PREFACE

In accordance with the Treaty of Mutual Co-operation and Security between Japan and the United States of America (Treaty No. 6 of 1960), and the Agreement under ARTICLE VI of the Treaty of Mutual Co-operation and Security between Japan and the United States of America, Regarding Facilities and Areas and the Status of United States Armed Forces in Japan (Treaty No. 7 of 1960), Kadena Air Base and Futenma Air Station are provided to the U.S. Forces as the "Facilities and Areas" for aircraft service and other such activities in addition to operating and managing the bases.

The negative impact of military activities on surrounding communities of the U.S. bases and facilities is extensive among which the chronic aircraft noise exposure around Kadena Air Base and Futenma Air Station situated in the midst of cities has caused serious disturbance to local residents due to incessant jet noise and helicopters as well as frequent engine tunings. Extremely intense aircraft noise occasionally exceeding 120 dB occurs in the area of the residences below the flight path of the U.S. Forces' aircraft that land and take off on the runways of the bases. In the air space over Kadena Air Base, touch-and-go flights and flight manoeuvres by the U.S. military aircraft have been conducted regularly as well as frequent engine tunings. At Futenma Air Station, individuals residing around the airfield have been exposed to intense noise generated by landings and departures during flight exercise and helicopter flight manoeuvres conducted in the air space over the base as well as over the surrounding residential areas.

The aircraft noise around the airfields in Okinawa had been recognised so tremendous that the noise has often been expressed "murderous" or "lethal" and that it has also been said that the residents suffer from various kinds of damages due to the noise exposure. In fact among scientists are accepted that noise does not only interfere with speech/conversation and sleep but also disrupts classes, jams TV/radio broadcasts, and is considered to cause physical and mental strains such as loss of hearing, fatigue and neurosis. The number of individuals affected by the aircraft noise exceeding the environmental standard for aircraft noise set by the Environment Agency, Japan, in 11 municipalities in Okinawa is estimated to be about 480,000, 38% of the prefectural population. However, there had not been comprehensive surveys undertaken on the effects of the aircraft noise in Okinawa.

Under the circumstance, the prefectural government undertook a study survey on the state of noise exposure and the possibly adverse effects of noise on the health of residents near Kadena and Futenma airfields from 1995 to 1999 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 headed by Dr. YAMAMOTO, Takeo, Professor Emeritus of Kyoto University. This is the English summary of a part of the report of the project.

Contents

Chapter 1

Introduction

1.1 An overview of Okinawa and the U.S. bases

In the Western Pacific Ocean from the southernmost of mainland of Japan to Taiwan is lying the Ryukyu archipelago composed of a chain of small islands (Figure 1.1). Okinawa Prefecture occupying the southern half of the Ryukyus is Japan's southernmost prefecture which is divided into three groups of islands known as Okinawa, Miyako, and Yaeyama.

Okinawa Prefecture is one of the smallest in Japan, 44th in area and 35th in population among 47 prefectures. The total land area of Okinawa consisting of 160 islands, among which about 50 are inhabited islands, is only

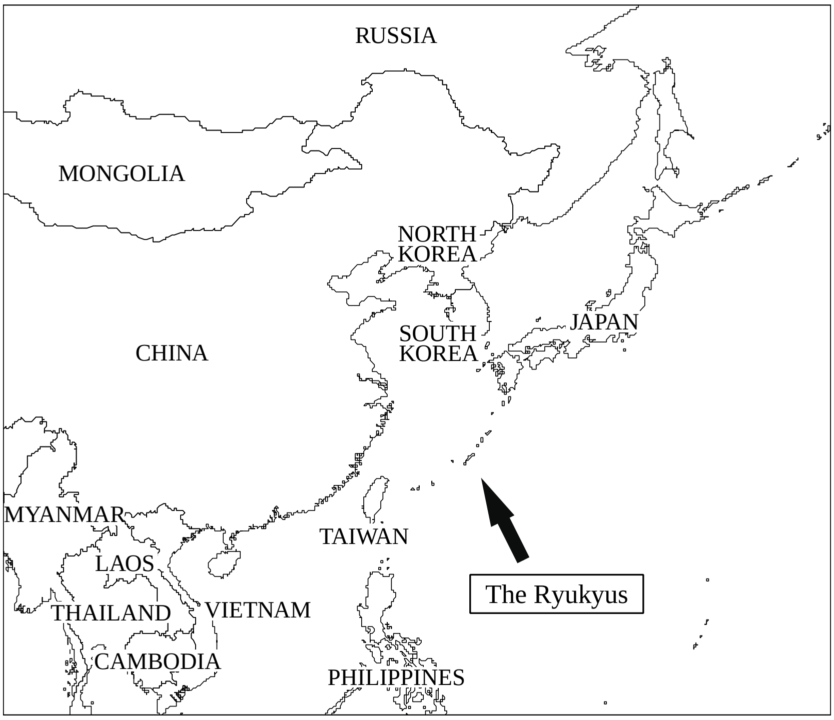

Figure 1.1 The Ryukyus in East Asia

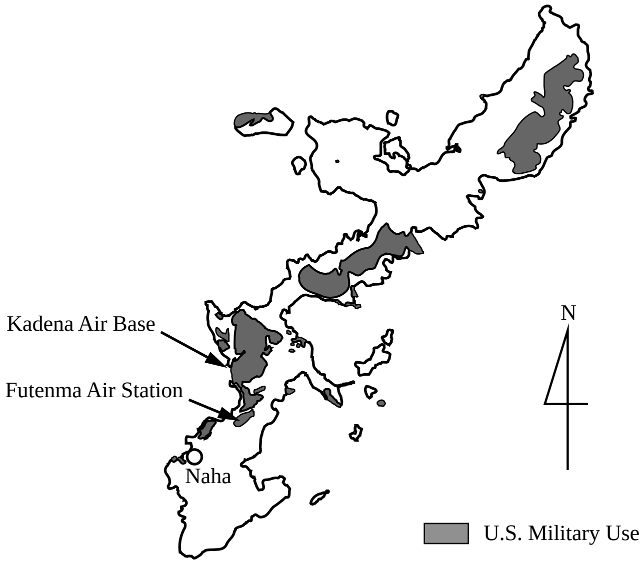

Figure 1.2 Okinawa Island in the Ryukyus and U.S. Bases.

about 0.6% of the land area of Japan and Okinawa is made up of 1.25 million individuals, 1.1% of the Japanese population. The population density is 9th after metropolitan areas such as Tokyo, Osaka, Nagoya and some others. The biggest island in the prefecture is Okinawa Island, the land area of which is about a half of the prefecture land area and one third of which 1.14 million individuals reside in. Moreover, for the historical, geographical and military strategic reasons, there exist 39 facilities of the U.S. Forces as of March 1998 which account for about 75% in area of the U.S. Bases and Facilities in Japan, and, particularly in Okinawa Island, 20 % of the small island area is used by the U.S. Forces (Figure 1.2). This results in high population density in the residential district in Okinawa and that is the case for even the area in the nearest vicinity of bases.

During World War II, Okinawa was the land of Japan where the only and most tragic land war in Japanese history unfolded, and then non-combatant individuals were involved and about 160,000 Okinawans were killed in the war.

The U.S. Forces, after landing in Okinawa, occupied military bases the former Japanese Imperial Army had built. After the war, the U.S. Forces' administrative authorities governed over Okinawa and took in surrounding land of the bases with the background of military power and further expanded and strengthened the bases.

In the situation where there was no place or home for the residents to live in and the U.S. Forces interned them in concentration camps, the U.S.

Figure 1.3 Aerial photograph of Kadena Air Base.

Forces took over one tract of land after another. When the residents were removed from the camps they found their land was in the bases. For example, the residents of Sunabe were released from the camp after one year or so, but part of their land was released after 10 years and the rest of their land is still within the fence of Kadena Base.

The sites of the both bases are on the fertile and flat land positioned in the heartland of Okinawa, and therefore, the place of residential and farm land owned and used by the residents until World War II. Kadena Air Base and Futenma Air Station were certainly built in the middle of highly cultivated part of the island. Thus Okinawa was transformed into an "island of bases."

Moreover, the post-war economy and urbanisation of Okinawa after the complete destruction due to the war took off from the gates of bases and concentration camps as early as in the period when currency was not reissued yet. This leads to the fact that the bases are located in the very middle of the most crowded residential and commercial parts of the island.

The reversion of the administrative authority of Okinawa from the U.S. to Japan in 1972 did not change the situation basically.

1.2 An overview of Kadena Air Base

Kadena Air Base (Figure 1.3) is spreading over the three municipalities of Chatan Town, Kadena Town and Okinawa City. The Base has two runways with accompanying taxiways, tarmacs, engine tuning shops, hangars,

Figure 1.4 Aerial photograph of Futenma Air Station.

and equipment as well as the headquarters, barracks, telecommunication facilities, homes, schools, clinics and other such facilities.

