Summary of the Report on the Aircraft Noise as a Public Health Problem in Okinawa

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March, 1999

The most serious impact of U.S. military activities on surrounding communities in this country is presumably the aircraft noise exposure around Kadena Air Base and Futenma Air Station located in Okinawa Island, the Ryukyus. The number of people affected by the aircraft noise exceeding the environmental standard for aircraft noise in Okinawa is estimated to be about 470,000, 38% of the prefectural population. In the air space over Kadena Air Base, touch-and-go flights and flight manoeuvres by U.S. military aircraft are conducted regularly as well as frequent engine tunings. These activities generate intolerable noise, which people residing near the base complain disrupts their daily lives. People residing around Futenma Air Station are exposed to intense noise generated by landings and take-offs during flight exercise and helicopter flight manoeuvres conducted in the air space over the base as well as over residential areas. The noise not only disturbs daily conversation and sleep but also disrupts classes, jams TV/radio broadcasts, and are considered to cause physical and mental strains such as loss of hearing and fatigue.

Under the circumstance, the prefectural government commenced a study survey on the state of noise exposure and the adverse effects of noise on the health of residents near Kadena and Futenma Air Bases in 1995 under the supervision of the Research Study Committee of Aircraft Noise Influences to Health which consisted of 18 medical scientists, environmental engineers, medical doctors and epidemiologists. This is the summary of the report of the four year project.

Noise Exposure: Analysis of the Measurement Data Acquired by the Monitoring System of Aircraft Noise in Okinawa

Okinawa Prefectural Government set up a remote monitoring system for aircraft noise exposure surrounding three military and civil airfields, two U.S. military bases and one airport which is used by both civil and military aviation. It has 23 observation stations as of March 1999, around the three airports. In the report are shown the state of art of the monitoring system and the analysis of the measurement records at the 23 stations for one year. The measured values are transferred via available telephone line to the central station installed at the local government office. Some of the data integrated in the central station are accessible from local municipalities. The result of the analysis shows that the peak A-weighted sound pressure levels of some of the events exceed over 110 dB and the maximum value of WECPNL is over 100 at a residential area in the vicinity of Kadena Air Base. The results of measurements are used for the epidemiological survey on the health effects due to aircraft noise.

Community Response with Respect to the Effects on Daily Lives

Annoyance reaction

The questionnaire survey was conducted around Kadena Air Base and Futenma Air Station. Responses of the people living around the bases to the questions with respect to annoyance reaction are analysed. The questionnaires were delivered to 7,894 inhabitants including 916 control inhabitants randomly sampled from the areas with different levels of aircraft noise exposure expressed in WECPNL, from 75 to 95 or more, and from the area without noise exposure. Among them 6,321 inhabitants, 5,693 of which gave valid answers, answered the questions asking if they found the aircraft noise annoying, if their thought and/or work were disturbed by the aircraft noise, if they found their relaxation are disturbed by aircraft noise and so forth. The subjects answered in the rating scales of five categories.

Taking the wide range of the levels of aircraft noise exposure in the study area into account, it is not surprising that very clear dose-response relationships are found in all the scales of the items related to annoyance reaction. The percentage of the "highly annoyed" for example starts increasing from WECPNL of 75, gets higher as the level of noise exposure is higher and reaches about 70% at WECPNL of over 95. The tendency is the same for the other items. The percentage of the respondents complaining their thinking are highly disturbed by aircraft noise, for example, begins to increase at WECPNL of 85 and gets higher as the level of noise exposure increases reaching to about 30% at WECPNL of over 95. The time in a day when they are disturbed is basically daytime, but even in the midnight and very early in the morning over 40% of the subjects living in the areas of WECPNL of 90 and over 95 complain disturbed.

Disturbance of TV/radio listening and telephone use

Responses with respect to the disturbance of TV/radio listening, conversational communication and telephone use are analysed. The rates of the disturbed in TV/radio listening, conversational communication and telephone use increase as linear functions of WECPNL. In the areas where aircraft noise exposure expressed in WECPNL is over 95, the rate of the always disturbed is over 60% or more. Analysis of the responses using multiple logistic regression shows the linear relation between the logarithm of odds ratio and WECPNL.

