Chapter 10

Conclusions

10.1 Noise exposure

10.1.1 Past noise exposure

A few measurements at the residential areas in the vicinity of Kadena Air Base in 1968 and 1972 during the Vietnam War are available to estimate the state of past noise exposure. The estimation of noise exposure based on the record tells WECPNL was around 105 which is by 5 to 15 higher than the WECPNL the Defense Facilities Administration Agency (DFAA) now designates, and $L_{\mathrm{Aeq,24h}}$ came up to 85 dB which is as high as the permissible criteria for hearing conservation for eight working hours a day recommended by the Japan Society for Occupational Health.

In 1977 the DFAA made noise measurement of an extensive scale around Kadena Air Base and Futenma Air Station. The maximum sound level recorded by the DFAA in 1972 was 127 dB at Yara and 124 dB at Sunabe, both in front of residences, while engine tuning was carried out. The values of the noise indices WECPNL and L_{Aeq} calculated using the record in November are in the range of 97 to 109 and 77 to 89, respectively, which are extremely high.

10.1.2 Present noise exposure

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 Japanese airport, which is used by both civil and military aviation. It has 19 observation stations as of April 1998, around the three airports. The maximum value of WECPNL is as high as over 100 at a monitoring station located in a residential area in the vicinity of Kadena Air Base, and the differences between the maximum and the mean values are remarkable suggesting the daily noise exposure varies one day after another.

The maximum sound levels recorded are over 110 dB at 6 among 19 observation points. Even in the nighttime, they exceed 100 dB at 6 observation points. The maximum number of daily noise events occurred at the point where maximum WECPNL observed is over 500 and the maximum number of flights having occurred in the nighttime at the point is 58.

10.2 Community response with respect to the effects on daily lives

A survey was conducted around Kadena Air Base and Futenma Air Station on the effect of aircraft noise on residents' daily activities and quality of life. The questionnaire consists of 98 questions asking about the neighbourhood satisfaction, the regional and life environment, the base and aircraft noise, and sleep disorders. Respondents were randomly sampled, by a stratified sub-sampling method, 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. The total sample size is 7,894 and the number of valid answers is 5,693.

The residents answer that the most disturbing time is basically daytime, but even in the midnight and very early in the morning over 40% of the population living in the areas of WECPNL of 90 and over 95 in the Kadena Air Base's surroundings complain disturbed.

Very clear dose-response relationships are found in the annoyance and its related reaction. The percentage of the "highly annoyed" starts increasing from the value of WECPNL of 75, becomes higher as the level of noise exposure is high and reaches about 70% at WECPNL of over 95. The tendency is the same for the other items such as anxieties of crash, drop of objects, explosion, involvement in war, fear of war memory and so on.

The rates of the disturbed in TV/radio listening, speech communication and telephone use increase as a function of WECPNL. The percentage of those complaining TV listening are always disturbed by aircraft noise, for example, begins to increase at WECPNL of 70 or 75 and becomes higher as the level of noise exposure increases reaching over 60% at WECPNL of over 95. The dose-response relationships between the rates and WECPNL are quite clear. The response rates regarding the disturbance of daily activities and rest are not high in the area with WECPNL below 85 but they increase with WECPNL in the region of over 90.

Two types of scores indicating the degree of sleep disorder are calculated based on the answers to four questions on sleep disorder. The questions did not specify the sleep disorder as caused by the aircraft noise. The rate of respondents with high score increases as WECPNL is higher, thus the clear dose-response relationships between the scores of sleep disorder and the level of noise exposure are found. Logistic regression analysis with the independent variables of WECPNL, age, sex, occupation and the interaction of age and sex shows that odds ratio regarding relatively frequent sleep disorder, more than once a week, is 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 disorder. Odds ratios regarding relatively scarce sleep disorder, more than once a month, are significantly higher than the control in all the exposed groups WECPNL of over 75 inclusive. The fact suggests that sleep disturbance occurs even in the areas with lower level of noise exposure.