It was set up as "Central Airfield" in September 1944 by the former Japanese Imperial Army. In April 1945 the U.S. Forces that landed on the Okinawa Island occupied this airfield. Thereafter the base was reconstructed, expanded and became more functional through the requisition of immense amounts of surrounding private land etc. During the Korean War (1950–1953) the base was used as a bomber unit base. During the Vietnam War in 1967 two runways were completed and the base played an important role for the bombers to make sorties and as a supply relay depot. From 1968 to 1970, B52 Stratofortress strategic bombers were stationed at the Base. In 1991, with the close of the Clark Base in the Philippines, the 353rd Special Operations Group and Air Transport C-12 aircraft were moved to Kadena Base. Presently, many aircraft such as F-15 Eagle fighters, KC-135 Tanker Transport, E3A Airborne Early Warning Aircraft, P-3C Orion Anti Submarine Warfare Aircraft, HC-130 Hercules rescue transports, and HH-3 rescue helicopters are in fact permanently stationed at Kadena Base.

1.3 An overview of Futenma Air Station

Futenma Air Station (Figure 1.4) was constructed immediately after the occupation of Okinawa by the U.S. Forces and is positioned in the centre of Ginowan City. In 1953 the runway was extended to 2,700m and now the base has a 2,800m $\times$ 46m runway. In 1960 the management of the base was transferred from the U.S. Air Force to the U.S. Marine Corps, and today Futenma is home to the Marine Aircraft Wing, 3rd Marine Expeditionary Force, which is prominent for helicopters. The base has many support facilities such as hangars, maintenance and repair facilities, storage facilities, a communication facility, parts warehouses, offices, PX, clubs, bars, health clinics, a fire station etc.

Chapter 2

Noise exposure

2.1 Past noise exposure

During the Vietnam War were there conducted a few measurements at the residential areas in the vicinity of Kadena Air Base in 1968 and 1972. In 1977, the DFAA (Defense Facilities Administration Agency) of Japan made noise measurement of an extensive scale around Kadena and Futenma airfields. Some of the local authorities installed monitoring stations around the bases and have filed up measurements for about 20 years. These data are available to grasp the past state of noise exposure and its chronological change around the bases.

2.1.1 Measurement at Kadena Fire Station in 1968

The local authority of Kadena Village undertook noise measurement at Kadena Fire Station which was located very near the fence of the northwest part of Kadena Air Base where engine tuning site was and still is positioned. In those days jet engine was tuned and tested without any noise insulation facility or barrier at a distance of about 150m or so from the local residences. The measurement record is precious because sound level meter was not as popular as today in those days when even in the main land of Japan only limited local authorities used the device.

The measurement was carried out for one month in the building of Kadena Fire Station, the position of which is shown in the map of Figure 2.1, with the windows open, and the time of noise event in a day, the maximum sound level in single noise event and the duration of noise exceeding the sound level of 70 dB were recorded during the course of the measurement. Here in the present report the data obtained by the continuous measurement from 12th to 17th February 1968, are used to estimate WECPNL (Weighted Equivalent Continuous Perceived Noise Level), the index of noise exposure for aircraft

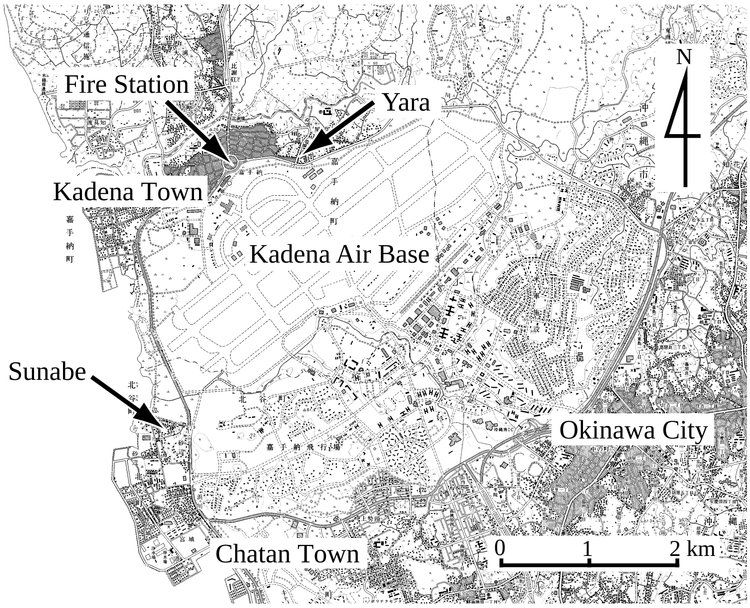

Figure 2.1 Measuring points of the noise data during Vietnam War.

noise.

WECPNL adopted by the Environment Agency of Japan is modified for simplification (Environment Agency; 1973) and is calculated by the following equation:

$$WECPNL = L_{\mathrm{A}} + 10 \log N - 27,$$

where L_{A} is the average maximum sound level of noise event on power basis in one day. The number of noise events is weighted for the time of flight in the day and the total number of noise events, N, is expressed by the following equation.

$$N = 10N_1 + N_2 + 3N_3 + 10N_4,$$

where N_1 is the number of flights from 0:00 to 7:00, N_2 is that from 7:00 to 19:00, N_3 is that from 19:00 to 22:00 and N_4 is that from 22:00 to 24:00. The Environment Agency designates the method for calculating the annual average WECPNL over daily WECPNLs on power basis as the environmental standard.

Since the situation of noise exposure around military airfields is different from that around airports for civil aviation, there is a disparity between the objects of investigation for civil and military airport flight conditions such as daily fluctuations in the number of flights, types of aircraft, and flight formations. Thus, the DFAA provides a slightly different method for calculation (DFAA; 1980) as compared to that provided by the Environment Agency, tak-

Table 2.1 The number of noise events at Kadena Fire Station

Date	0–7	7–19	19–22	22–24 (hour)	Sum	Weighted sum
1968/2/12	34	44	12	6	96	480
1968/2/13	41	49	24	11	125	641
1968/2/14	28	49	10	5	92	409
1968/2/15	9	25	9	5	48	192
1968/2/16	37	45	13	4	99	494
1968/2/17	41	51	23	16	131	690
Average	32	44	15	8	99	484

The weighted sum is calculated by the formula; $10N_1 + N_2 + 3N_3 + 10N_4$, where N_1, N_2, N_3 and N_4 show the number of noise events during night (0:00–7:00), day (7:00–19:00), evening (19:00–22:00) and night (22:00–24:00), respectively.

ing the report (Kimura et al.; 1980) into account which concludes that the dose-response relationship around military airfields for WECPNL with the DFAA system corresponds to that around civil airport for WECPNL with the system of Environment Agency.

The biggest point of the difference between the two measurement systems is that the DFAA system employs the 90 percentile of the number of daily flights in one year as a standard number of flights while the system of Environment Agency uses the mean value of daily flights. Analysis of the data offered from the local authorities of base surroundings in Japan including Okinawa tells that the difference of the values calculated in the two systems is from 3 to 5 units, WECPNL with the DFAA system being higher than that with the system of Environment Agency (Matsui et al.; 1996).

The difference needs to be paid attention since automatic measuring devices for aircraft noise available in the market of Japan follow the system of the Environment Agency giving the outcome different from the value derived from the DFAA system around the bases.

In Table 2.1 are shown the number of noise events for the different hours of a day. From the table one can see that the number of noise events which occurred from 7 p.m. to 7 a.m. exceeded that from 7 a.m. to 7 p.m. Thus the number of noise events weighted for the time of flight in a day became as high as about 500. In Table 2.2 are shown the daily maximum sound level, WECPNL and $L_{\mathrm{Aeq,24h}}$. The index $L_{\mathrm{Aeq,24h}}$ (the equivalent continuous sound pressure level) is the level of time variant noise exposure averaged over 24 hours on power basis.

The estimation of noise exposure based on the record tells WECPNL is around 105 which is by 5 to 15 higher than the WECPNL the DFAA now

Table 2.2 Noise indices calculated by the measurements at Kadena Fire Station

Date	Greatest L_{max} (dB)	WECPNL by DFAA	$L_{Aeq,24h}$ (dB)
1968/2/12	107	100 – 106	79 – 86
1968/2/13	107	101 – 110	80 – 89
1968/2/14	110	100 – 110	83 – 93
1968/2/15	100	88 – 92	68 – 73
1968/2/16	104	199 – 109	80 – 88
1968/2/17	110	99 – 107	79 – 87
Average		99 – 108	80 – 88

Table 2.3 Monthly noise measurements at Sunabe

Month	Maximum level (dB)	Avg. of daily cumulated exposure time (sec) ≥100	95–99	90–94 (dB)	Sum
1972/Nov	124	345	595	990	1,930
1972/Dec	120	300	585	1,190	2,075
1973/Jan	120	325	595	990	1,910
1973/Feb	120	410	455	830	1,695
1973/Mar	122	450	525	850	1,825
Average		366	551	970	1,887

designates, and $L_{Aeq,24h}$ comes 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.

