

THE EFFECT OF CHANGED NOISE LEVELS AT SYDNEY AIRPORT ON HEALTH OUTCOMES I: AREA DIFFERENCES.

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ABSTRACT

Noise exposure may contribute to health problems. Data from steady state noise areas may underestimate immediate noise effects (because of selective attrition of vulnerable individuals and habituation/adaptation). Conversely, some effects may require chronic exposure. When the runways at Sydney Airport were reconfigured, noise increased in some low noise areas and decreased in some high noise areas (while other areas remained unchanged). Residents were surveyed before (N=1015), immediately after, and several years after the reconfiguration. Area differences in self-reported physical health (general symptoms, substance use) and psychological health (anxiety, depression) suggest a negative impact of increased noise exposure on health.

INTRODUCTION

A major concern regarding human exposure to noise is that it may have adverse physiological consequence. Much research has focused on investigating this possibility and there is now a substantial body of evidence suggesting that noise exposure contributes to various illnesses, although the evidence is stronger for some health problems than others [for reviews see 1,2].

Most relevant data come from studies conducted in steady-state noise areas, and these data may underestimate the immediate effects of noise exposure for several reasons.

First, vulnerable individuals may avoid living in high noise areas, especially if they have experienced health problems that they attribute to noise exposure. "Noise sensitive" individuals may be particularly susceptible to its health effects [2,3], but evidence for a correlation between self-reported noise sensitivity and noise exposure is weak. Selective attrition of vulnerable individuals out of high noise areas would result in underestimation of the potential health effects of noise

(although not of the actual effects) when dose-response relationships are generated from steady-state noise area data.

Second, responses to noise may adapt, so that dose-response curves generated from steady-state noise area data identify relationships with adapted levels. Predictions based on these curves underestimate initial responses to a new noise source (and thus the potential health effects of noise), although this may reflect over-reaction rather than adaptation [4]. Adaptation refers to a temporarily reduced sensory responsiveness with repeated or extended stimulus exposure. Several illness-relevant responses to noise do appear to reduce with time, including peripheral vasoconstriction (under some conditions [5,6, but see 7]) and several indicators of sleep disturbance (body movements within each night and probability of awakening [1]). In contrast, minimal response reduction has been observed for cardiac response during sleep [8], body movements across nights [9,10], shifts towards earlier sleep stages¹, and reaction to noise (dissatisfaction, annoyance etc) [11,12]. However, failure to observe adaptation in field studies may itself be due to testing in steady state noise areas, where adaptation has already occurred. Indeed, human laboratory studies show reductions in response to noise relatively early in the exposures [13,14,15,16]. Of course, adaptation may actually reduce negative physiological health effects of noise – if these effects require responses that are provoked repeatedly or for extended periods. For example, hypertension may require repeated or prolonged blood pressure elevations.

Apparent reduction in response to a particular noise “dose” may be produced by habituation as well as adaptation. Habituation refers to a reduced response to the sensory input detected, and its possible implications for physiological noise effects are less clear than for adaptation (although continued responses to sensory input, such as annoyance, may have unhealthy effects [17]).

The present socio-acoustic survey was conducted before, within one year after, and again six years after reconfiguration of runways at Sydney Airport resulted in noise increases in some low noise areas (but not others), and noise decreases in some high noise areas (but not others). For various health effects of exposure to aircraft noise, baseline measures were compared to post-reconfiguration and follow-up measures in each noise area.

METHODS

Subjects and Sample Selection

Residents were randomly selected from areas selected on the basis of location relative to Sydney (Kingsford Smith) Airport to produce a 2x2 design; initial noise level was "high" or "low" and noise level either changed or to remained unchanged, due to runway reconfiguration. Sampling aimed to achieve similar representation of the four areas thus produced- "high to high" (High/High), "high to low" (High/Low), "low to low" (Low/Low), "low to high" (Low/High). From random starting points, every 7th residence along a predetermined path was approached, and one respondent selected within each household using the "last birthday" technique, without replacement. Before the reconfiguration (pre-reconfiguration stage), 532 female and 482 male residents were interviewed. Up to one year after the reconfiguration (post-reconfiguration stage), 110 female and 108 male residents (not from the pre-reconfiguration sample) were interviewed. About 6 years after the reconfiguration (follow-up stage), 95 female and 71 male pre-reconfiguration respondents were re-interviewed. In addition, a further 232 female and 175 male participants from residences nearby and similar to the pre-reconfiguration residences were interviewed.

