Relationship between subjective health and disturbances of daily life due to aircraft noise exposure – Questionnaire study conducted around Narita International Airport –

Masamitsu Miyakawa[1*], Toshihito Matsui[2], Iwao Uchiyama[2], Kozo Hiramatsu[3], Naoki Hayashi[4], Iwao Morita [4], Kenichi Morio [5], Koichi Yamashita [5], Shinji Ohashi [5]

1 Kibi International University, 8 Iga-machi, Takahashi, Okayama 716-8508, Japan

2 Graduate School of Engineering, Kyoto University, Kyotodaigaku Katsura, Kyoto 615-8540, Japan

3 Graduate School of Asian and African Area Studies, Kyoto University, Kyoto 606-8501, Japan

4 Airport Division, Narita City Office, Hanazaki-cho, Narita, Chiba 286-8585, Japan

5 Nittobo Acoustic Engineering Co., Ltd., 1-21-10 Midori, Sumida-ku, Tokyo 130-0021, Japan

* corresponding author: e-mail: miyakawa@kiui.ac.jp

INTRODUCTION

Many studies have reported that environmental noise has adverse effects such as annoyance, dissatisfaction, and disturbances of daily life (e.g. sleep disturbance and hearing interference). It also causes adverse health effects (e.g. physiological health problems such as cardiovascular disease and hypertension) (WHO 1999). Annoyance is one of the most widely investigated effects since it is considered to be a comprehensive indicator of the adverse effects of environmental noise. However, the causation between annoyance and adverse health effects has not been fully confirmed.

We carried out a questionnaire-based study in a residential area around Narita International Airport in 2005 and 2006. The questionnaire included the 28-item General Health Questionnaire (GHQ-28) (Goldberg 1978; Goldberg & Hillier 1979), Weinstein's noise sensitivity scale (WNS) (Weinstein 1978, 1980), questions on disturbances of daily life due to aircraft noise exposure, and questions on annoyance at aircraft noise exposure.

The present paper investigates the effects of aircraft noise exposure on subjective health identified by the GHQ-28 taking noise sensitivity into account. Furthermore, the relationships among subjective health, disturbances of daily life, and annoyance were analyzed in order to find the primary cause of the adverse effects on subjective health.

METHODS

Study area and population

Narita International Airport, located in the eastern part of the greater Tokyo area, opened in 1978. Subsequently, an interium parallel runway (Runway B) opened in 2002. In 2005 and 2006, the questionnaire study was carried out in the residential area around the airport using a leave-and-pick up method. Urbanized areas and newly developed areas were excluded from this study. Figure 1 indicates the studied area and the runways of the airport. In the figure, the noise-exposed area is divided into three parts (Areas A, B, and C).

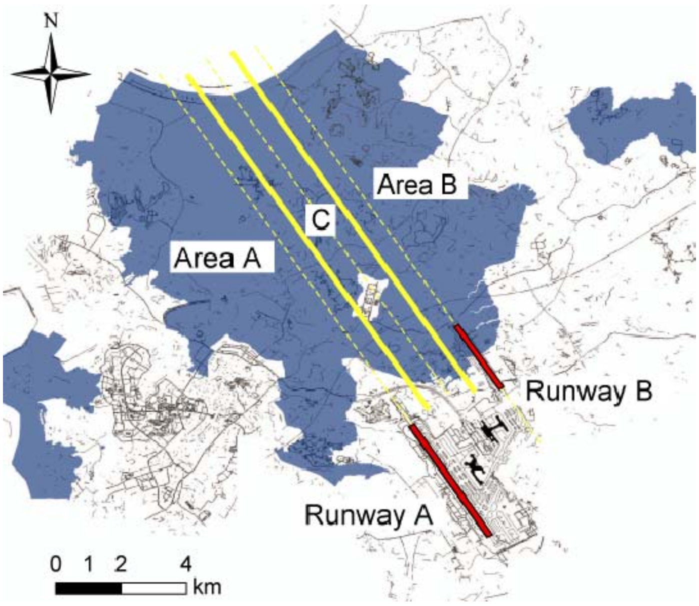


Figure 1: Map of Narita International Airport and the studied area

All adult residents living in the area were asked to complete the questionnaire after signing a consent form for the study. The total population of the adult residents in the studied area was about 12,000.