2.1.2 Measurement at Sunabe and Yara in 1972 by the DFAA

In November 1972, half a year after the reversion of Okinawa's administrative authority to Japan and in the fierce period of Vietnam War, the DFAA installed monitoring stations at Yara in Kadena Village and at Sunabe in Chatan Village as shown in the map of Figure 2.1. Sunabe is the area under the flight paths of aircraft landing and taking off on the Kadena airfield and now suffering from the highest noise exposure in Okinawa. Yara is the area nearest to the engine tuning and testing spot. At one of the ends of the runways close to Sunabe also engine was tuned occasionally. The record of the sound level was made every 5 seconds and the statistics over 5 months from November 1972 to March 1973 were given to the local authorities which are shown in Tables 2.3 and 2.4.

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 tun-

Table 2.4 Monthly noise measurements at Yara

Month	Maximum level (dB)	Avg. of daily cumulated exposure time (sec) ≥100	95–99	90–94 (dB)	Sum
1972/Nov	118	465	775	1,465	2,705
1972/Dec	123	575	950	1,575	3,100
1973/Jan	127	560	765	1,405	2,730
1973/Feb	126	320	795	1,565	2,680
1973/Mar	118	475	770	1,885	3,130
Average		479	811	1,579	2,869

Table 2.5 Statistics of noise indices at Sunabe in Nov/1972

Index	Min.	Max.	Average	90 percentile
Daily cumulated exposure time (sec)				
≥ 70 dB	17,730	7,055	10,788	13,952
≥ 80 dB	8,475	3,655	6,300	7,879
≥ 90 dB	3,115	775	1,861	2,369
≥ 100 dB	1,155	40	349	736
≥ 110 dB	85	0	16	53
WECPNL	107	98	103	105
$L_{\mathrm{Aeq,24h}}$ (dB)	87	78	83	85

Table 2.6 Statistics of noise indices at Yara in Nov/1972

Index	Min.	Max.	Average	90 percintile
Daily cumulated exposure time (sec)				
≥ 70 dB	30,645	7,610	16,352	22,564
≥ 80 dB	15,265	4,760	10,006	14,424
≥ 90 dB	5,850	825	2,589	3,866
≥ 100 dB	1,560	55	437	783
≥ 110 dB	220	0	15	40
WECPNL	109	97	104	107
$L_{\mathrm{Aeq,24h}}$ (dB)	89	77	84	87

ing was carried out. Using the record in November 1972 the noise indices WECPNL and L_{Aeq} are calculated as shown in Tables 2.5 and 2.6. The values of WECPNL and L_{Aeq} shown in the tables are extremely high and strongly suggest that the residents in the areas could suffer from hearing loss due to the noise from the base.

2.1.3 Large scale noise measurement by the DFAA in 1977

The DFAA conducted a large scale noise measurement at 127 points around Kadena Air Base and Futenma Air Station in 1977. They made con-

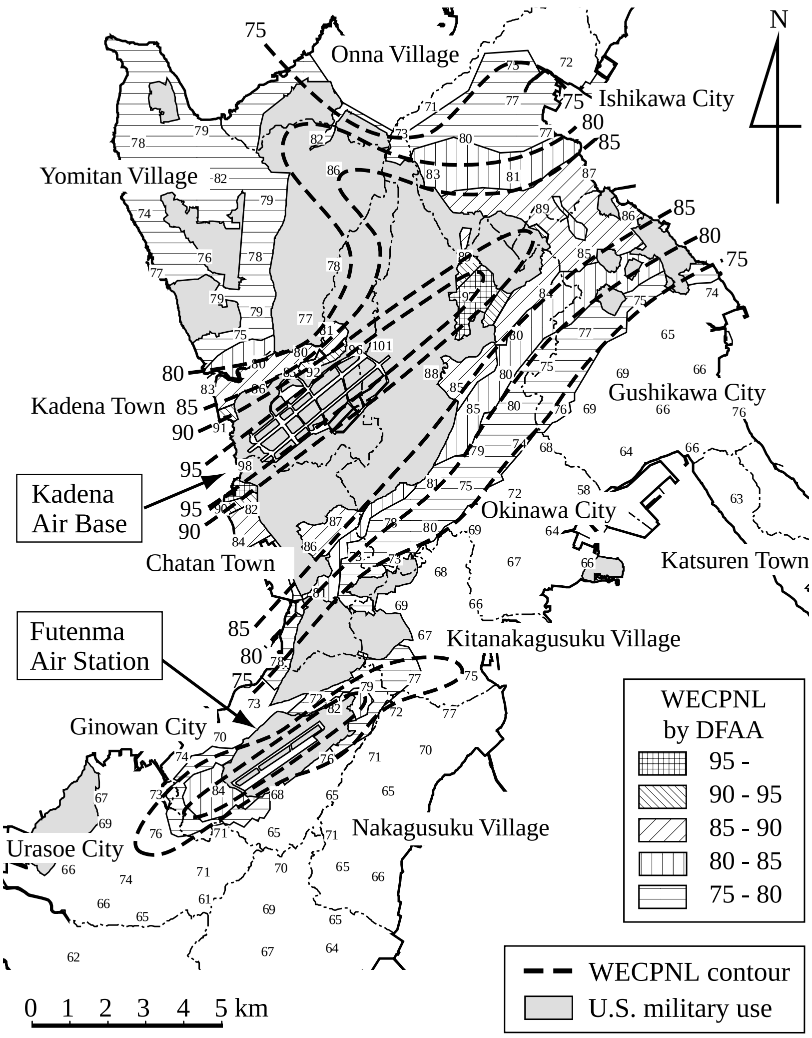

Figure 2.2 Noise contour based on the measurement in 1977.

tinuous observations at 4 measurement bases for 8 days. In the various items of observation were type of aircraft, flight path, sound level and time of event. The DFAA drew contours of WECPNL on the basis of the results of the measurements and designated the areas for the sake of taking counter measures or mitigation around the bases such as residential sound insulation.

In Figure 2.2 are illustrated the areas designated by the DFAA as such and the noise contours which are redrawn using the data shown in the report (Acoutech; 1978) for the DFAA's measurement project. Since the areas designated by the DFAA and the measured noise contour represent good agreement, WECPNL by the DFAA has shown the noise exposure in those days. The area illustrated in the figure is the middle part of the island and densely populated district.

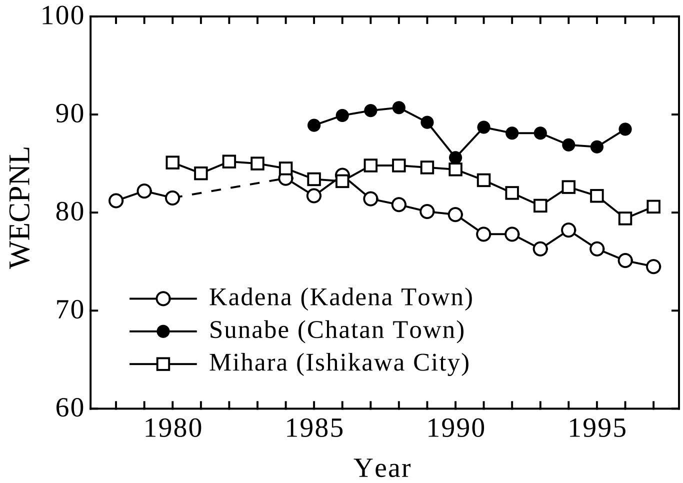

Figure 2.3 Change of the annual average of WECPNL.

2.1.4 Chronological trend of aircraft noise exposure

Okinawa Prefecture and some municipalities have monitored the aircraft noise exposure around Kadena and Futenma airfields. Records are filed up as to three monitoring stations around Kadena Air Base, Yara in Kadena Town, Sunabe in Chatan Town and Mihara in Ishikawa City, from 1978 to 1996. The results of the analysis of the records are presented in Figure 2.3. From the figure one can see that the noise exposure at Yara where noise generated by engine tunings used to be extremely intense and that at Mihara where acrobat-like flight manoeuvres were regularly conducted represent the trend of gradual decrease after 1986 because of the installation of silencers for engine tuning and the change of flight manoeuvres, but the noise exposure at Sunabe which is located under the flight paths has been basically the same for the past 10 years.

2.2 Analysis of the measurement data acquired by the monitoring system of aircraft noise installed by Okinawa Prefectural Government

Okinawa Prefectural Government set up a remote monitoring system for aircraft noise exposure surrounding the two U.S. military airfields and Naha International Airport used by both Japanese civil and military aviation. There are nineteen observation stations as of April 1998. In the following are described the state of art of the monitoring system and the results of analysis of the measurements at the 19 stations for one year.

