircraft noise exposure (in ANEI units), baseline, girls 177-178
Figure 3.17 Systolic blood pressure (mmHg) by school aircraft noise in ordinal scale of ANEI units, baseline and follow-up 180
Figure 3.18 Diastolic blood pressure (mmHg) versus school aircraft noise exposure, ordinal scale of ANEI units, baseline and follow-up 181
Figure 3.19 Scatter plots of systolic blood pressure by total aircraft noise exposure (school + home), scaled ordinally in ANEI units, baseline and follow-up 182
Figure 3.20 Scatter plots of diastolic blood pressure by total aircraft noise exposure (school + home), scaled ordinally in ANEI units, baseline and follow-up 183
Figure 3.21 Scatter plots of systolic blood pressure and school aircraft noise exposure 15 ANEI and above, baseline and follow-up 184
Figure 3.22 Scatter plots of diastolic blood pressure and school aircraft noise exposure 15 ANEI and above, baseline and follow-up 185
Figure 3.23 Scatter plots of systolic blood pressure and school or home aircraft noise exposure 15 ANEI and above, baseline and follow-up 186
Figure 3.24 Scatter plots of diastolic blood pressure and total aircraft noise exposure, school or home aircraft noise exposure 15 ANEI and above, baseline and follow-up 187
Figure 3.25 Baseline systolic BP (mmHg) and prior change in school aircraft noise exposure (ANEI), boys and girls 206
Figure 3.26 Baseline diastolic BP (mmHg) and prior change in school aircraft noise exposure (ANEI), boys and girls 207
Figure 3.27 Baseline systolic BP (mmHg) and recent pre-baseline change in total (school + home) aircraft noise exposure (ANEI), boys & girls 209
Figure 3.28 Baseline diastolic BP (mmHg) and pre-baseline total aircraft noise exposure change (ANEI), boys & girls 210
Figure 3.29 Follow-up systolic BP (mmHg) and recent school aircraft noise exposure change (ANEI) 212
Figure 3.30 Follow-up diastolic BP (mmHg) and recent change in school noise exposure (ANEI) 213

Figure 3.31 Follow-up systolic BP (mmHg) and recent change in total noise exposure (ANEI) 213
Figure 3.32 Follow-up diastolic BP (mmHg) and recent change in total aircraft noise exposure (ANEI) 214
Figure 3.33 Baseline-to-follow-up school aircraft noise exposure change (ANEI) and follow-up systolic BP (mmHg) 221
Figure 3.34 Baseline-to-follow-up school aircraft noise exposure change (ANEI) and follow-up diastolic BP (mmHg) 221
Figure 3.35 Follow-up systolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI) 223
Figure 3.36 Follow-up diastolic BP (mmHg) and baseline-to-follow-up total aircraft noise exposure change (ANEI) 223
Figure 3.37 Baseline-to-follow-up change in systolic BP (mmHg) and corresponding change in school aircraft noise exposure (ANEI), boys, girls 227-228
Figure 3.38 Baseline-to-follow-up change in diastolic BP (mmHg) and corresponding change in school aircraft noise exposure (ANEI), boys, girls 228-229
Figure 3.39 Baseline-to-follow-up change in systolic BP (mmHg) and corresponding change in total aircraft noise exposure (ANEI), boys & girls 230
Figure 3.40 Baseline-to-follow-up change in diastolic BP (mmHg) and corresponding change in total aircraft noise exposure (ANEI), boys & girls 231

PREFACE

I. NOTE ON THE AUTHOR'S CONTRIBUTION

The Inner Sydney Child Blood Pressure Study was part of a suite of studies commissioned and funded by the Federal Airports Corporation to examine aspects of the health effects of domestic aircraft noise exposure. The role of the author in the Inner Sydney Child Blood Pressure Study was in the design of the study itself, in supervision of child BP data collection, both at baseline and follow-up, and in the processing and statistical and epidemiological analyses of the BP, survey and noise and physical measurement data. The author was also responsible for the design of the survey instrument and the measurement protocols used.