Questionnaire

On the front sheet of the questionnaire, gender, age, and occupation of the householder were asked. The occupation of the householder was used as a measure of socio-economic status. The questionnaire included the following items:

- Subjective health
- Noise sensitivity
- Disturbances of daily life due to aircraft noise exposure
- Annoyance at aircraft noise
- Usual time to wake up and to go to bed.

Subjective health was measured by the GHQ-28. The GHQ is a self-administered screening questionnaire designed for use in consulting settings aimed at detecting those with a diagnosable psychiatric disorder. As for the Japanese version of the GHQ-28, those with a score of 6 and above are identified as having a psychiatric disorder with a sensitivity of 90 % and a specificity of 86 % (Nakagawa & Daibo 1985). The GHQ-28 yields the following four subscales: 'somatic symptoms,' 'anxiety and insomnia,' 'social dysfunction,' and 'severe depression.' With regard to 'somatic symptoms,' those with a score of 4 and above are identified as having a moderate/severe somatic symptom by the Japanese version of the GHQ-28 (Nakagawa & Daibo 1985).

The Weinstein's noise sensitivity scale (WNS), containing 10 questions, was included to measure subjective noise sensitivity. In this study, the respondents were divided into two groups based on their score of noise sensitivity scale WNS-6B, an improved WNS having been proposed by some of the present authors (Kishikawa et al. 2006), with median as cut-off point (4/5). No significant association was found between the WNS-6B score and aircraft noise exposure in the study area (Hayashi et al. 2007).

Three questions on sleep disturbance (i.e. difficulty in falling asleep, awakening during sleep, and awakening early in the morning) were included in the questionnaire. In each question, frequency of sleep disturbance was asked with 5 choices (not at all, 1–2 days a month, 1–2 days a week, 3–4 days a week, and almost every day). Among the three questions, the most frequent sleep disturbance was used to evaluate the sleep disturbance. Hearing interference was also asked with 5 choices (not at all, 1–2 times a week, 1–2 times a day, 5–6 times a day, and more than 10 times a day).

Annoyance was asked with 5 choices (not annoyed, a little annoyed, annoyed, very annoyed, and intolerably annoyed).

Statistical analysis

Dose-response relationships between subjective health identified by the GHQ-28 and L_{den} were obtained for both the sensitive and insensitive groups by multiple logistic regression analysis with adjustment for gender, age, occupation of the householder, and the interaction between gender and age. Trend test of the dose-response relationships was also carried out for the sensitive and insensitive groups, respectively.

Relationships between moderate/severe somatic symptoms identified by the GHQ-28 and disturbances of daily life were analysed by multiple logistic regression analysis with adjustment for gender, age, occupation of the householder, and the interaction between gender and age in order to find the primary cause of the adverse effects on subjective health. Furthermore, an analysis with adjustment for annoyance was also conducted in order to evaluate the effects of annoyance on subjective health.

All statistical analyses were performed using SPSS, version 15.0.

RESULTS AND DISCUSSION

Sample

About 12,000 questionnaires were distributed to all the adult residents and approximately 70 % of them were collected. The collected questionnaires without a signature on the consent form were regarded as invalid. About 85 % of the collected questionnaires were valid. Furthermore, respondents aged over 80 years or less than 20 years were excluded because the number of such respondents was small. Thus, the number of the valid sample was 6,527, which was more than half of the distributed questionnaires.

In the present paper, the 2,861 questionnaires obtained from Area A (see Figure 1) were entered into the analysis. Areas B and C were excluded from the analysis because of the high reaction with the opening of the new runway (Hayashi et al. 2007). Table 1 lists the number of analysed sample stratified by L_{den}, gender, and age. The noise exposure level in Area A ranged from 51 to 67 dB in L_{den}. There was no particular difference in the demographic attributes (i.e. gender, age, and occupation of the householder) of the respondents among the noise exposure levels.

Effects of aircraft noise exposure on subjective health

Figure 2 presents the dose-response relationships between subjective health identified by the GHQ-28 and L_{den}.