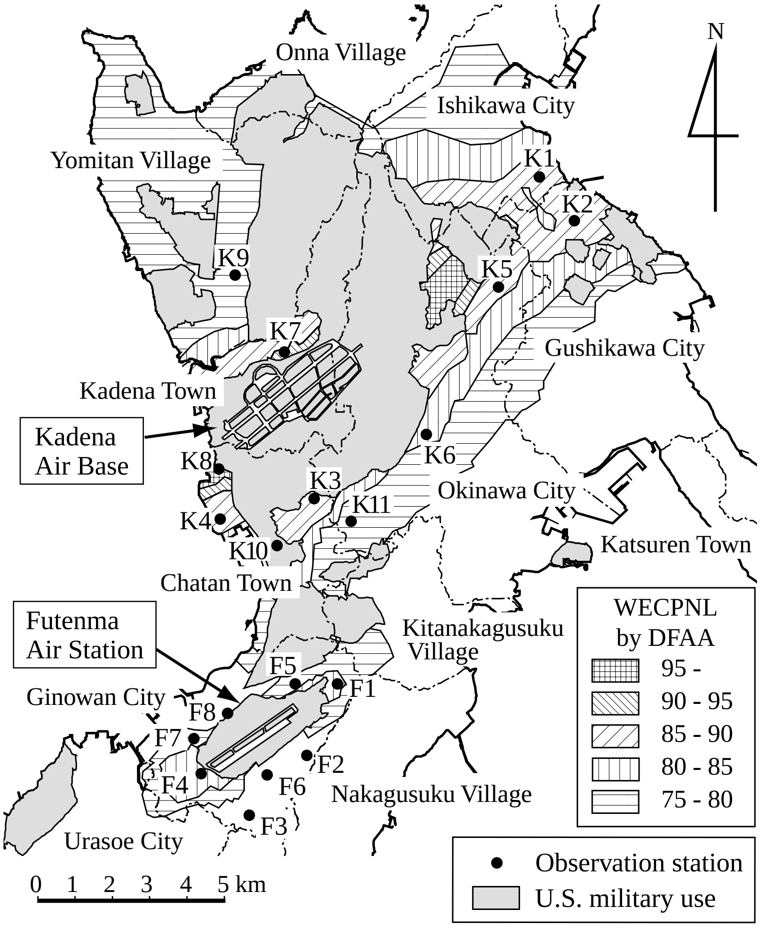

Figure 2.4 Observation stations of the monitoring system for aircraft noise.

2.2.1 System of monitoring aircraft noise in Okinawa

Figure 2.4 shows the positions of nineteen observation stations around the three airfields. Each station has a sound level meter and a computer for data acquisition. The items of observation are the maximum sound level, the time of a day of each noise event, duration of noise event and L_{AE}. Transponder signals emitted from air planes are also monitored to tell the aircraft noise from the other noises. The observed data are transferred via available telephone line to the central station installed at the prefectural government office. Some of the data integrated in the central station are accessible from local municipalities via telephone line.

2.2.2 Analysis of aircraft noise

Several noise indices were calculated from the observed data. Table 2.7 shows the statistics of daily WECPNL and L_{dn}. The items max, 98%, 90%

Table 2.7 Statistics of the daily WECPNL and $L_{\rm dn}$

Observation station		WECPNL by DFAA	Num. of days	WECPNL Max.	WECPNL 98%	WECPNL 90%	WECPNL Mean	$L_{\rm dn}$ (dB) Max.	$L_{\rm dn}$ (dB) 98%	$L_{\rm dn}$ (dB) 90%	$L_{\rm dn}$ (dB) Mean
K1	Mihara	85–90	357	91	86	85	81	77	75	72	68
K2	Konbu	85–90	337	88	83	81	77	74	71	68	64
K3	Kamisei	85–90	293	86	83	76	73	70	68	62	58
K4	Miyagi	85–90	342	84	82	79	75	71	69	65	61
K5	Kitami	85–90	346	84	80	77	73	70	67	64	60
K6	Yaejima	80–85	315	77	74	71	66	61	59	55	50
K7	Yara	90–95	281	85	83	81	77	74	70	68	64
K8	Sunabe	95–	297	101	98	95	91	87	82	79	75
K9	Iramina	75–80	177	82	76	68	67	69	60	53	51
K10	Kuwae	–75	79	80	79	74	69	64	63	58	54
K11	Yamauchi	75–80	60	74	72	67	64	59	57	53	50
F1	Nodake	80–85	350	88	83	80	77	73	68	65	61
F2	Aichi	70–75	331	76	73	70	66	61	58	55	51
F3	Ganeko	70–75	356	76	71	68	63	62	56	53	49
F4	Ueohjana	80–85	279	96	91	87	83	78	74	69	66
F5	Aragusuku	75–80	296	88	80	76	73	71	66	62	58
F6	Ginowan	70–75	315	76	75	72	67	61	59	57	53
F7	Mashiki	75–80	342	80	76	74	70	64	62	59	55
F8	Ohyama	70–75	79	73	73	70	65	58	57	55	51

and mean, in the table indicate the maximum value, the 98 percentile, the 90 percentile and the power mean of the noise indices over one year, respectively. The power mean of daily WECPNL is used to compare with the environmental quality standard for aircraft noise set by Environment Agency. As is shown in Table 2.7, the maximum value of WECPNL is as high as over 100 at the monitoring point K8 which is 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.

Tables 2.8 and 2.9 show the statistics of the daily maximum levels and the numbers of noise events. In the table, (7–22) and (0–7, 22–24) indicate the hours in a day. The statistics tells that the maximum level is over 110 dB at 6 among 19 observation points. Even in the nighttime, they exceed 100 dB at 6 observation points.

When one looks at the statistics of the number of noise event over one year as tabulated in Table 2.9, he or she will see that the number of noise event varies one day after another. The maximum numbers observed are 4 to 6 times of the mean value in the daytime and 6 to 50 times in the nighttime.

Table 2.8 Statistics of the daily L_{max}

Observation station		Num. of days	$L_{max,day}$ (dB) (7–22)				$L_{max,night}$ (dB) (0–7, 22-24)			
			Max.	98%	90%	Mean	Max.	98%	90%	Mean
K1	Mihara	357	113	107	103	100	109	106	95	94
K2	Konbu	337	111	103	99	96	107	94	89	86
K3	Kamisei	293	112	105	97	95	92	88	75	76
K4	Miyagi	342	108	103	98	95	97	90	85	80
K5	Kitami	346	107	99	94	91	92	88	83	79
K6	Yaejima	315	102	98	93	89	87	81	75	70
K7	Yara	281	104	102	99	95	100	95	86	85
K8	Sunabe	297	118	115	113	109	115	111	106	100
K9	Iramina	177	102	96	91	87	96	85	75	77
K10	Kuwae	79	104	103	97	92	70	68	–	54
K11	Yamauchi	60	100	95	89	86	79	77	–	64
F1	Nodake	350	110	107	104	99	100	94	86	83
F2	Aichi	331	98	93	90	87	91	85	71	73
F3	Ganeko	356	101	95	89	86	87	81	69	69
F4	Ueohjana	279	119	115	109	106	109	97	79	88
F5	Aragusuku	296	109	103	98	95	98	88	78	78
F6	Ginowan	315	99	95	93	88	92	84	70	72
F7	Mashiki	342	106	97	94	90	92	80	74	73
F8	Ohyama	79	97	93	90	86	82	–	–	63

Table 2.9 Statistics of the number of noise events

Observation station		Num. of days	N_{day} (7–22)				N_{night} (0–7, 22-24)			
			Max.	98%	90%	Mean	Max.	98%	90%	Mean
K1	Mihara	357	211	143	103	51	23	13	6	2.4
K2	Konbu	337	179	98	75	40	13	9	5	1.9
K3	Kamisei	293	191	133	90	36	20	6	2	0.6
K4	Miyagi	342	200	141	95	43	11	8	3	1.2
K5	Kitami	346	141	71	51	23	19	8	3	1.2
K6	Yaejima	315	69	62	29	11	10	1	1	0.2
K7	Yara	281	351	261	191	88	22	15	9	3.5
K8	Sunabe	297	545	463	343	128	58	30	10	4.7
K9	Iramina	177	43	28	14	6	7	5	1	0.3
K10	Kuwae	79	82	75	48	15	1	1	0	0.0
K11	Yamauchi	60	80	70	45	18	3	2	0	0.1
F1	Nodake	350	124	88	66	30	18	5	2	0.5
F2	Aichi	331	107	69	46	18	5	3	1	0.3
F3	Ganeko	356	79	65	39	16	8	3	1	0.3
F4	Ueohjana	279	217	186	135	60	6	4	1	0.4
F5	Aragusuku	296	330	227	159	68	40	17	3	1.3
F6	Ginowan	315	184	122	79	31	7	2	1	0.3
F7	Mashiki	342	330	180	115	53	16	3	2	0.5
F8	Ohyama	79	70	61	36	14	1	0	0	0.0

The maximum number of daily noise events occurred at the point K8, that is Sunabe, is over 500 and the maximum number of flights having occurred in the nighttime at the point is 58.

