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POPULATION-BASED QUESTIONNAIRE SURVEY ON HEALTH EFFECTS OF AIRCRAFT NOISE ON RESIDENTS LIVING AROUND U.S. AIRFIELDS IN THE RYUKYUS—PART I: AN ANALYSIS OF 12 SCALE SCORES

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A questionnaire survey was made of health effects of aircraft noise on residents living around Kadena and Futenma airfields using the Todai Health Index. Aircraft noise exposure expressed by L_{dn} ranged from under 55 to over 70 in the surveyed area. The number of valid answers was 7095, including 848 among the control group. Twelve scale scores were converted to dichotomous variables based on scale scores of the 90 percentile value or the 10 percentile value in the control group. Multiple logistic regression analysis was done taking 12 scale scores converted into the dependent variable and L_{dn}, age (six levels), sex, occupation (four categories) and the interaction of age and sex as the independent variables. Significant dose–response relationships were found in the scale scores for vague complaints, respiratory, digestive, mental instability, depression and nervousness. The results suggest that the residents living around Kadena and Futenma airfields may suffer both physical and mental effects as a result of exposure to military aircraft noise and that such responses increase with the level of noise exposure (L_{dn}).

1. INTRODUCTION

Because of the Security Treaty between Japan and the United States, there are about 130 U.S. military bases and facilities around Japan, 75% of which are located in Okinawa Prefecture. For historical and geographical reasons there is a heavy concentration of U.S. bases in Okinawa Prefecture, taking up 20% of the land area of Okinawa which comprises only 0·6% of the entire Japanese territory. This results in a high population density, which is ninth after metropolitan areas such as Tokyo and Osaka, in the residential district in Okinawa. This is also the case for areas in the closest vicinity of the bases. The negative impact of military activities on the communities surrounding the U.S. bases and facilities is extensive. The chronic aircraft noise exposure around Kadena Air Base and Futenma Air Station located in the middle of cities has caused serious disturbance to local residents due to the incessant noise from jets and helicopters as well as frequent engine tunings. The number of individuals living in areas exposed to aircraft noise exceeding the environmental standard for aircraft noise set by the Ministry of Environment, Japan, in 11 municipalities in Okinawa is estimated to be about 480 000, which is 38% of the prefectural population. However, no comprehensive surveys have been undertaken on the effects of aircraft noise in Okinawa. Against this background, the prefectural government decided in 1993 to organize a research committee to investigate the state of aircraft noise exposure and its impact on health and welfare around the bases. The present study using the Todai Health Index (THI) [1] is a part of a large field survey [2].

2. MATERIALS AND METHODS

The THI questionnaire, one of the self-administered questionnaires developed by Suzuki *et al.* [1], consists of 130 questions regarding vague complaints, mental health, personality, health habits, and so forth. Based on answers to 130 questions, 12 scale scores [3] were calculated to reveal the pattern of complaints. The 12 scales and their contents are tabulated in Table 1. The survey was done in six municipalities around Kadena Air Base and three around Futenma Air Station from October 1995 to September 1996. As controls, three municipalities in the southern part of the island were selected where there is little aircraft noise exposure. The map in Figure 1 illustrates the communities, indicated by small solid circles, where questionnaires were distributed in the middle and southern parts of Okinawa Island. The respondents were sampled from the pollbook by means of the stratified random sampling method with respect to noise exposure level. As a noise-exposed group, residents living around the airfields were stratified into five groups according to the level of noise exposure expressed in L_{dn}, under 55, 55–60, 60–65, 65–70 and over 70. These levels of noise exposure are based on measurements made by the prefectural government and the municipalities around the airfields [4].

The questionnaire was distributed by means of the leave-and-pick-up method to 4840 residents around Kadena Air Base, 2213 around Futenma Air Station and 1031 in the Shimajiri district as the control group. The number of residents living in the area with the highest noise exposure with an L_{dn} over 70 was so limited that the questionnaire was distributed to all the residents of the area over 15 years. Individuals under 15 or over 75 years of age or unable to answer the questions, for example owing to hospitalization, were eliminated from the distribution list. The total sample size was 8084. Neither the residents nor the distributors of the questionnaire were informed of the purpose of the survey that was to investigate the health effect of aircraft noise, but both were told that it was a general health survey conducted by the Okinawa Prefectural Institute of Public Health.