Figure 2(a) presents the dose-response relationships of psychiatric disorders. No significant relationship was observed between psychiatric disorders and L_{den}.

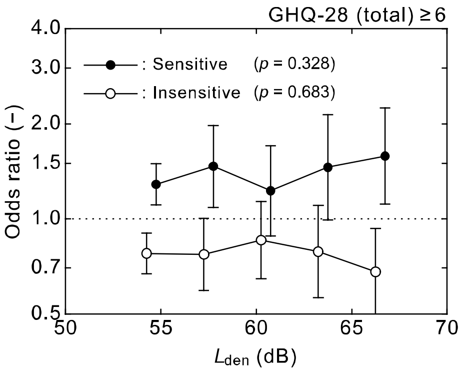
Table 1: The number of analysed samples stratified by L_{den}, gender, and age

L_{den} (dB)	Gender		Age						Total
	Male	Female	20-29	30-39	40-49	50-59	60-69	70-79	
51–53	20	23	3	4	12	7	12	5	43
53–56	412	418	90	86	118	227	164	145	830
56–59	331	339	68	86	96	187	136	97	670
59–62	270	270	55	48	108	132	99	98	540
62–65	176	167	44	39	63	80	58	59	343
65–67	226	209	40	65	68	109	82	71	435
Total	1,435	1,426	300	328	465	742	551	475	2,861

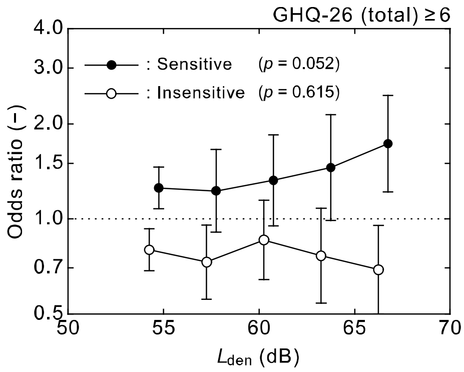
Figure 2(b) presents the dose-response relationships obtained by an analysis in which two questions related to sleep quality were excluded from the GHQ-28. The dose-response relationship showed an increasing trend in the sensitive group; however, it was not statistically significant (p = 0.052).

Figure 2(c) shows the dose-response relationships of moderate/severe somatic symptoms. A significant dose-response relationship was found between somatic symptoms and L_{den} in the sensitive group (p = 0.007), but was not in the insensitive group.

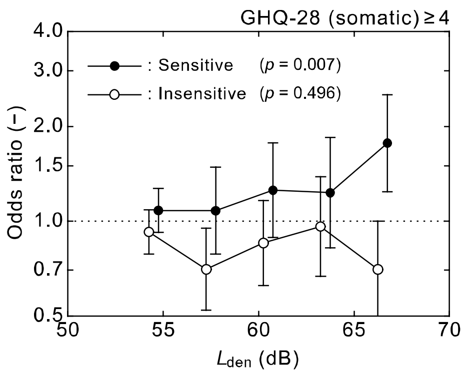
No significant dose-response relationships were observed between the other subscales and L_{den}.



(a) Total score



(b) Total score (without sleep)



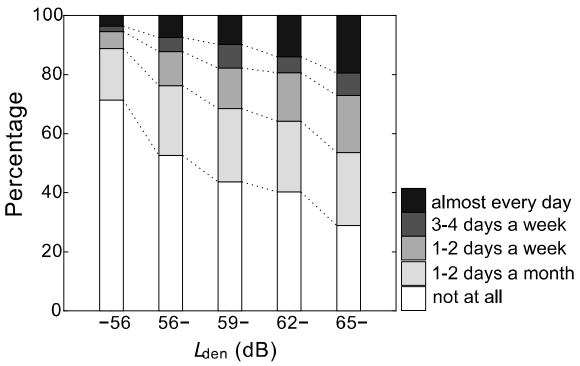
(c) Somatic symptoms

Figure 2: Dose-response relationships of subjective health identified by the GHQ-28 for the sensitive and insensitive groups. The symbols and whiskers indicate the odds ratios and their 95 % confidence intervals with adjustment for gender, age, and occupation of the householder. All respondents in the 53–56 dB group were set to the reference group. The 51–53 dB group was included in the 53-56 dB group since the number of respondents in this group was small. The p-values in the figures are the significance probabilities of the trend tests.