Overall supervision of the project was by a steering committee consisting of members making up the Inner Sydney Child Blood Pressure Study group, including Associate Richard Taylor (School of Public Health, University of Sydney), Dr Norman Carter and Mr Peter Peploe (both of the National Acoustic Laboratories), Dr Soames Job, Department of Psychology, University of Sydney, and the author. Project supervision included liaising with the various school authorities and with the individual school principals in the recruitment of subjects to the study; the training and supervision of fieldworkers; assessment of data quality and its analysis; and the writing of reports for the funding body. Three major and two interim reports were prepared for the funding body relating to this study, co-authored by the study group members. These were:

Morrell S, Taylor R, Carter N, Peploe P, Job RFS (1999). *Draft final report on Phase II of the Inner Sydney Child Blood Pressure Study*. Department of Public Health and Community of Medicine, University of Sydney.

Carter NL, Job RFS, Taylor R, Peploe P, Morrell S (1997). *Sydney Airport Health Studies -- final report on phase I*. Department of Public Health, University of Sydney.

Carter NL, Peter Peploe, Taylor R, Job RFS, Morrell S (1996). *Sydney Airport Health Studies*, Interim reports nos 1 & 2. [Prepared for the Federal Airports Corporation]. Department of Public Health, University of Sydney.

Carter NL, Peploe P, Taylor R, Job RFS, Jenkins A, Morrell S (1993). *Proposal for study of the*

effects of aircraft noise from Sydney (Kingsford Smith) airport on health. [report for Sydney Airport Health Study Committee/Federal Airports Corporation] Department of Public Health, University of Sydney.

Aircraft noise exposure data were collected and processed by Peter Peploe of the National Acoustic Laboratories, both at baseline and follow-up. Geocoding of school and home addresses and aircraft noise exposure data at study baseline was carried out by a research assistant (Layton Walton); geocoding of follow-up addresses and noise data was carried out by the author. The author also supervised a dietary salt study of a baseline subsample, with use of a standard food frequency questionnaire, and co-supervised the subsequent analysis and writing up of these data in 1997, as a treatise by a Master of Public Health candidate in the School of Public Health, University of Sydney.

Parts of the literature review, have been published previously in a peer-reviewed journal and were co-authored by Associate Professor Richard Taylor and Professor David Lyle:

Morrell S, Taylor R, Lyle D (1997). A review of the health effects of aircraft noise. *Australian and New Zealand Journal of Public Health.* 21(2): 221-236.

This publication has been included in Appendix 3.

The remaining work, including the formulation of specific hypotheses for testing within a coherent theoretical paradigm,.the interpretation of the results, and the writing up and presentation of this thesis is that of the author.

II. INSTITUTIONAL HUMAN ETHICS COMMITTEE APPROVALS AND CONSENT

Ethics committee approvals were obtained from both the Sydney University Human Ethics Committee and the Central Sydney Area Health Service Ethics Committee to conduct this study. Permission was obtained from the NSW Department of Schools Education and the Catholic Schools Commission to survey and measure primary schoolchildren from schools proximate to the existing and projected flight paths of Sydney airport. Schools unaffected by aircraft noise were also approved for inclusion in the study in order to provide a suitable control comparison group (unexposed to aircraft noise). Permission was sought from each school principal of the individual schools to take part in the study. Also included at this level were independent schools not subject to the central State or Catholic education authorities.

Finally, individual consent was sought from the parents of the children. Consent was active -- that is, only those children whose parents had signed and returned the consent form to the school were measured.

III. ACKNOWLEDGMENTS

First I would like to acknowledge the Federal Airports Corporation (FAC), as it was known at the time, for funding both the baseline and follow-up phases of this study. Thanks in particular are due to Heloise Campbell who was the main liaison person at the FAC.

The most important component of any research project involving empirical measurement of study and outcome factors is the personnel responsible for the collection of the data. In this regard, I unreservedly acknowledge the contributions of the blood pressure measuring teams who comprised:

Baseline BP measurement team: Sara-Jane Bush, Gladys Hitchin, Amelia Howland, Denise Lawson, Yvette Lawson and Patrick Parlow.