Sleep disorders

The questionnaire contains the items on sleep disturbance. Two types of scores indicating the degree of the sleep disturbance were calculated based on the answers to four questions on sleep disturbance. The rate of the respondents with high score increases as WECPNL gets higher,

thus the clear dose-response relationships between the scores of sleep disturbance and the level of noise exposure are found. Logistic regression analysis with the independent variables of WECPNL, age, and sex shows that odds ratios regarding relatively frequent sleep disturbance, more than once a week, are from 3.4 in the group with WECPNL of over 95, so as to suggest that the residents exposed to high level of aircraft noise suffer from serious sleep disturbance. Odds ratios regarding relatively scarce sleep disturbance, more than once a month, are significantly higher than the control in all the exposed groups including that of WECPNL of 75. The fact suggests that sleep disturbance occurs even in the areas with lower level of noise exposure.

Evaluation of residential environment

The questionnaire contains the items with respect to the quality of residential environment evaluated by the individuals living around the base. The respondents answered the questions asking if they are satisfied with their lives, if they are happy with their places of residence, if they wish to live in the present places longer. Logistic regression analysis shows the odds ratios regarding life dissatisfaction are significantly higher in the areas of WECPNL of 90 and 95 than those of other level of aircraft noise and the control. The odds ratio regarding the lower evaluation of the place of residence increases as the level of noise exposure gets higher and the difference in odds ratios from that of the control are significant over 85 of WECPNL. The odds ratio regarding longer inhabitation decreases as the level of noise exposure gets higher. The significant difference is found in the odds ratio between the noise exposed groups and the control group.

Residential sound insulation and community response

The questionnaire contains some items on the sound insulation of the residences of the respondents. They answered questions asking if soundproofing had been implemented for their houses by the government, the Defence Facilities Administration Agency (DFAA), and if the sound insulation was satisfactory. Responses to the disturbance of TV/Radio listening and telephone use, and sleep disorders are analysed in terms of the answers to the questions on soundproofing. Independently of WECPNL groups, the implementation rate for soundproofing by DFAA is around 60%. Although the positive evaluation of sound insulation is relatively high (80%) among those in the group with WECPNL of 75, the rate decreases to about 30% among residents with WECPNL of over 95. To investigate the difference in the positive response rate regarding sleep disorders and disturbance of TV/radio listening and telephone use, respondents are divided into those whose homes are soundproofed by DFAA and those whose homes are not. Logistic regression analysis shows no difference between the two groups in odds ratios regarding

sleep disorders and disturbance of TV/radio listening and telephone use. It can be concluded that the soundproofing implemented by DFAA does not, in actual context, relieve the effects of noise in the daily lives of residents —the aforementioned positive responses reflecting its physical reduction notwithstanding.

Effects on Children

Preschool children's misbehaviours

Questionnaire surveys on children's misbehaviour were conducted in nursery schools and kindergartens around Kadena and Futenma U.S. Air Bases. The areas were divided into four groups according to WECPNL values of under 75, 75, 80, and over 85. The subjects were male and female preschool children (3–6 yeas old), whose parents, caregivers, and teachers answered the questions. The numbers of valid samples were 1,580 from the noise-exposed area (915 around Kadena, 665 around Futenma), and 308 from the control area.

The responses are analysed by means of the method of multiple logistic regression taking the number of misbehaviours concerning "biological function", "social standard", "physical constitution", "movement habit", "character", "all the misbehaviours", "reaction to noise" or "TV etc." as the dependent variables and "dose of noise exposure", "age", "sex", "size of family", "birth order", "mother's age at birth", "father's job", and "mother's job" as independent variables. Linear relationships are found between the logarithm of odds ratio and WECPNL in the categories of "all the misbehaviours", "physical constitution", "character", "reaction to noise" and "TV etc.".

Multiple logistic regression analysis is conducted with the same independent variables as above and with the dependent variable of the cluster score of each of 17 clusters obtained by means of cluster analysis. It is found that the clusters showing the linear relation between the logarithm of odds ratio and WECPNL are "cold symptom", "headache-stomachache", "eating problem", "passive inclination" and "emotional instability" around Kadena, and "cold symptom", "eating problem", and "passive inclination" around Futenma. To put it tersely, children exposed to aircraft noise are likely to have the following inclinations: they easily catch cold, have a poor appetite, and take a long time to make friends.