Judging from the analysis of the acquired data in the monitoring system of aircraft noise, it can be said that the state of noise exposure observed in the communities around the two military airfields are still high over the extended area in the middle part of Okinawa Island.

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Chapter 3

Community response with respect to the effects on daily lives

In the present project a questionnaire survey was conducted on the state of the damage to the daily lives in communities surrounding Kadena Air Base and Futenma Air Station.

3.1 Materials and methods

3.1.1 Questionnaire

The questionnaire consists of 98 questions including face sheet asking about the neighbourhood satisfaction, the regional and life environment, the base and aircraft noise and sleep disorders. The questionnaire is attached as Appendix A.

3.1.2 Methods

The questionnaire was distributed to 4,973 residents over 15 years of age around Kadena Air Base, 2,005 around Futenma Air Station and 916 as control in Shimajiri district, southernmost part of the island where aircraft noise exposure is scarce. The total sample size is 7,894. Figure 3.1 illustrates the communities, as indicated by solid small circles, where questionnaires were distributed in the map of middle and south parts of Okinawa Island.

The respondents were sampled from pole book by means of the stratified random sampling method with respect to WECPNL. The number of residents living in the area of the highest noise exposure with WECPNL over 95 is so limited that the questionnaire was distributed to all the residents over 15 years.

The distribution was done from November 1996 to January 1997 by means of the leave-and-pick-up method and the answers were collected from November 1996 to March 1997. The valid answers are selected on the following

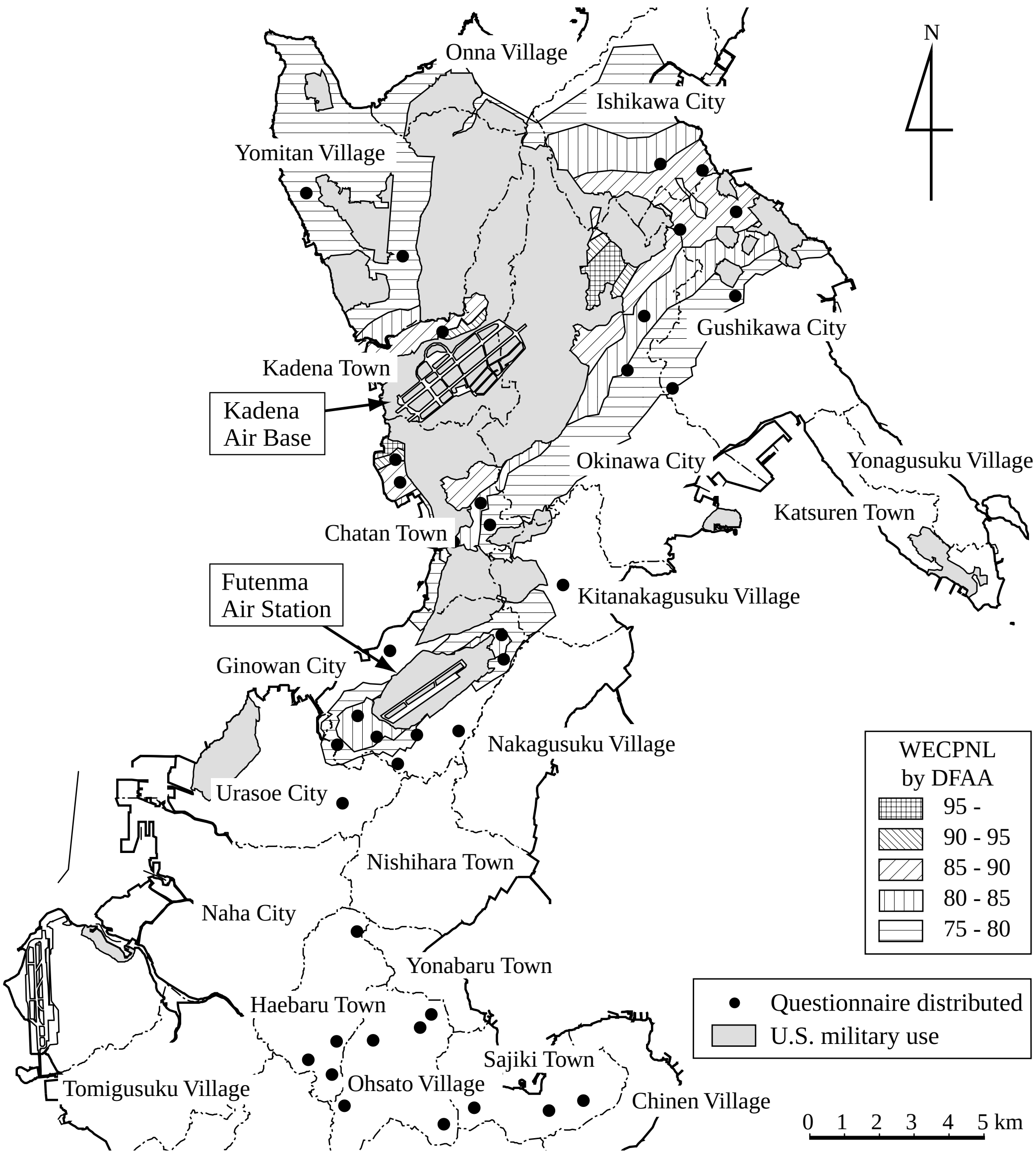


Figure 3.1 Investigated area around Kadena Air Base and Futenma Air Station.

Table 3.1 Number of distribution, answers, and valid answers

	Distribution	Answer	Valid answer	Rate of answer(%)	Rate of valid answer(%)
Kadena Air Base	4,973	3,961	3,560	79.7	71.6
Futenma Air Station	2,005	1,566	1,448	78.1	72.2
Control	916	794	685	86.7	74.8
Total	7,894	6,321	5,693	80.1	72.1

condition where in the individual answer respondent's age and sex are written as well as his or her address so as to identify the noise exposure in WECPNL and the respondent's age is 15 to 74 years. The number of valid answers obtained was 5,693. In Table 3.1 is shown the number of distribution, answers, and valid answers.

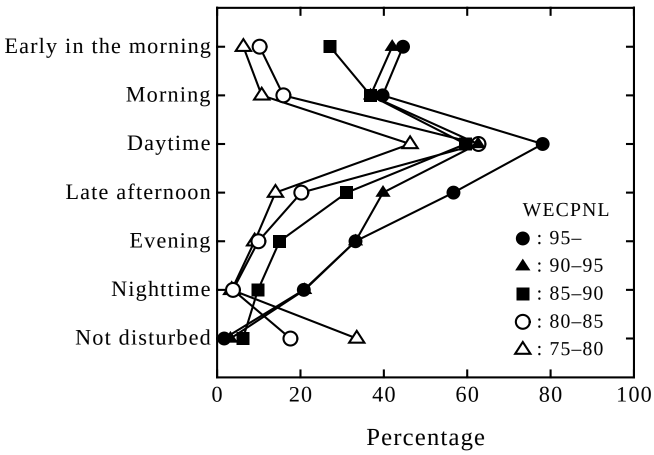
3.2 Results and discussions

3.2.1 Time in a day of disturbance and type of annoying noise

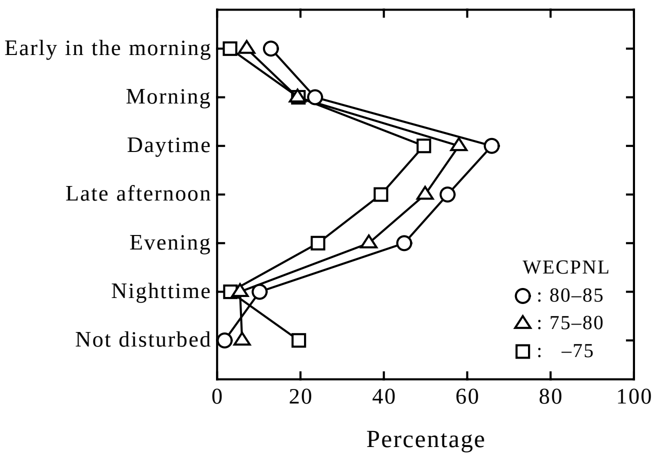
Answers to the questions (ref. Appendix A/ Question C5) asking about the time of a day when the residents are disturbed by the aircraft noise from the bases are analysed.

In Figure 3.2 are presented the time of a day the residents around Kadena Air Base (Figure 3.2(a)) and Futenma Air Station (Figure 3.2(b)) are disturbed much by the aircraft noise from the bases for the different levels of noise exposure. The most disturbing time is basically daytime as can be seen in the figure, 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 in the Kadena Air Base's surroundings complain disturbed.

In Figure 3.3 are plotted the percentage of the response on the type of the noises from the bases the respondents are particularly annoyed by (ref. Appendix A/ Question C6). The difference between the two airfields is shown in the rate of helicopter noise which about 60% of the population around Futenma Air Station report annoying, while those around Kadena Air Base report much less except in the area of WECPNL of 75. Around Kadena Air Base the noise is basically due to jet aircraft. As will be described below the difference of the type of aircraft used could be a factor of the difference in the response rates between the two airfields.