TABLE 1

Twelve scale scores of THI (Reference [1])

Scale	Contents or meaning
Vague complaints	Dullness or heaviness in the legs, desire to lie down, head feels heavy or dull, headaches, stiffness or pain in the shoulders, pains in various parts of the body, feel flushed or feverish, etc.
Respiratory	Cough up phlegm, sneeze, have a runny nose, cough, have mucus in the throat, irritation or pain in the throat, etc.
Eye and skin	Sensitive skin, itchy skin, skin eruptions or rashes, pain or itching in the eyes, inflamed or red eyes, etc.
Mouth and anal	Rough or raspy tongue, swelling or inflammation in the mouth, bleeding hemorrhoids, bleeding gums, constipation, etc.
Digestive	Stomach problems, stomach pain, discomfort in the stomach, diarrhea, indigestion, etc.
Irritability	Easily irritated, lose temper, act without considering the consequences, get upset, etc.
Lie scale	Like to make people think that one is a better person, social desirability, acquiescence tendency, etc.
Mental instability	Worry about small things, feel uneasy when work is observed by others, nervous and shaky, tremble or feel weak, worry about the past, cold sweats, become mentally tired, mania and depression, etc.
Depression	Hopeless, lonely, unhappy and depressed, has less confidence, etc.
Aggression	Never become ill, not timid, over weight, no orthostatic dizziness, drink a lot, not sensitive to cold, etc.
Nervousness	Nervous, sensitive, worry about soil and dirt, worry about everything, etc.
Irregularity of life	Do not go to bed early, do not get up early, difficulty in awaking early, often skip breakfast, meals are irregular, poor appetite, low energy, etc.

A total of 6695 answers were collected (response rate 82·8%). The valid answers were selected on the basis of the condition that the answer contained the respondent's age and sex and address so as to identify the noise exposure in L_{dn} and the respondent's age as being 15–74 years. The number of valid answers thus obtained was 6480. The 615 answers in the previous survey conducted in Chatan Town in 1992 [5] were added to the valid answers. The numbers of valid answers stratified by L_{dn} are listed in Table 2. Finally, 7095 answers were used for the analysis. However, since not all the respondents answered all the questions, the number of valid answers varies between scales within the range of 6862–6966. Twelve scale scores are converted into dichotomous variables based on scale scores of the 90 percentile value or the 10 percentile value in the control group. Multiple logistic regression analysis was done taking 12 scores converted as the dependent variable and L_{dn}, age (six levels), sex, occupation (four categories) and the interaction of age and sex as the independent variables.

3. RESULTS

Table 3 shows the significance probabilities (two-tailed) for 12 scale scores obtained in the multiple logistic regression analysis observed for the residents around Kadena Air Base and Futenma Air Station. The p-values in the table give the significance probabilities of the