Materials

A structured interview (based on previous socio-acoustic surveys [18] and pilot results) assessed health, reactions to noise (dissatisfaction, affectedness, annoyance), attitudes to the noise source, noise sensitivity, demographic variables and noise-induced activity disturbance. At the pre- and post-reconfiguration stage, subjects indicated which of 9 symptoms (startle, irritability, headaches,

tenseness/nervousness, edginess, tiredness/listlessness, difficulty sleeping, upset stomach, health effects generally) they experienced in response to noise. At the follow-up stage edginess, tiredness, and difficulty sleeping were omitted. A general-symptoms index was computed by averaging experienced symptoms. Subjects also indicated whether they had increased, decreased, or not changed their use of each of 5 substances (cigarettes, alcohol, tranquilisers, sleeping pills or headache pills) as a result of noise exposure. Subjects could also indicate that they had never used these substances. Subjects also completed the POMS Depression, Anxiety and Anger scales (19 items [19]) (as well as Grossarth-Matticek health risk personality questionnaire).

Procedure

Before the reconfiguration, a letter was first sent to each selected residence announcing the investigation. Then trained interviewers door-knocked at these residences and asked to speak to the person over 18 living at the residence who last had a birthday. If an eligible individual agreed to participate, the structured interview was conducted before they completed the questionnaires while the interviewer waited. Respondents were told that the researchers may want to re-interview them at a later time. At the post-reconfiguration stage, subjects were sampled employing the same selection technique as was employed at the pre-reconfiguration stage, with the additional requirement that subjects not have participated in the pre-reconfiguration stage. Around six years later (follow-up stage), people who had been interviewed at the pre-reconfiguration stage were telephoned to make an appointment for re-interview. Up to three attempts were made to contact each respondent. Respondents were re-interviewed in their homes, and again completed some questionnaires. In addition, a new sample was collected by door-knocking at residences nearby and similar to residences housing respondents from the pre-reconfiguration stage. Respondent selection from the residences proceeded as for the pre-reconfiguration stage.

RESULTS

Changes in Noise-related Symptoms in Each Noise Change Area

*Table 1. Mean (and standard deviation) scores on the noise-related symptoms index at pre-reconfiguration (3 item/2 item), post-reconfiguration and follow-up within each of the 4 noise change areas. *differs from pre-reconfiguration at .05 level.*

	High/High	Low/High	High/Low	Low/Low
Pre	.28 (.23)/ .26 (.23)	.21 (.26)/ .20 (.26)	.25 (.25)/ .23 (.25)	.06 (.13)/ .06 (.13)
Post	.38 (.25)*	.30 (.23)*	.15 (.24)*	.06 (.18)
Follow-up	.22 (.26)	.22 (.24)	.23 (.29)	.09 (.18)*

Separate two-tailed independent samples t-tests were conducted to compare pre-reconfiguration with post-reconfiguration and follow-up means within each noise change area. Noise-related symptoms significantly increased from pre- to post-reconfiguration in the High/High area ($t_{305} = -2.80$, $p = .005$) and the Low/High area ($t_{306} = -2.36$, $p = .019$). Noise-related symptoms significantly decreased from pre- to post-reconfiguration in the High/Low area ($t_{308} = 2.69$, $p = .007$). No significant change in noise-related symptoms was observed from pre- to post-reconfiguration in the Low/Low area ($t_{301} = -.07$, $p = .947$). Noise-related symptoms were significantly greater at follow-up than at pre-reconfiguration in the Low/Low area ($t_{379} = -2.34$, $p = .020$), but did not change significantly in the High/High, Low/High, or High/Low area (highest nonsig. $t_{399} = 1.57$, $p = .116$).

Changes in Noise-related Substance Use from in Each Noise Change Area

For each substance, separate chi-square tests were conducted to compare pre-reconfiguration with post-reconfiguration and follow-up response percentages within each noise change area. A significant change in response percentages was observed for use of headache pills in the Low/High area ($\chi^2_{2,248} = 7.50$, $p = .024$), with a higher percentage of subjects reporting increased use of

Table 2. Percentage of each of four responses at pre-reconfiguration, post-reconfiguration, and follow-up within each of the 4 noise change areas, for noise-related a) alcohol use.