Special thanks are due to Patrick Parlow for his efforts in liaising with school principals in ensuring the maximum response to the survey; and to Gladys Hitchin whose eye for detail, persistence and organisational aptitude ensured that the child BP data were collected in an orderly manner and entered into computer format accurately.

Follow-up BP measurement team: Gladys Hitchin, Estella Ortiz, Pam Richardson and Alice Uribe.

Special thanks again are due to Gladys Hitchin who was untiring in her efforts in liaising with school principals, and in collecting and entering the follow-up BP data into computer format. I thank Gladys also for training the follow-up BP measurement team.

I thank Peter Peploe from the National Acoustic Laboratories for his input and expertise in the devising of a system for measuring aircraft noise exposures and converting these raw data into the noise metric used in this study. This was an involved and arduous task requiring a rare and innovative talent and expertise in sound and noise measurement and analysis that has contributed to the cutting-edge rigour of the exposure measures used in this thesis.

I acknowledge the input of Layton Walton who was responsible for geocoding baseline

school and home address information along with baseline noise data into a geographic information system data base which in turn enabled analysis of BP and aircraft noise exposure data.

I thank Dr Norman Carter who headed our study team and provided overall guidance to the project. I thank Norm also for co-supervising this thesis.

I also would like to thank Professor Geoffrey Berry for reading an earlier draft of this thesis to check for statistical and methodological errors.

I especially would like to thank Associate Professor Richard Taylor who is the main supervisor of this thesis and who has been my mentor for the past 12 years. Without Richard's patient, persistent and good-natured encouragement and sharply insightful critiques this thesis would not have appeared.

I also owe thanks for the moral support given freely by my parents, and by work colleagues, especially Dr KC Tang, Dr Milton Lewis and Professor Charles Kerr.

Finally, I would like to thank my wife, Margaret Penman, who has been more persistent than anyone in ensuring that I completed this thesis. She has made sacrifices above and beyond anything that might be called 'spousal duty' and I owe her a debt also beyond 'spousal duty'.

ABSTRACT

The purpose of the study was to examine the existence of an association between child blood pressure (BP) and exposure to domestic jet aircraft noise in the context of the construction of a new parallel north-south runway at Sydney (Kingsford-Smith) Airport. The baseline study was commissioned and funded by the Federal Airports Corporation (FAC), with measurements conducted in 1994 and 1995. A follow-up longitudinal component to the study was subsequently commissioned and funded by the FAC in 1997, and measurements conducted in the same year. As the same individuals were measured and re-measured over changing conditions of exposure to aircraft noise, the quasi-experimental nature of the study allowed inferences to be made regarding exposure to aircraft noise and child BP.

The main hypotheses for testing were that BP, and within-subject longitudinal changes in BP, are positively related to domestic jet aircraft noise exposure and longitudinal changes in domestic jet aircraft noise exposure respectively. Subsidiary hypotheses tested for evidence of short- and long-term BP adaptation effects where BPs were related to prior changes to aircraft noise exposures.

A sample of 75 primary schools within a 20 km radius of Sydney Airport under various noise exposure conditions, both existing and those projected with the advent of the new runway, participated in the study. The baseline cohort comprised 1,230 Year 3/4 children attending the schools in 1994 and 1995, and the follow-up participants comprised 628 of the original baseline sample re-measured in 1997. Study participants were enrolled by active parental consent. The baseline response rate was approximately 40% of children in the participating schools.

Systolic (SBP) and diastolic (DBP) blood pressure readings of the children were taken using automated BP measuring equipment along with anthropometric measurements (heights, weights, skinfold thicknesses and waist measurements). Parental surveys captured items pertaining to the child's ethnic background as measured by the country of birth of the child and parent(s), residential address and housing structure, child eating habits and activity levels, along with family and child history of high blood pressure.

Aircraft noise exposure data were collected by the National Acoustic Laboratories and

processed into the energy-averaged noise metric used in Australia for aircraft noise exposure assessment called the Australian Noise Exposure Index (ANEI). Mean exposures for a given calendar month were used in the analysis. ANEI values were geocoded to exact geographic locations using digitised street maps from which values for each house and school address, also geocoded, were interpolated. A child BP measured in a given month was matched to a aircraft noise exposure value both at their school and residential address for that month for analysis.