From the results it would be safe to say that the aircraft noise exposure is a factor of increasing the number of the preschool children's misbehaviours physical and mental.

Effect on long term memory

Learning ability is determined by the social and educational environmental factors besides the natural talent. It has long been pointed that the school children and high school students of the schools located around Kadena Air Base and Futenma Air Station loose thousands of their study hours a year due to the interruption of the lessons by aircraft noise. Moreover, previous studies have reported that noise exposure inhibits performance and learning which results in lower learning ability of the children living in noisy environment. Evans et al. reported that the ability of retention of long-term memory was deteriorated in children living near former Munich airport than in those of the control and it was not recovered after one or more years from the close down of the airport.

In the present study 2,269 third and fifth year pupils of 11 schools located around Kadena Air Base and Futenma Air Station as well as in the area without aircraft noise exposure, the control, attended the series of tests for measuring the abilities of short-term memory, long-term memory, learning motivation etc. Logistic regression analysis was applied to analyse the results of the tests with the independent variables of aircraft noise exposure, grade, sex, number of lessons taking after school, score of listening test of nonsense syllables, learning motivation test. The result of the analysis suggests that the significant relationship was not found between the Odds ratio of short-term memory and aircraft noise exposure, but it was found between that of long-term memory and aircraft noise exposure. It is very likely that aircraft noise exposure around Kadena Air Base and Futenma Air Station in Okinawa reduces the ability of long-term memory of school children and as a result they run the risk of making lower learning ability of school work.

Higher rate of low birth-weight infants

The birth weights of infants were analysed using the birth records from 1974 to 1993 in Okinawa Prefecture. The records had been accumulated by Japanese government for every municipality to file up 357,845 infants for the 20 years. The odds ratio with respect to the birth rate of infants with low birth weight (under 2,500 grams or under 2,000 grams) was tested by means of multiple logistic analysis taking the rate of non-noise-exposed area as the control. The primary factors that would be related to infant's weight such as mother's age, single or multiple embryo, sex, and infant's legitimacy are applied as the independent variables in the logistic regression analysis.

Since the information available does not include the precise addresses of the birthplaces, it is impossible to raise the dose-response relationship. The birth rate of infants with low birth weights under 2,500g in Kadena-cho town, which is located in the most vicinal of Kadena Air

Base, was 8.3%, while that of other municipalities around Kadena and Futenma Air Bases was on average 7.0%. The average rate of low birth weight in the control group was 6.4%. The difference in odds ratio between Kadena-cho town and the control was statistically significant. Kadena-cho is a town of small area, 15.08 km^2, 83% of which is used by U.S. Air Base. The Defence Facilities Administration Agency (DFAA) of Japan designates the aircraft noise exposure expressed in WECPNL from 85 to 95 in the town. The environmental standard for aircraft noise set by the Environment Agency is 70 in WECPNL. In some parts of Chatan-cho town, WECPNL is designated to be over 95 or from 90 to 94. Majority of the people in the town, however, live in less noisy area where WECPNL is designated to be from 75 to 79. As a result, the response of higher exposed group is, say, diluted through the operation of averaging and the low birth weight in the town was 7.0%. Situation of other municipalities around Kadena Air Base except Kadena-cho is more or less the same as that. Another hypothesis that the mere existence of U.S. base might have incurred the higher rate of low birth weight was investigated and rejected by means of the multiple logistic analysis. It is possible to calculate the weighted average of WECPNL over population in the municipalities using the information available on the population residing in the areas of different WECPNLs. Taking the weighted average of WECPNL as the dose of noise exposure, significant increasing trend of the rate of low birth weight was found with the increase of the dose of noise exposure. Thus the authors have reached a conclusion that the aircraft noise exposure could be a factor raising the rate of low birth weight around KAB.