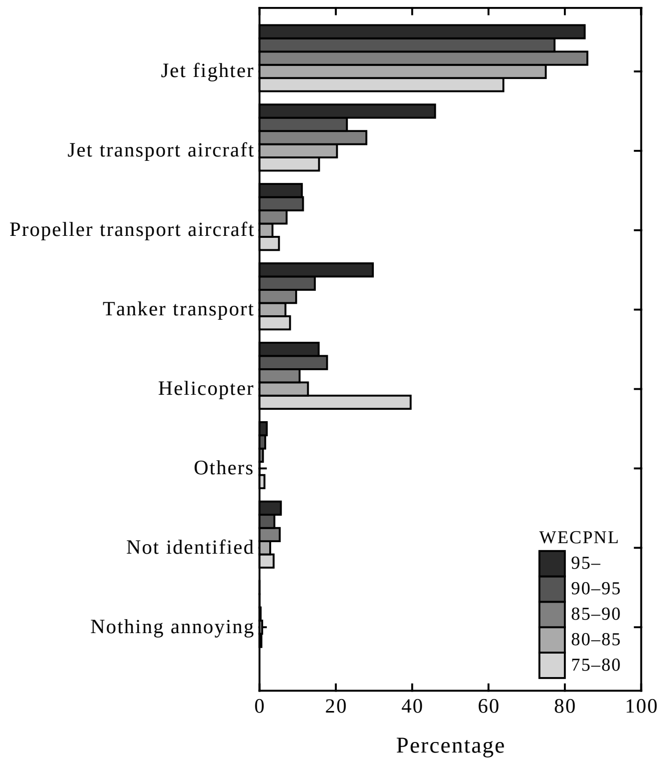


(a) Around Kadena Air Base.

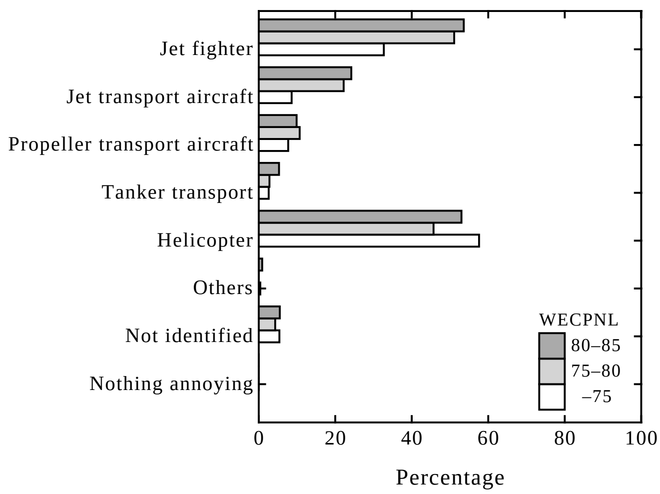


(b) Around Futenma Air Station.

Figure 3.2 Percentage of the response on the time of a day of disturbance in different WECPNL groups.



(a) Around Kadena Air Base.



(b) Around Futenma Air Station.

Figure 3.3 Percentage of the response on the type of the noises from the bases the respondents are particularly annoyed by.

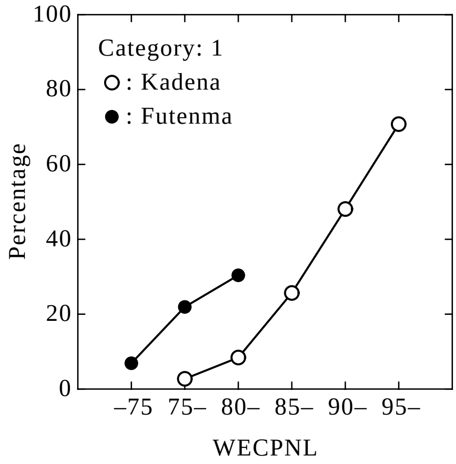


Figure 3.4 Percentage of the highly annoyed *vs.* WECPNL.

Category: "1. Very annoying."

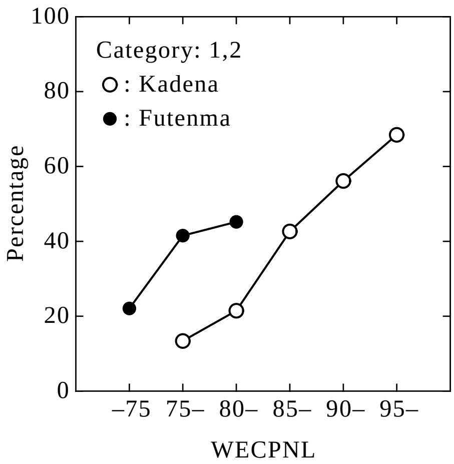
3.2.2 Annoyance and its related reactions and disturbance of daily activities

This section deals with annoyance reaction to the aircraft noise, its related reactions and disturbance of daily activities. The question as to annoyance is shown in Appendix A/ Question C1, and those of the related reactions and disturbance of daily activities are listed in Appendix A/ Question C4.

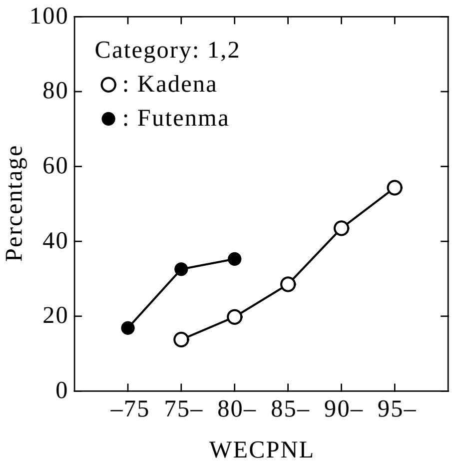
In Figure 3.4 is plotted the percentage of the highly annoyed as a function of WECPNL. Here "highly annoyed" response means answers marking "very annoying." In the figures open circles and solid ones indicate the percentages of residents around Futenma and Kadena airfields, respectively.

As can be seen in the figure, very clear dose-response relationships are found in the annoyance reaction. It is not surprising if one takes the questions and the wide range of the levels of aircraft noise exposure in the study area into account. The percentage of the "highly annoyed" starts increasing from the value of WECPNL of 75, gets higher as the level of noise exposure is high and reaches about 70% at WECPNL of over 95.

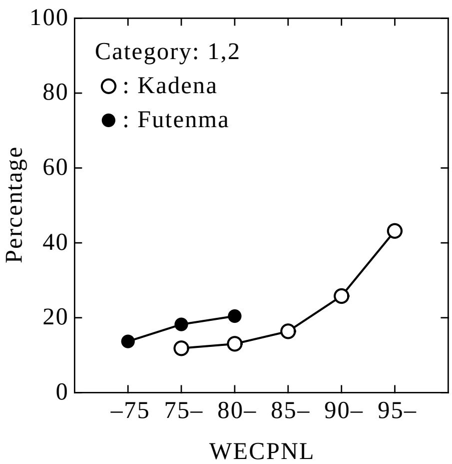
In Figure 3.5 are shown the annoyance related reactions such as "vexation (in local dialect)," "fear of aircraft noise" and "fear of the memory of war." The response is the answers to the alternatives of "1. always," and "2. often." In Figure 3.6 are shown other annoyance related reactions expressed as anxiety of aircraft crash, drop of objects, explosion and involvement in war. The trends of the dose-response relationships found in the figures are more or



(a) Vexation.



(b) Fear of aircraft noise.



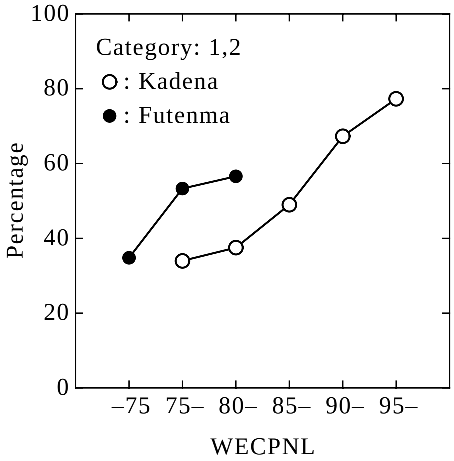
(c) Fear of the memory of war.

Figure 3.5 Percentage of the annoyance related reactions *vs.* WECPNL.

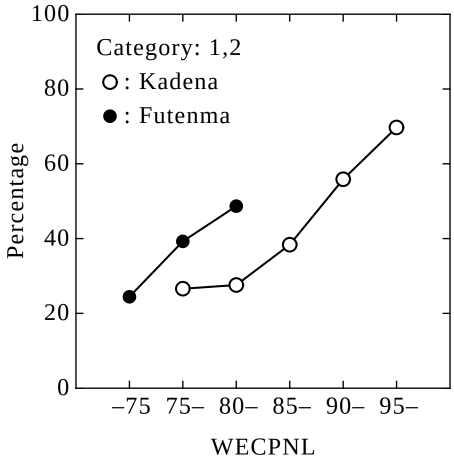
Category: "1. Always." "2. Often."

less the same as that of annoyance reaction.