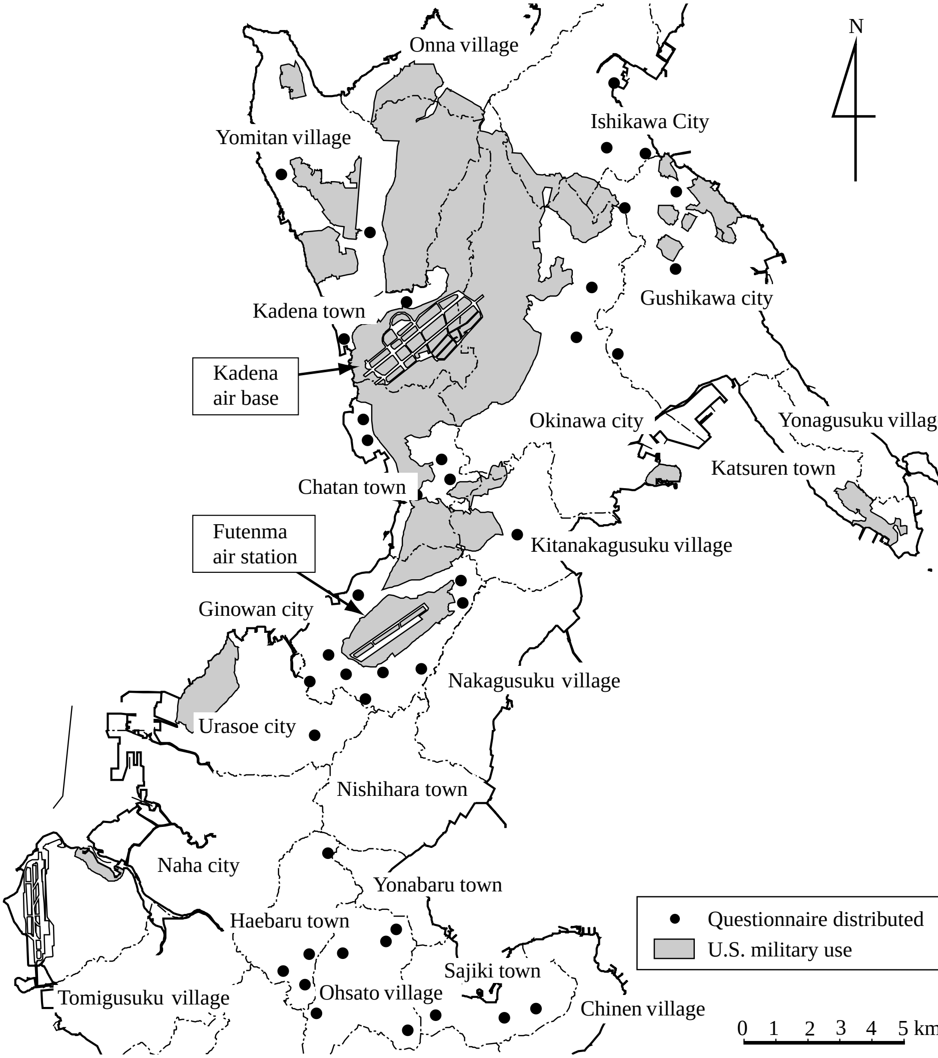

Figure 1. Investigated area around Kadena Air Base and Futenma Air Station.

TABLE 2

The number of respondents stratified by L_{dn}

		L_{dn} (dB)					
Airfield	Ctrl.	−55	55–	60–	65–	70–	Total
Kadena	—	1838	811	721	933	199	4502
Futenma	—	1055	277	413			1745
Ctrl.	848						848
Total	848	2898	1088	1134	933	199	7095

TABLE 3

Significance probability of L_{dn} for 12 scale scores

Scale	Threshold	*p*-value
Vague complaints	$\geqslant 39$	0·0010**
Respiratory	$\geqslant 18$	0·0000***
Eye and skin	$\geqslant 19$	0·4718
Mouth and anal	$\geqslant 16$	0·1157
Digestive	$\geqslant 16$	0·0009***
Irritablity	$\geqslant 23$	0·0652
Lie scale	$\leqslant 14$	0·9481
	$\geqslant 22$	0·5621
Mental instability	$\geqslant 30$	0·0462*
Depression	$\geqslant 20$	0·0379*
Aggression	$\leqslant 12$	0·0920
	$\geqslant 18$	0·2015
Nervousness	$\leqslant 11$	0·4350
	$\geqslant 20$	0·0035**
Irregularity of life	$\geqslant 24$	0·3027

trend test, in which linear dose–response relationships are assumed between L_{dn} and logarithmic values of the odds ratio. As can be seen in the table, significant dose–response relationships were found in the scale scores of vague complaints ($p = 0{\cdot}0010$), respiratory ($p < 0{\cdot}0001$), digestive ($p = 0{\cdot}0009$), mental instability ($p = 0{\cdot}0462$), depression ($p = 0{\cdot}0379$) and nervousness ($p = 0{\cdot}0035$).

The odds ratios of the six scale scores, in which significant dose–response relationships were found, were plotted against L_{dn} in Figure 2. With respect to vague complaints, the odds ratios of subjects with a scale score of 39 and over were statistically significant in Groups 65 and 70. With regard to respiratory, the odds ratio of subjects with a scale score of 18 and over was elevated for the group with L_{dn} 65. The same tendency was observed in the scale score for digestive. The odds ratio for mental instability with a scale score of 30 and over exceeded 2·0 in the L_{dn} 70 group. For depression, the odds ratio of subjects with a scale score of over 20 inclusive was higher in the L_{dn} 70 group. Significant increases in the odds ratio were observed for nervousness, even in the groups with lower noise exposure such as Groups 55 and 60, as well as in Groups 65 and 70.

4. DISCUSSION

As a non-specific biological stressor, noise can influence the body via both the autonomic nervous system and neuroendocrine system [6, 7]. In this sense, it would be reasonable to hypothesize that prolonged and repeated exposure to aircraft noise may adversely affect the health and well-being of the people living around Kadena and Futenma airfields, considering the serious noise exposure level in the residential area [8] and the high community responses regarding sleep disturbance, disturbance of rest, fear of possible danger and annoyance [9, 10]. However, exposure to noise does not necessarily result in an increase in the use of hospital facilities, in the morbidity of certain diseases or in mortality [11].