General Health Questionnaire Survey —Todai Health Index—

Analysis of the 12 scale scores

A survey on health effects of aircraft noise on people residing around Kadena Air Base and Futenma Air Station was conducted. The questionnaire used in the present investigation is the Todai Health Index (THI), developed for the purpose of supplementing the Cornell Medical Index (CMI), which consists of 130 questions regarding subjective symptoms, mental health, habits and so forth. In this paper, 12 scale scores, SUSY (many subjective symptoms), DEPR (depressiveness), MOUT (complaints regarding mouth and evacuation), LIFE (irregularity of daily life), LISC (lie scale), MENT (mental instability), EYSK (complaints regarding eyes and skin), NERV (nervousness), NEURO (neurosis), RESP (complaints regarding respiratory organs), and AGGR (aggressiveness), are calculated and analysed in relation to the aircraft noise exposure. As a noise-exposed group, residents living around the air fields were stratified into five groups according to the level of noise exposure expressed in WECPNL from 75–79, 80–84, 85–89, 90–94 and over 95. Questionnaires were delivered to 7,053 residents sampled from

the poll book of each group by stratified random sampling. They were also delivered to 1,031 residents sampled from Shimajiri district where aircraft noise exposure was very scarce. The numbers of valid answers were 6,247 of the noise exposed group and 848 of the control group. The 615 answers of the previous survey conducted in the same area in 1992 was also used for the analysis. Logistic regression analysis with the independent variables of age, sex and their interaction showed significant dose-response relationships in the scale scores of SUSY, RESP, DIGE, MENT and NERV. As to SUSY, odds ratios of subjects with the scale score of over 39 inclusive were statistically significant in Group 90 and Group 95. As for NERV, significant increase of odds ratio was observed even in the groups with lower noise exposure such as Groups 75, 80 and 85 as well as Groups 90 and 95. Odds ratio regarding MENT increases as WECPNL is higher and that with scale score of over 30 inclusive exceeds 2.0 in Group 95. The results suggest that the residents living around Kadena Air Base and Futenma Air Station may suffer from both physical and mental effects due to the exposure to military aircraft noise and that such responses increase with the level of noise exposure (WECPNL).

Analysis of the discriminant score and the factor score

Factor analysis was carried out using the 12 scale scores obtained as above and the discriminant function values were calculated from the responses to THI questionnaire. The study applies the discriminant function (DF) value and the factor score as the dependent variables in the logistic regression analysis with the independent variables of age, sex and their interaction. Results of the analysis indicate that the odds ratio of the DF values of psychosomatics increases as the level of noise exposure expressed by WECPNL increases and the dose-response relationship is quite clear and significant. The odds ratio of the subjects living in the area of WECPNL 95, which is the very vicinity of the base, is over 2.0. The result also indicates that the odds ratio of DF value of neurotics is significantly high in the area of WECPNL 95. Factor analysis of the 12 scale scores extracted 2 factors which the authors call “somatic factor” and “mental factor”. The factor scores of the 80 and 90 percentiles of the subjects in the control group was used as the thresholds to carry out the logistic regression analysis. The results of the analysis indicate that the odds ratio of the somatic factor increases in the lower noise exposure area of WECPNL of 75 and gets higher as WECPNL increases. The dose-response relationship is highly significant. As to the odds ratio of mental factor, the dose-response relationship is less clear than that of the somatic factor, but the test of the increasing trend shows it is significant with the significance level of 5%. The odds ratios in the both factors of the subjects living in the area of WECPNL 95 were over 2.0.

Analysis of the Data Obtained in General Health Examination

Citizens over 40 years are suggested by the government to receive health examination on the basis of Health and Medical Service Act for the Elderly. The data obtained by the health examination for the years of 1994 and 1995 were analysed with respect to systolic blood pressure and diastolic blood pressure (28,781 cases), numbers of red cells (28,692 cases), white blood cells (13,404 cases) and the concentration of uric acid (8,449 cases). Logistic regression analysis was applied to analyse the data acquired.

The rates of those with systolic blood pressure and diastolic blood pressure exceeding the thresholds determined for age groups were taken as the response, and clear dose-response relationships were found in terms of the aircraft noise exposure expressed by WECPNL. The Odds ratio of 90 percentile of those of the noise exposed group with WECPNL over 85 was 1.3 reference to that of the control. This implies the number of persons with the blood pressure exceeding the threshold increases by about 30 % in the noise exposed group. The increase of Odds ratio was also found in the noise exposed group with WECPNL from 75 to 80 compared with the control.