The questionnaire contains the items with respect to the quality of residential environment evaluated by the individuals living around the base. The respondents answer the questions asking if they are satisfied with their lives, if they are happy with their places of residence, and if they wish to live in the present places permanently. 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 neighbourhood satisfaction 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 the intention of permanent residence decreases as the level of noise exposure gets higher. The significant difference is found in the odds ratio the noise exposed groups and the control group.

10.3 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 sound insulation had been implemented for their homes by the DFAA and if the performance was satisfactory. Difference in the responses to the questions on reported annoyance, interference with communication, sleep disorders and neighbourhood satisfaction are analysed between the residents of homes sound

insulated and not insulated.

The results show that independently of WECPNL groups, the implementation rate is around 60%. Although the negative evaluation of sound insulation is relatively low (20%) among those in the group with WECPNL of 75, the rate increases to about 70% among residents with WECPNL of over 95. The percentage of the response on the dissatisfaction with sound insulation is as low as about 10% in the group of WECPNL of 75, but it increases with WECPNL and reaches about 60% in the group of WECPNL of over 95.

The dose-response relationships of reported annoyance, interference with conversation, sleep disorders and neighbourhood satisfaction of the residents of homes with and without sound insulation show surprisingly good agreement with each other. The result of logistic regression analysis shows no difference between the two populations in odds ratios, either. It can be concluded that the sound insulation implemented by the DFAA does not, in actual context, mitigate the effects of noise in the daily lives of residents — the aforementioned positive responses reflecting its physical reduction notwithstanding.

10.4 Effects on children

A questionnaire survey on children's misbehaviour was conducted in nursery schools and kindergartens around Kadena Air Base and Futenma Air Station. The areas were divided into four groups according to WECPNL values of under75, 75, 80, and over 85. The subjects were male and female preschool children (3–6 years old), whose parents, caregivers, and teachers answered the questions. The numbers of valid answers were 1,580 from the noise-exposed area (915 around Kadena Air Base, 665 around Futenma Air Station), 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 with positive slope 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." around Kadena Air Base and "social standard," "physical constitution" and "reaction to noise" around Futenma Air Station.

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 with positive slope between the logarithm of odds ratio and WECPNL are "cold symptoms," "headache-stomachache," "eating problem," "passive inclination" and "emotional instability" around Kadena Air Base, and "cold symptoms," "eating problem" and "passive inclination" around Futenma Air Station. 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 physical and mental misbehaviours.

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.

10.5 General health questionnaire survey: Todai Health Index

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, VCOM (vague complaints), RESP (respiratory), EYSK (eye and skin), MOUT (mouth and anal), DIGE (digestive), IMPU (irritability), LISC (lie scale), MENT (mental instability), DEPR (depression), AGGR (aggression), NERV (nervousness) and LIFE (irregularity of life), are calculated and analysed in relation to the aircraft noise exposure. As a noise-exposed group, residents living around the airfields were stratified into five groups according to the level of noise exposure expressed in WECPNL from 75–80, 80–85, 85–90, 90–95 and over 95. Questionnaires were distributed to 7,053 residents sampled from the poll book of each group by stratified random sampling. Including 1,031 samples from the control, total sample size comes to be 8,084. The 615 answers of the previous survey conducted in the same area in 1992 were also used for the analysis.

Twelve scale scores are converted to dichotomous variables based on scale scores of 90 percentile value or 10 percentile value in the control group. Multiple logistic regression analysis taking twelve scores converted as the de-

pendent variable and WECPNL, age, sex, occupation and the interaction of age and sex as the independent variables is conducted. Significant dose-response relationships are found around Kadena Air Base in the scale scores of VCOM ($p = 0.0009$), RESP ($p < 0.0001$), DIGE ($p = 0.0004$), MENT ($p = 0.0085$), AGGR ($p = 0.0124$) and NERV ($p = 0.0005$), where p denotes significance probability of trend test. Around Futenma significant dose-response relationships are found in the scale scores of EYSK ($p = 0.0201$) and NERV ($p = 0.0014$).

The discriminant function (DF) value for psychosomatics and neurosis are calculated and logistic regression analysis is conducted with the independent variables of WECPNL, age, sex, occupation and the interaction of age and sex. The result shows that odds ratio of DF value of psychosomatics represents clear dose-response relationship and that of neurosis is significantly high in the area of WECPNL of 95.