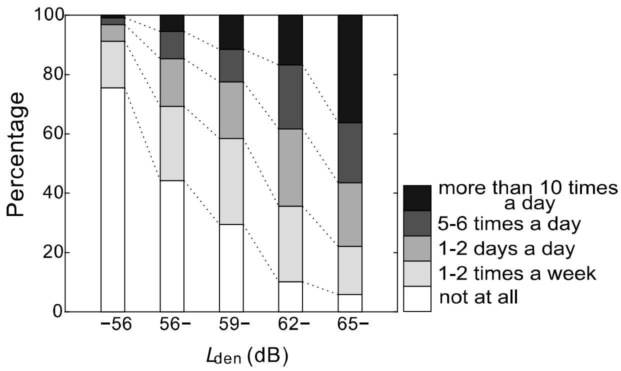
The results mentioned above suggest that the adverse effects on subjective health due to aircraft noise exposure may exist especially in sensitive subgroups and that aircraft noise exposure has adverse effects on somatic symptoms of the residents in the study area.

Disturbances of daily life and annoyance due to aircraft noise exposure

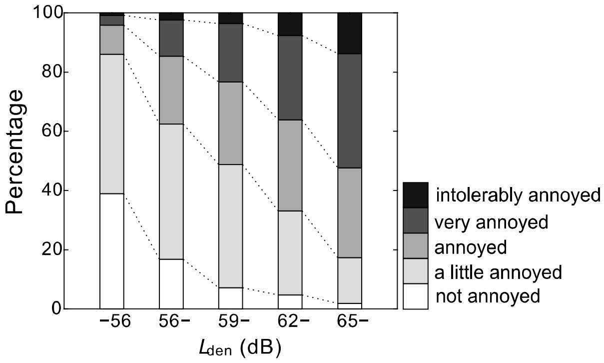
Figure 3 presents the dose-response relationships of disturbances of daily life and annoyance due to aircraft noise exposure. In the highest noise-exposed area, about 27 % of the respondents were disturbed in their sleep 3–4 days a week or almost every day, and about 52 % of the respondents were highly annoyed (very/intolerably annoyed).



(a) Sleep disturbance



(b) Hearing interference



(c) Annoyance

Figure 3: Disturbances of daily life and annoyance *vs.* L_{den}

Relationship among somatic symptoms, disturbances of daily life, and annoyance

Relationships among moderate/severe somatic symptoms identified by the GHQ-28, disturbances of daily life, and annoyance were analysed in order to find the primary cause of the adverse effects on subjective health. In the analyses, the sample was limited to the sensitive residents in the 59–67 dB group, since the higher odds ratios for somatic symptoms were obtained only in the group (see Figure 2(c)).

Figure 4 shows the relationships among moderate/severe somatic symptoms, disturbances of daily life, and annoyance.

Sleep disturbance correlated significantly with somatic symptoms. On the other hand, hearing interference did not show any significant associations with somatic symptoms.