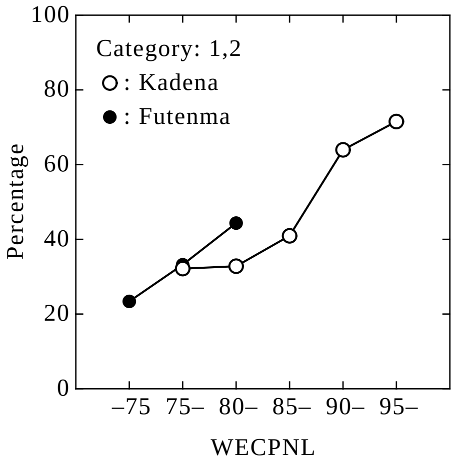
The results shown in the figures manifest the prominent difference in the curves between the two airfields. Response of the residents around Futenma Air Station is higher as far as the present questionnaire items are concerned. If one shifts the curves of Futenma toward right by about 5 to 10 units of WECPNL, then they approximately lie upon the curves of Kadena. The cause of the difference, which is not small amount, is not very clear, but two theories



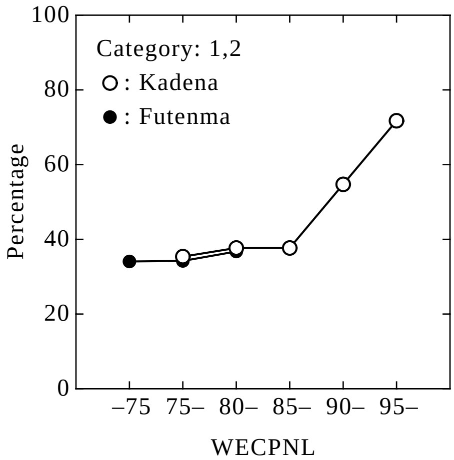
(a) Anxiety of aircraft crash.



(b) Anxiety of drop of objects.



(c) Anxiety of explosion.



(d) Anxiety of involvement in war.

Figure 3.6 Percentage of the annoyance related reactions annoyance expressed as anxiety *vs.* WECPNL.

Category: "1. Very much." " 2. Pretty much."

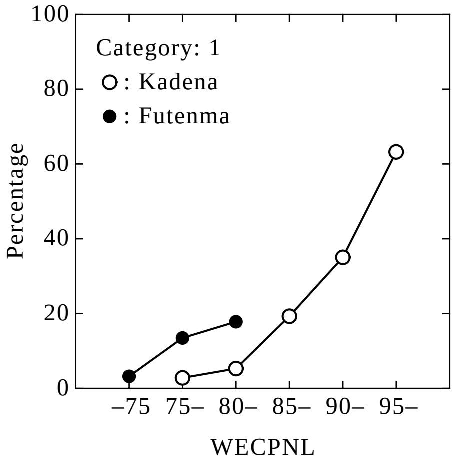
can be raised. (1) The values of WECPNL having been designated in 1978 by the DFAA do not represent the recent state of the noise exposure around the airfields. (2) As a rating scale, WECPNL does not apply to the variety of aircraft noise patterns. Although the question must be open to answer under the situation of lack of sufficient information, it should be pointed out that the Futenma Air Station, the U.S. Marines stations at, is used by helicopters much more than the Kadena U.S. Air Force Base. As a result, the noise around Futenma airfield is of comparatively low level with longer duration, which makes it difficult for the automated measurement devices installed around the airfield to identify aircraft noise from other environmental noises and thus results in missing to record the lower level of noise.

In Figure 3.7 are shown the responses regarding the interference with listening/communication. As is shown in the figure, the rates of the disturbed always in TV/radio listening, speech communication and telephone use increase as functions of WECPNL. The percentage of the respondents complaining their TV listening are disturbed by aircraft noise, for example, begins to increase at WECPNL of 70 or 75 and gets higher as the level of noise exposure increases reaching about 60% at WECPNL of over 95. The quite clear dose-response relationships between the rates and WECPNL are found as can be seen in the figure. In the areas where aircraft noise exposure expressed in WECPNL is from 90 to 95, the rate of the disturbed always is about 40%. In the areas where WECPNL is over 95, the rate of the disturbed always is over 60%. From the figure it can be said that in the vicinity of Kadena Air Base with WECPNL of 90 and 95, the residents find the interference with communication pretty serious due to aircraft noise.

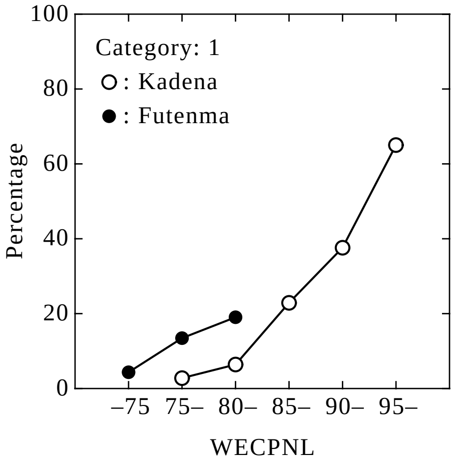
In Figure 3.8 are shown the responses regarding the disturbance of daily activities and rest. The response rates regarding the disturbance of daily activities and rest are not high in the area with WECPNL below 85 but they increase with WECPNL in the region of over 90.

3.2.3 Sleep disorders

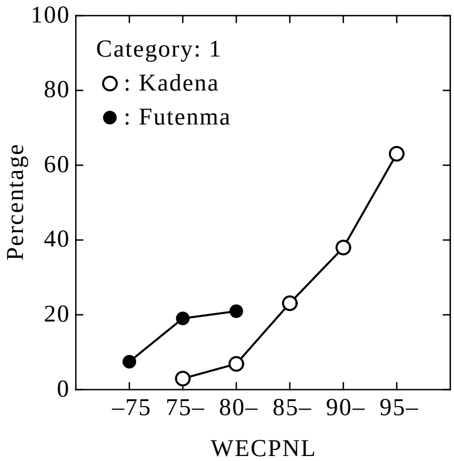
Answers regarding sleep disorders are analysed in relation to the level of noise exposure. The residents answered four questions regarding sleep disorders listed from Appendix A/ Questions D2 to D5. The questions did not specify the sleep disturbance as caused by the aircraft noise. A rating scale with five categories was prepared for these questions and the respondents were required to answer by putting a circle on one of five alternatives.



(a) Interference with conversation.



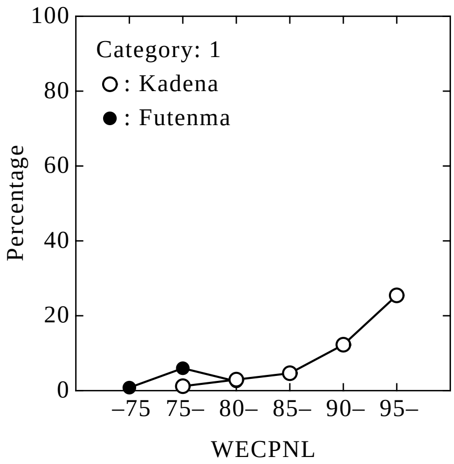
(b) Interference with telephone use.



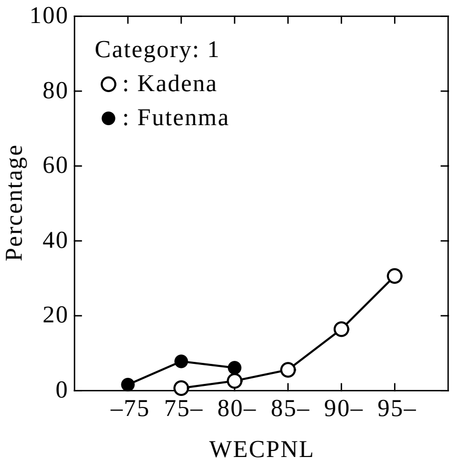
(c) Interference with listening to TV etc.

Figure 3.7 Percentage of the response regarding the interference with listening/communication *vs.* WECPNL.

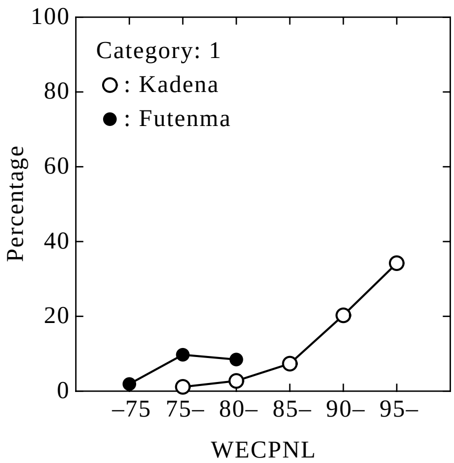
Category: "1. Always."