Factor analysis was carried out using the 12 scale scores obtained as above and 2 factors are extracted which may be called "somatic factor" and "mental factor." The factor scores of the 90 percentile of the subjects in the control group are 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 tendency shows it is significant with the significance level of 5%.

10.6 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), the numbers of red blood cells (28,692 cases), white blood cells (13,404 cases) and the concentration of uric acid (8,449 cases) adjusted for creatinine. Logistic regression analysis was applied to analyse the data acquired.

The rates of those with systolic blood pressure and diastolic blood pres-

sure 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 increase 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 (creatinine adjusted) decreases as WECPNL is higher. The odds ratio of those exceeding the threshold corresponding 90 percentile of the population is 0.6 in the noise exposed group with WECPNL of 80.

10.7 Higher rate of low birth-weight infants

The birth weight of infants were analysed using the birth records from 1974 to 1993 in Okinawa Prefecture. The birth records including the information on year of birth, address, sex, birth-weight, mother's age, single or multiple pregnancy, legitimacy of the infant, the period of pregnancy, live birth order, experience of stillbirth, occupation of householder, etc. The number of births in Okinawa Prefecture recorded for the 20 years was 356,549 among which 164,028 records of 15 municipalities around Kadena Air Base and Futenma Air Station are used for the analysis in the present investigation. The municipalities are classified according to the population weighted average WECPNL. In the following analysis the 8 municipalities with WECPNL under 75 are treated as the control, the 5 municipalities with WECPNL from 75 to 80 are treated as "lower noise exposed group." Chatan Town and Kadena Town are independent groups.

The birth rate of low birth-weight infants of Kadena Town is 8.3% which is by about 2% higher than the rate 6.4% of the control and the ratio of the rate of Kadena to that of the control is about 1.3. Chatan Town and the 5 municipalities of lower noise exposure have nearly the same birth rates of low birth-weight infants as each other.

The odds ratio with respect to the birth rate of infants with low birth weight (under 2,500 grams) was tested by means of the multiple logistic regression method. The primary factors that would be related to infants' weights such as sex, mother's age, live birth order, occupation of householder, legiti-

macy of the infant, year of birth and interaction of mother's age and live birth are applied as the independent variables in the logistic regression analysis. Significant increasing trend of the rate of low birth weight is found with the increase of the dose of noise exposure.

Higher birth rates of preterm births are found in the municipalities with higher noise exposure. The preterm birth rate of Kadena Town is by about 2% higher than the rate of the control and the ratio of the rate of Kadena to that of the control is about 1.2. Chatan Town and the 5 municipalities of lower noise exposure have by about 0.5% higher rates of preterm birth than the control. As was found in the case of low birth-weight, the trend of increase of odds ratio regarding preterm birth with the increase of WECPNL is clear and significant according to the trend test.

It is very unlikely for possibly higher rate of smoking habit among females in Kadena Town, which is unknown actually, might raise the birth rate of low birth-weight infants. Thus the aircraft noise exposure is considered to be the most likely factor raising the rate of low birth weight around Kadena Air Base.

10.8 Hearing loss

10.8.1 TTS and NIPTS calculated based on the past noise exposure

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 TTS (temporary threshold shift) in excess of 20 dB. Noise induced permanent threshold shift (NIPTS) is calculated according to Robinson's method for 90 percentile of NIPTS to be about 20 dB.

10.8.2 Hearing test

Hearing test was conducted at three wards A, B and C, in two towns neighbouring Kadena Air Base. The noise exposures expressed in WECPNL are over 95 inclusive in the ward A, 85 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. Three hun-

dred and forty three individuals received the test. They were 137 males and 206 females. Among them, 40 individuals who were judged to have possible noise induced hearing loss were sent to Okinawa Chubu Hospital as subjects for the secondary test. 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 cochlear hearing loss.

Thus twelve subjects are selected whose hearing loss is very likely noise induced hearing loss. The examiners interviewed selected subjects as above to confirm that they had not experienced habitual or repeated intense noise exposure at their residential or working life 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 draw 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 Kadena Air Base.

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