No significant dose-response relationship was found as to the numbers of white blood cells and red blood cells. Clear trend was found that the concentration of uric acid decreases as WECPNL is higher. The Odds ratio of those exceeding the threshold corresponding 90 percentile of the population is 0.8 in the noise exposed group with WECPNL of 80.

Hearing Loss

Estimation of noise induced hearing loss on the basis of the record of past noise exposure

Noise-induced hearing loss is considered to become a detectable permanent hearing loss through the repetition of temporary hearing loss and its recovery that starts an undetectable infinitesimal permanent hearing loss and its accumulation. A method of computation of average temporary hearing loss is available if the temporal and spectral characteristics of noise exposure are given; in its turn, permanent average hearing loss can be estimated to a certain extent from past measurement of noise exposure. The past noise exposure during the Vietnam War era was estimated using measurements recorded at the residential areas in the vicinity of Kadena Air Base in 1968 and 1972. The estimated WECPNL was around 105, and the equivalent noise level L_{Aeq} for averaging time of 24 hours came up to 85 dB. One can see how these values are serious when compared with the permissible criteria for occupational noise exposure for hearing conservation recommended by Japan Society for Occupational Health which is 80 dB for 24

working hours a day. The criteria is provided in the expectation that average hearing loss can be controlled after prolonged exposure of over 10 years under 20 dB for the test frequency of 4 kHz which is the most sensitive frequency. The time history of sound level during 24 hours is estimated from the measurement conducted in 1968 and 1972, and the sound level is converted into the critical band level for the test frequency using the results of spectrum analysis of military aircraft noise. The maximum temporary hearing loss due to noise exposure at that time was calculated from the time history of critical band level. Results of calculation indicate the noise exposure around Kadena Air Base causes hearing loss in excess of 20 dB. This is an average estimation for the exposed groups; further hearing loss is suspected among some highly susceptible individuals.

Results of the hearing tests around Kadena Air Base

The estimation of temporary threshold shift due to aircraft noise exposure recorded in the vicinity of Kadena U.S. Air Base suggests the possibility that the noise exposure could have caused the people living around the base noise induced hearing loss. Thus hearing tests were conducted at three wards A, B and C, in two towns neighbouring the base. The noise exposures expressed in WECPNL are over 95 inclusive in the ward A, 90 to 95 in the ward B, and 85 to 90 in the ward C. The subjects to receive the test were limited to the individuals aged between 25 and 69 years inclusive, whose numbers were 2,035.

Hearing tests were conducted at three occasions from 1996 to 1998. Before the test, the subjects were asked about the state of hearing, tinnitus, otological anamnesis, occupational noise exposure, head injury, ototoxic drugs, military service, hobbies and so on. Tests were carried out by experienced and qualified medics in audiometric booths. The SPL of the background noise in the booths was under 30 dB. Hearing levels of the subjects were measured by means of ascending method of limits with 5 dB step at 7 test frequencies from 500 to 8000 Hz. One hundred thirty eight individuals attended the test at the ward A, 121 at the ward B and 84 at the ward C. Forty among them who showed a dip in the frequency range of 3 to 6 kHz in the audiogram, were wondered to have noise induced hearing loss and sent to the Oto-rhino-laryngology section of Okinawa Chubu Hospital for the secondary examination. In the secondary examination the external and middle ears were first checked by visual inspection of tympanic membrane and by tympanometry and then air-bone gap of hearing acuity was investigated in order to omit the subjects with conductive hearing loss. Thirdly, SISI test was conducted to detect the subjects showing recruitment phenomena. Positive recruitment phenomena are considered that the hearing loss is not retrocochlear but sensori-neural.

Thus twelve subjects were found whose hearing loss is very likely noise induced hearing loss. The examiners interviewed thus found subjects to confirm that they had not experienced

habitual or repeated intense noise exposure at their residential or working sites other than aircraft noise exposure in their home place. The geographical locations of the subjects' residences are concentrated to the very vicinity of the air base, which strongly supports one to reach a conclusion that the cause of their hearing loss is most likely their exposure to the intense noise of aircraft take-offs, landings and tune-ups at KAB.