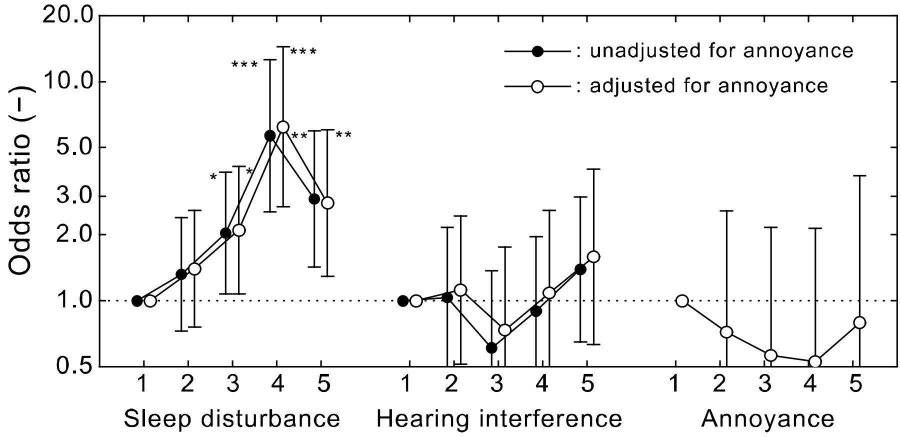


Figure 4: Relationships among moderate/severe somatic symptoms, disturbances of daily life, and annoyance. The open and closed circles indicate the adjusted and unadjusted odds ratios for annoyance, respectively. *: p < 0.05, **: p < 0.01, ***: p < 0.001. Sleep disturbance: 1 = not at all; 2 = 1–2 days a month; 3 = 1–2 days a week; 4 = 3–4 days a week; 5 = almost every day. Hearing interference: 1 = not at all; 2 = 1–2 times a week; 3 = 1–2 times a day; 4 = 5–6 times a day; 5 = more than 10 times a day. Annoyance: 1 = not annoyed; 2 = a little annoyed; 3 = annoyed; 4 = very annoyed; 5 = intolerably annoyed.

Assuming that psychological stress responses such as annoyance cause adverse health effects, the odds ratio of disturbances of daily life will decrease by adjusting for annoyance. However, the odds ratios of disturbances of daily life did not decrease after adjustment for annoyance. In additon, annoyance did not significantly correlate with somatic symptoms, although it has been considered as a comprehensive indicator of the adverse effects of environmental noise. The odds ratios of annoyance were lower than those of sleep disturbance.

In order to find the factor related to annoyance, relationships between annoyance and disturbances of daily life were analysed by the same method as in Figure 4. In this analysis, the choice of ‘very/intolerably annoyed’ was considered as ‘highly annoyed’ and the answer was converted into a dichotomous variable. An analysis with adjustment for L_{den} was also conducted.

Figure 5 indicates the relationships among annoyance, disturbances of daily life, and L_{den}. Although both sleep disturbance and hearing interference were significantly associated with annoyance, the dose-response relationship of hearing interference showed a more remarkable increasing trend ($p = 1.50 \times 10^{-20}$) than that of sleep disturbance ($p = 5.06 \times 10^{-8}$). The analysis with adjustment for L_{den} yielded similar results. In the sensitive residents with 59–67 dB in L_{den}, noise exposure level showed a relatively low correlation with annoyance after adjustment for hearing interference and sleep disturbance.

Figure 6 indicates the causation of adverse health effects estimated from the present study. The results of the present study strongly suggest that sleep disturbance due to aircraft noise exposure can be the primary factor causing adverse health effects. The results also suggest that annoyance may not be associated with adverse health effects but with hearing interference.

The same causation of adverse health effects of noise were also found in our recent studies conducted (1) around Kadena airfield in Okinawa (Matsui et al. 2006), (2) along a Shinkansen railway (Kishikawa et al. 2007), and (3) along trunk roads (Miyakawa et al. 2008). Consequently, reduction of sleep disturbance seems to be important in order to mitigate health effects of noise.