	High/High			Low/High			High/Low			Low/Low		
	Pre	Post	F-up	Pre	Post	F-up *	Pre	Post	F-up	Pre	Post	F-up
Not affected	71.7	69.8	70.7	78.2	73.6	65.7	60.1	71.7	55.9	70.9	73.1	60.0
Reduced	1.2	0.0	0.0	0.0	0.0	2.9	0.4	0.0	1.4	0.8	0.0	0.0
Increased	2.4	5.7	3.4	2.7	3.8	4.3	1.6	1.7	2.1	0.4	0.0	0.9
Never used	24.8	24.5	26.5	19.1	22.6	27.11	37.9	26.7	40.6	27.9	26.9	39.1

b) cigarette use.

	High/High			Low/High			High/Low			Low/Low		
	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up
Not affected	33.9	42.3	19.7	46.3	39.6	29.3	37.5	50.8	21.7	51.4	59.6	19.1
Reduced	0.8	0.0	0.0	0.4	0.0	0.7	0.8	1.7	0.7	0.4	0.0	0.0
Increased	3.1	5.8	4.8	3.5	3.8	4.3	2.0	0.0	2.8	0.4	0.0	0.9
Never used	62.2	51.9	75.5	49.8	56.6	65.7	59.7	47.5	74.8	47.8	40.4	80.0

c) tranquilliser use.

	High/High			Low/High			High/Low			Low/Low		
	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up
Not affected	31.1	28.3	13.0	33.9	22.6	18.7	32.8	50.0	22.4	46.2	59.6	12.7
Reduced	0.0	0.0	0.0	1.2	0.0	0.7	0.8	1.7	1.4	0.0	1.9	0.0
Increased	3.5	7.5	3.4	3.9	7.5	5.0	5.5	1.7	3.5	1.2	0.0	0.9
Never used	65.4	64.2	83.6	61.1	69.8	75.5	60.9	46.7	72.7	52.6	38.5	86.4

d) sleeping pill use.

	High/High			Low/High			High/Low			Low/Low		
	Pre	Post	F-up *	Pre	Post	F-up	Pre	Post	F-up	Pre	Post	F-up
Not affected	21.7	28.3	11.0	28.4	17.0	14.3	24.9	50.0	17.5	41.4	59.6	11.8
Reduced	0.4	0.0	0.0	0.8	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Increased	3.5	1.9	8.2	4.3	7.5	5.7	3.2	0.0	5.6	2.0	0.0	0.9
Never used	74.4	69.8	80.8	66.5	75.5	80.0	71.5	50.0	76.9	56.6	40.4	87.3

e) headache tablet use.

	High/High			Low/High			High/Low			Low/Low		
	Pre	Post	F-up	Pre	Post*	F-up	Pre	Post	F-up	Pre	Post	F-up
Not affected	61.0	54.7	63.7	65.4	56.6	65.0	62.5	70.0	57.3	69.3	69.2	75.5
Reduced	0.4	0.0	0.7	1.9	0.0	2.9	2.0	1.7	0.0	0.4	0.0	1.8
Increased	16.1	20.8	14.4	12.1	26.4	10.7	11.5	8.3	14.0	2.8	1.9	5.5
Never used	22.4	24.5	21.2	20.6	17.0	21.4	24.1	20.0	28.7	27.5	28.8	17.3

*=differs from pre-reconfiguration at .05 level.

headache pills due to aircraft noise at post- than at pre-reconfiguration. No significant change in response percentages was observed within any area for alcohol, cigarette, tranquilliser, or sleeping pill use ($p > .1$ in all cases). While few changes in response percentages reached conventional statistical significance, the percentage of subjects reporting increased substance use due to aircraft noise tended to be greater at post- than at pre-reconfiguration in the High/High and Low/High areas, and smaller at post- than at pre-reconfiguration in the High/Low and Low/Low areas. A significant change in response percentages was observed for alcohol use in the Low/High area ($\chi^2_{2, 310} = 9.49$, $p = .009$), but this is mostly due to an increase in the number of respondents who reported that they had "never used" alcohol at follow-up than at pre-reconfiguration. A significant change in response percentages was also observed for sleeping pill use in the High/High area ($\chi^2_{2, 93} = 9.66$, $p = .008$), with a higher percentage of subjects reporting increased use of sleeping pills due to aircraft noise at follow-up than at pre-reconfiguration. No significant change in response percentages was found in any area with regard to cigarette, tranquilliser, or headache pill use ($p > .1$ in all cases).