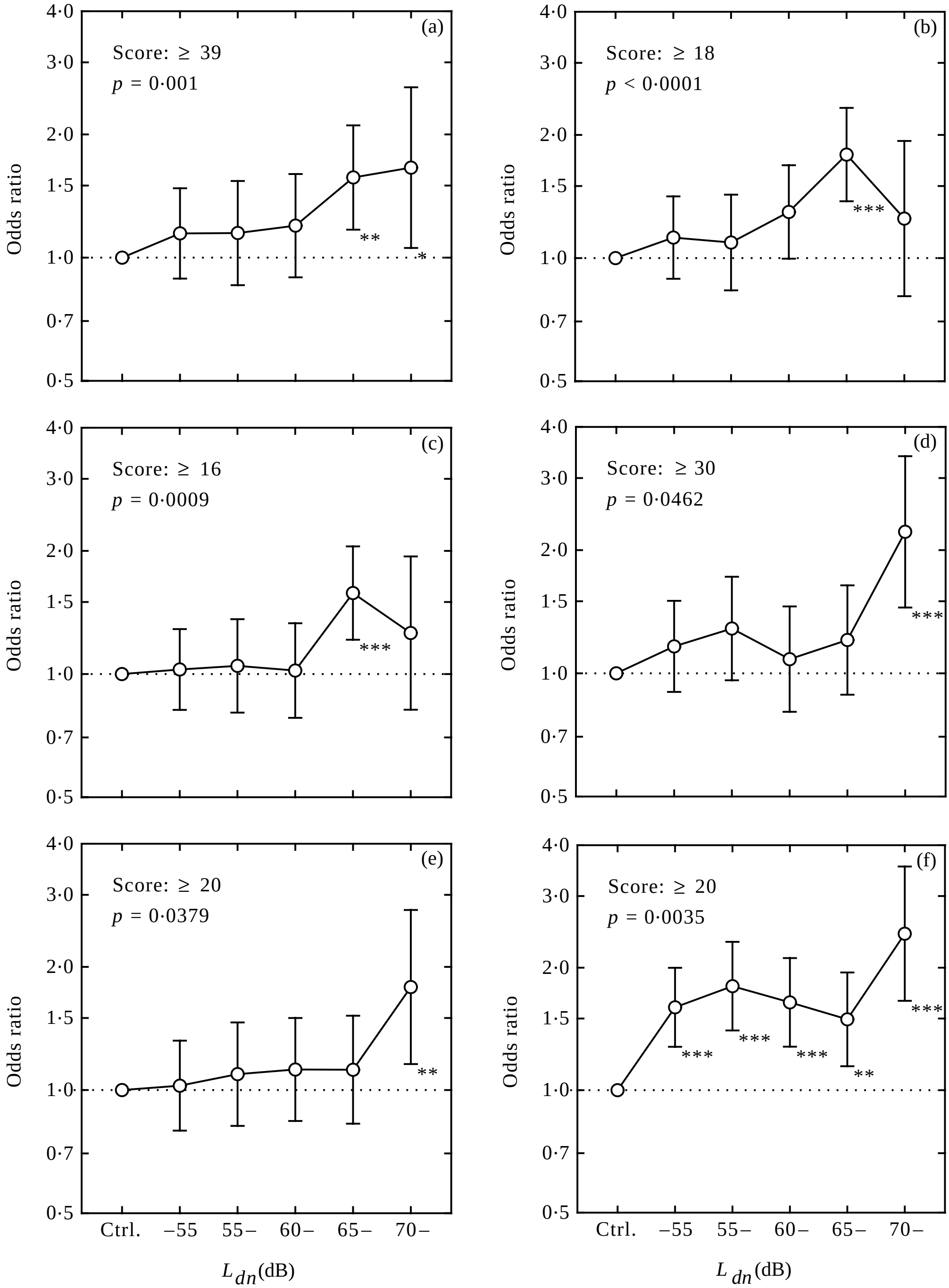

Figure 2. Odds ratio versus L_{dn} on 12 scale scores. Open circles sho the odds ratios with the 95% confidence interval and significance probability (*, $p < 0{\cdot}05$; **, $p < 0{\cdot}01$; ***, $p < 0{\cdot}001$): (a) vague complaints; (b) respiratory; (c) digestive; (d) mental instability; (e) depression; (f) nervousness.