After adjusting for confounding and other factors, the cross-sectional relationship between BP and aircraft noise exposure was found to be inconsistent. SBP was non-significantly negatively associated with school aircraft noise exposure at baseline (−0.05 mmHg/ANEI, cluster-sampling-adjusted $p>0.05$), but positively and non-significantly associated with school aircraft noise exposure at follow-up (0.05 mmHg/ANEI, $p>0.05$). As for SBP, baseline DBP was significantly negatively related to school aircraft noise exposure at (−0.09 mmHg/ANEI, $p< 0.001$) and non-significantly positively associated with school aircraft noise exposure at follow-up (0.05 mmHg/ANEI, $p>0.05$).

Within-subject BP changes, occurring from baseline to follow-up, regressed on corresponding longitudinal changes in aircraft noise exposures produced inconsistent results. SBP change was positively and non-significantly (0.027 mmHg/ΔANEI, $p>0.05$) associated with corresponding school aircraft noise exposure change, while SBP change was negatively associated total aircraft noise exposure change (statistically non-significant, −0.06 mmHg/ΔANEI, $p>0.05$). DBP changes were similarly and non-significantly related to corresponding aircraft noise exposure changes.

Some evidence for short-term BP adaptation to recent changes in aircraft noise exposure was found. Consistent negative associations between systolic and diastolic BP and recent changes in school aircraft noise exposure were found. This association was statistically significant at study baseline (SBP: −0.19 mmHg/ΔANEI, $p<0.001$; DBP: −0.12 mmHg/ΔANEI, $p<0.001$), and of similar magnitude although not statistically significant at follow-up (SBP: −0.14 mmHg/ΔANEI; DBP: −0.10 mmHg/ΔANEI, $p>0.05$). In the presence of inconsistent cross-sectional BP-aircraft noise exposure associations, this finding is consistent with evidence of a homoeostatic BP response to recent changes in aircraft noise exposure, where resting BP returns to pre-existing levels unrelated to aircraft noise exposure. The public health implication of this finding appears to be benign.

GLOSSARY OF TERMS AND ABBREVIATIONS

AAMI	American Association for Advancement of Medical Instrumentation
ACTH	Adrenocorticotropic Hormone
ADH	Antidiuretic Hormone
AMP	Adenosine Monophosphate
ANEC	Australian Noise Exposure Concept
ANEF	Australian Noise Exposure Forecast
ANEI	Australian Noise Exposure Index
AV	Atrioventricular
BCE	Before the Current Era (a secular version of Before Christ)
BMI	Body Mass Index
BP	Blood Pressure
CAD	Coronary Artery Disease
CHD	Coronary Heart Disease
CVD	Cardiovascular Disease
dB	Decibel
dB(A/B/C)	A, B or C-weighted decibel
DBP	Diastolic Blood Pressure
EIS	Environmental Impact Study
EPNdB	Effective Perceived Noise Decibel
EPNL	Effective Perceived Noise Level
ESB	English Speaking Background
GAS	General Adaptation Syndrome
GHQ	General Health Questionnaire
INM	Integrated Noise Model
K4/5	4th/5th Korotkov phase
Ldn	Average sound level with day/night weighting
LAeq	Equivalent continuous sound pressure level, A-weighted
MAP	Mean Arterial Pressure
MPP	Multi-centre Postinfarction Program
MRFIT	Multi Risk Factor Intervention Trial
N70	Mean hourly number of noise events exceeding 70 dB(A)
NEF	Noise Exposure Forecast
NESB	Non-English Speaking Background

NIMBY	Not In My Back Yard
N.I.	Noise Number Index
PNdB	Perceived Noise Decibel
PNL	Perceived Noise Level
RSNA	Renal Sympathetic Nerve Activity
SA	Sinoatrial
SBP	Systolic Blood Pressure
SES	Socio-economic Status
SEL	Sound Exposure Level
SPL	Sound Pressure Level
WCGS	Western Collaborative Group Study
WCH	White-coat Hypertension