Changes in Mood in Each Noise Change Area

Separate two-tailed independent samples t-tests were conducted to compare pre-reconfiguration with post-reconfiguration and follow-up means within each noise change area.

Table 3. Mean (and standard deviation) depression at pre-reconfiguration, post-reconfiguration and follow-up within each of the 4 noise change areas (High/High, Low/High, High/Low, Low/Low). *=*differs from pre-reconfiguration at .05 level.*

	High/High	Low/High	High/Low	Low/Low
Pre	.56 (.66)	.58 (.74)	.52 (.65)	.49 (.53)
Post	.73 (.83)	.63 (.79)	.48 (.65)	.07 (2.40) *
Follow-up	.66 (.85)	.64 (.79)	.70 (.86)*	.62 (.76)

Table 4. Mean (and standard deviation) anxiety at pre-reconfiguration, post-reconfiguration, and follow-up within each of the 4 noise change areas (High/High, Low/High, High/Low, Low/Low). *=*differs from pre-reconfiguration at .05 level.*

	High/High	Low/High	High/Low	Low/Low
Pre	0.94 (.72)	1.01 (.82)	.86 (.77)	.76 (.66)
Post	1.17 (.98) *	1.02 (.77)	.82 (.73)	.73 (.50)
Follow-up	1.06 (.87)	1.03 (.79)	.98 (.83)	.79 (.75)

Depression scores decreased significantly from pre- to post-reconfiguration in the Low/Low area ($t_{299} = 2.46, p = .014$), but did not change significantly in the High/High, Low/High, or High/Low areas (highest nonsignificant $t_{303} = -1.60, p = .112$). Anxiety scores increased significantly from pre- to post-reconfiguration in the High/High area ($t_{304} = -2.04, p = .042$), but did not change significantly from pre to post-reconfiguration in any other area (highest nonsignificant $t_{298} = .31, p = .755$). Depression scores increased significantly from pre-reconfiguration to follow-up in the High/Low area ($t_{377} = -2.32, p = .021$), but did not change significantly in the High/High, Low/High, or Low/Low areas (highest nonsignificant $t_{373} = -1.91, p = .057$). Anxiety scores also did not change significantly from pre-reconfiguration to follow-up in any area ($p > .1$ in all cases).

CONCLUSIONS

The pre- versus post-reconfiguration comparisons support the literature suggesting that noise may have a detrimental effect on health. The incidence of noise-related general symptoms increased significantly in areas in which noise increased, and decreased significantly in areas in which noise decreased. The percentage of respondents who reported that they had increased their use of headache pills as a result of noise also increased in areas in which noise increased (and while a similar pattern of results was observed in the use of other substances, changes were not statistically significant).

These differences were no longer observed at follow-up, which differed significantly from pre-reconfiguration only in terms of having *increased* levels of depression in areas in which noise was supposed to *decrease*. These results support the claim that the initial effects noise exposure may adapt, and thus the claim that dose-response curves established in steady state noise areas may underestimate these effects.

Pre- versus post-reconfiguration comparisons also support the hypothesis that some health effects may increase with chronic exposure. The incidence of noise-related general symptoms, and anxiety levels, increased significantly in areas with ongoing exposure to high noise levels. Further, depression levels decreased significantly in areas with ongoing low noise exposure, although no significant effect (i.e. a nonsignificant increase) was observed in areas with ongoing high noise exposure.

Similarly, the percentage of respondents who reported that they had increased their use of sleeping pills as a result of noise (or had previously never used them) increased in areas with ongoing high noise exposure. However, the differences observed at post-reconfiguration were not observed at follow-up, and there was an *increased* incidence of noise-related general symptoms in the area with

ongoing low noise exposure. In fact, though, by the follow-up, noise had also increased in these areas (due to a policy of "spreading" the noise).

In sum, these results suggest an initial impact of noise on health, although, like results derived from steady state noise areas, they may underestimate the impact of noise to the extent that noise reaction influences physiological effects, and had already changed at the pre-reconfiguration stage due to anticipating noise changes [see20].

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