Figure 3 shows the four different dimensions of health effects. Although the mortality and morbidity rates for certain diseases based on population health statistics are considered to be objective and reliable indices of the health of the population, these indices are not very

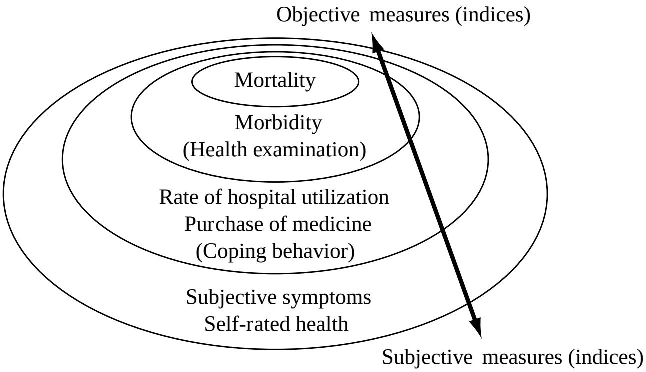

Figure 3. Dimensions of health effects.

sensitive and are not necessarily adequate to provide insight into the general health status of a population [12]. On the other hand, personal responses to questions on perceived health status and symptoms reflect a complex pattern of illness perception and behaviour that goes beyond the narrower conceptual definition of morbidity [13]. In comparison with health examination surveys, questionnaire surveys are less expensive and the non-response rate is usually lower.

The present study used self-administered questionnaires, and significant dose–response relationships were found between the odds ratio of the 12 scale scores. Several studies have examined the relationship between aircraft noise exposure and self-reported symptoms [5, 14–16, 17]. Graeven [14] surveyed 552 residents in five different noise zones including a quiet control zone around the San Francisco Airport and found a significant correlation between noise awareness and annoyance and the number of health problems reported in a symptoms checklist. In the exposed area, most of the variance is explained by noise awareness and annoyance. Tarnopolsky *et al.* [15] conducted a questionnaire survey (sample size of *circa* 6000) using GHQ in areas of different aircraft noise exposure affected by London (Heathrow) Airport and investigated the relationship between 27 acute and chronic symptoms and noise exposure. The results were controlled for the effects of age, sex and other standard epidemiological variables. Several acute symptoms showed an increase with noise, particularly irritability, depression and difficulty in falling asleep. Most chronic symptoms, except tinnitus and ear problems, were more common in low-noise conditions. Irrespective of their association with noise, most symptoms, chronic and acute, were more frequent among those respondents who also reported high annoyance. Koszarny *et al.* [16] gave a health questionnaire to 256 residents in an area where the aircraft noise levels exceeded 100 dB(A) and to 255 residents in somewhat quieter areas. They found significantly greater numbers of complaints related to the cardiovascular system, the digestive system and nervousness in women living in the noisier area. Higashitani [17] conducted a questionnaire survey using THI in the area around the Osaka International Airport. The subjects were 1065 adult women without full-time occupations. In the younger group (20s and 30s), complaints of some physical and psychological symptoms, especially digestive complaints, were more common in the higher than in the lower noise exposure group. In the older group over 60 years of age, the occurrence of multiple psychological symptoms correlated significantly with noise exposure level. In the middle age group (40s and 50s), however, neither the psychological nor the physiological complaints showed a significant correlation with the noise exposure level. Hiramatsu *et al.* [5] made a questionnaire survey using THI in the town bordering on Kadena Air Base. The sample size was 1200, including a 200-person "control" group. The exposed residents suffered psychosomatic effects, especially perceived psychological disorders, due to the noise exposure to military aircraft. These responses increase with the level of noise exposure.

In evaluations of the health effects of aircraft noise in the community, we must keep in mind the following three points. First, there is a time lag between the onset of noise exposure and the manifestation of health problems in question. Second, there exist relatively large individual differences in sensitivity to noise. Health effects of noise may manifest themselves in susceptible subgroups within a population and the sites where various symptoms appear are different among individuals even in the same conditions of noise exposure. Third, there are various socio-economic confounding factors in the onset of health problems. These points must be taken into account in studies to clarify the relationship between aircraft noise exposure and its health effects in field studies.

5. CONCLUSIONS

A questionnaire survey was done on health effects of aircraft noise among residents living around Kadena and Futenma airfields, using the Todai Health Index. Aircraft noise exposure expressed by L_{dn} ranged from under 55 to over 70. The number of valid answers was 7095. The results suggest that the residents living around Kadena airfield suffer from both physical and mental effects due to the exposure to military aircraft noise and that the extent of such responses increases with the level of noise exposure (L_{dn}).

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