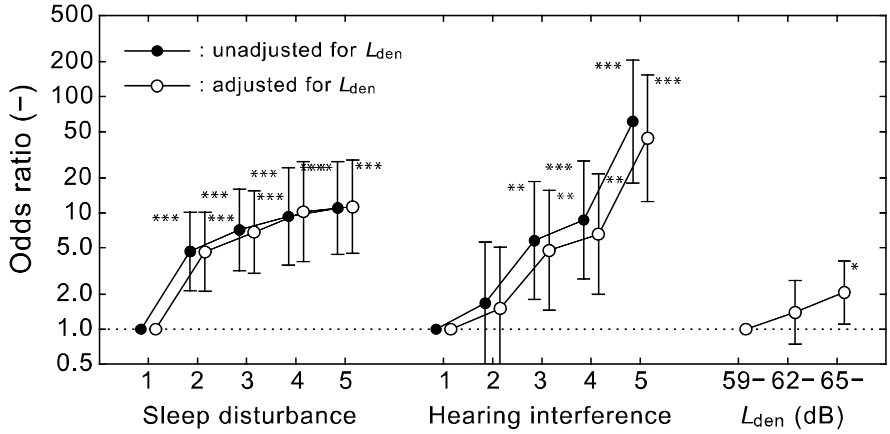


Figure 5: Relationships among annoyance, disturbances of daily life, and L_{den}. The open and closed circles indicate the adjusted and unadjusted odds ratios for L_{den}, respectively. *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$. Sleep disturbance: 1 = not at all; 2 = 1–2 days a month; 3 = 1–2 days a week; 4 = 3–4 days a week; 5 = almost every day. Hearing interference: 1 = not at all; 2 = 1–2 times a week; 3 = 1–2 times a day; 4 = 5–6 times a day; 5 = more than 10 times a day.

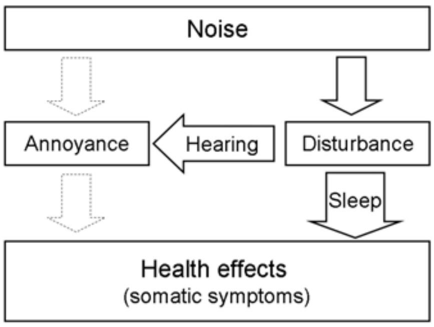
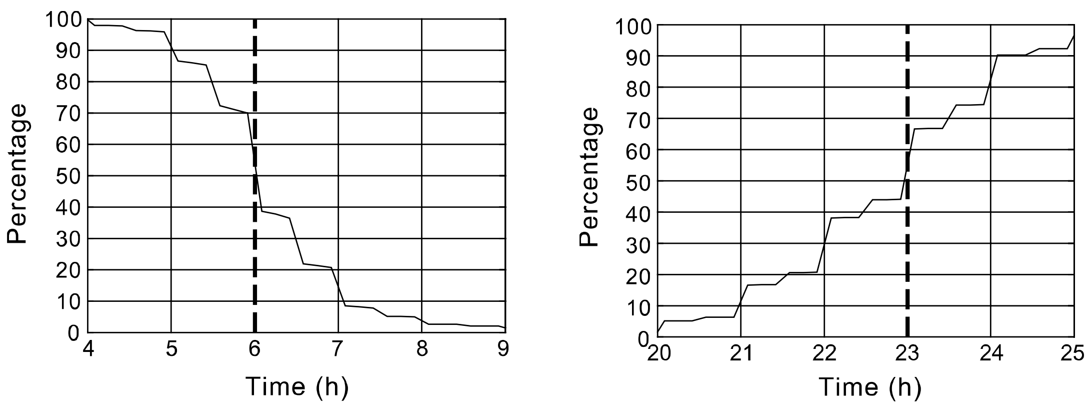


Figure 6: Causation of adverse health effects estimated from this study

There is no night flight from 2300 to 0600 hours at Narita International Airport for the sake of noise reduction. However, as shown in Figure 7, about 55 % of the respondents are asleep at 0600 h, and about 55 % of the respondents are asleep at 2300 h in the studied area. The noise abatement should be reconsidered taking the residents' lifestyle into account in order to mitigate the adverse health effects.



(a) Morning (b) Evening

Figure 7: Rate of sleeping respondents based on the answers of usual time to wake up and to go to bed

CONCLUSIONS

The cross-sectional field study conducted around Narita International Airport revealed a significant correlation between moderate/severe somatic symptoms identified by the GHQ-28 and aircraft noise exposure in the sensitive group. This result suggests that the adverse effects on subjective health due to aircraft noise exposure may exist especially in sensitive subgroups and that aircraft noise exposure has adverse effects on somatic symptoms of the residents in the study area.

The investigation on the relationships among somatic symptoms, disturbances of daily life, and annoyance revealed a significantly high correlation with sleep disturbance and no correlation with hearing interference and annoyance. The investigation also revealed that annoyance was strongly correlated with hearing interference. These results suggest that sleep disturbance due to aircraft noise exposure can be the primary factor causing adverse health effects and that annoyance may not be associated with adverse health effects.

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