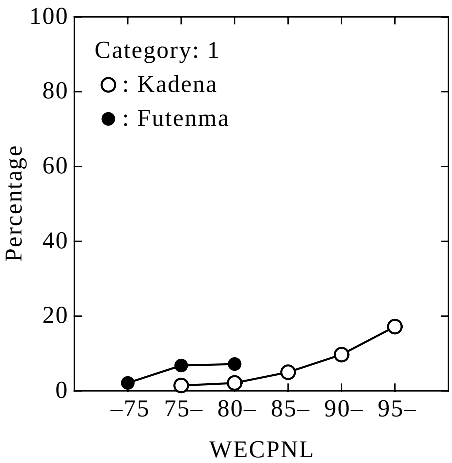
(a) Interference with work.



(b) Interruption of reading and thinking.



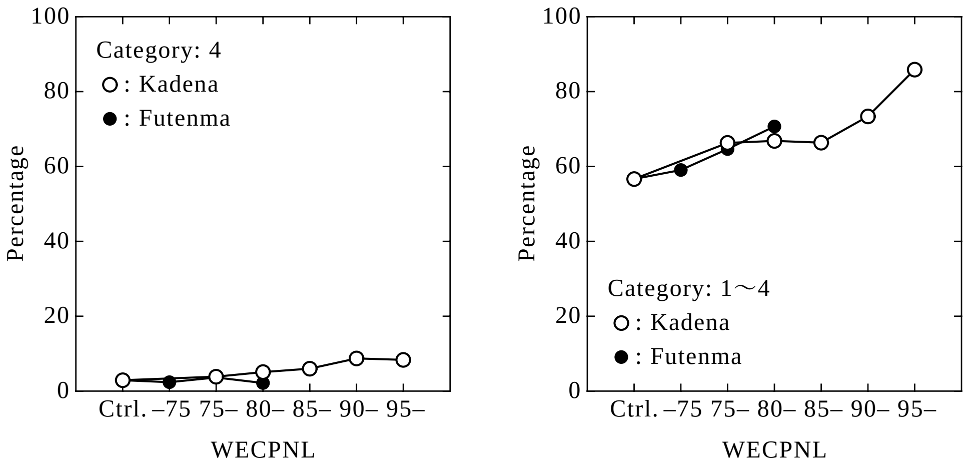
(c) Disturbance of rest.



(d) Interruption of watching TV.

Figure 3.8 Percentage of the response regarding the disturbance of daily activities and rest *vs.* WECPNL.

Category: "1. Always."



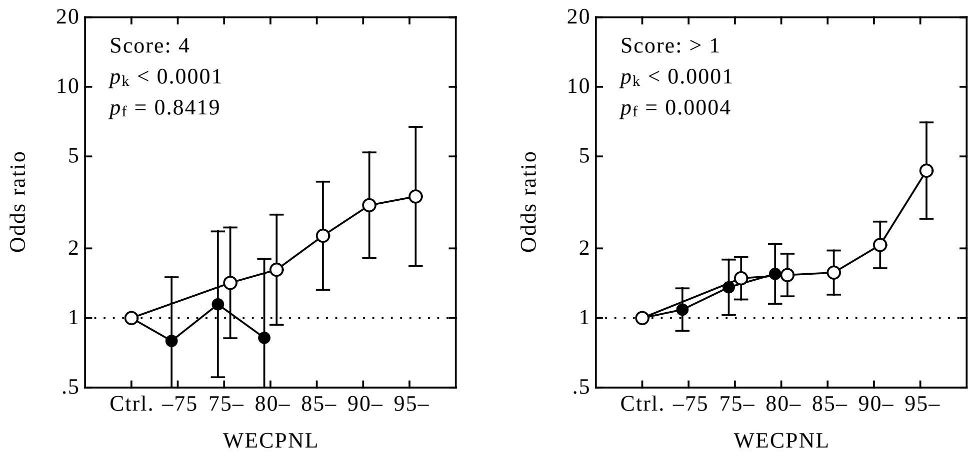
(a) Once or more a week: Score = 4 (b) Once or more a month: Score ≥ 1

Figure 3.9 Percentage of the scores on the sleep disorders *vs.* WECPNL.

Two types of scores indicating the degree of the sleep disorder are calculated based on the answers to the four questions as follows: The score "once or more a week" is the number of questions answered for the alternative 1 or 2; and the score "once or more a month" for 1, 2 or 3. Either score has the range from zero to four. It can be said that higher score indicates higher degree of sleep disorder.

In Figure 3.9 are shown the percentages of the scores on the sleep disorders as a function of noise exposure expressed in WECPNL and the control. Note the percentage is adjusted for the distribution of age and sex of the control. It is shown in the figures that the rate of the respondents with high score increases as WECPNL becomes higher, thus the clear dose-response relationships between the scores of sleep disorder and the level of noise exposure are found. It is also shown that about 60% of the control complain sleep disorder with the frequency of once or more a month, which suggests that people may have experience of sleep disorder to such a degree in general. This fact requires examining how the rate of sleep disorder among exposure groups increases in comparison with that of the control.

For this purpose, logistic regression model is applied with the independent variables of WECPNL, age, sex, occupation and the interaction of age and sex. In Figure 3.10 are shown the results of the analyses. The abscissa and ordinate of each figure indicate the noise exposure expressed in WECPNL and the odds ratio of the respondents, respectively. Vertical bars in the figures



(a) Once or more a week: Score = 4

(b) Once or more a month: Score ≥ 1

Figure 3.10 Odds ratio of the scores on the sleep disorders *vs.* WECPNL.

○ : Around Kadena Air Base. ● : Around Futenma Air Station.
p_k and p_f are the significance probabilities of trend test around Kadena Air Base and Futenma Air Station, respectively.

show the 95% confidence limits of odds ratios. In the figures p_k and p_f indicate the significance probabilities of trend test for Kadena Air Base and Futenma Air Station, respectively.

Clear dose-response relationships are found in all the figures, which are supported also by the result that the significance probability is less than 0.0001. The odds ratios of the group of highest noise exposure are 3.0 and 4.8 where that of the control group is one, so as to suggest that the residents exposed to high level of aircraft noise suffer from serious sleep disorder.

Lower odds ratio found in Figure 3.10(a) might be attributed to less frequent flights in the night time around Futenma Air Station than around Kadena Air Base as shown in Figure 3.2. Moreover, in the case of "once or more a month", significant differences from the odds ratio of the control are found even in lower exposed groups. These results imply that the sleep disorder of comparatively low degree occurs among residents even in areas of lower noise exposure.

3.2.4 Evaluation of the residential environment

Answers to the questions regarding the quality of residential environment evaluated by the residents are analysed in relation to the level of noise

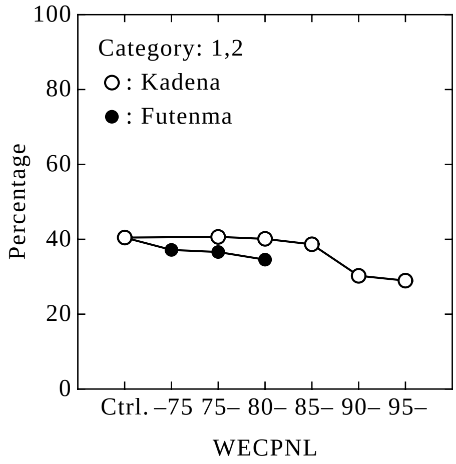


Figure 3.11 Percentage of the responses on the satisfaction with life *vs.* WECPNL. Category: "1. Highly satisfied." "2. Satisfied."

exposure. The questions ask if they are satisfied with their life (ref. Appendix A/ Question A1), if they are happy with their place of residence (ref. Appendix A/ Question B1), if they intend to live at the present place permanently (ref. Appendix A/ Question B2).

In Figure 3.11 is shown the percentage of the responses on satisfaction with life for different levels of noise exposure expressed in WECPNL and of the control. Note that the response rate is adjusted so that every cell of age and sex matrix in each class of WECPNL has the same percentage of the respondents as the total respondents of the noise exposed areas. The percentages of the respondents who expressed their satisfaction with life by putting a circle on the answer item of 1 or 2 are about 40 in the control group and the noise exposed groups of WECPNL less than 90. However, the rate presents a sharp decrease to be about 30% for the noise exposed groups with WECPNL of 90 and over 95. Note that WECPNL 90– in the figure indicates the noise exposure is from 90 inclusive to 95 exclusive of WECPNL.

In Figures 3.12 is shown the percentage of the response to the question asking about the neighbourhood satisfaction. The rate of those finding their neighbourhood more or less satisfying (Figure 3.12(b)) is about 80% in the control group which decreases as the level of noise exposure is higher and becomes about 30 in the highest noise exposure group with WECPNL of 95. Clearly the rate of those who are dissatisfied with the neighbourhood increases with WECPNL.

The result of the logistic regression analysis regarding neighbourhood

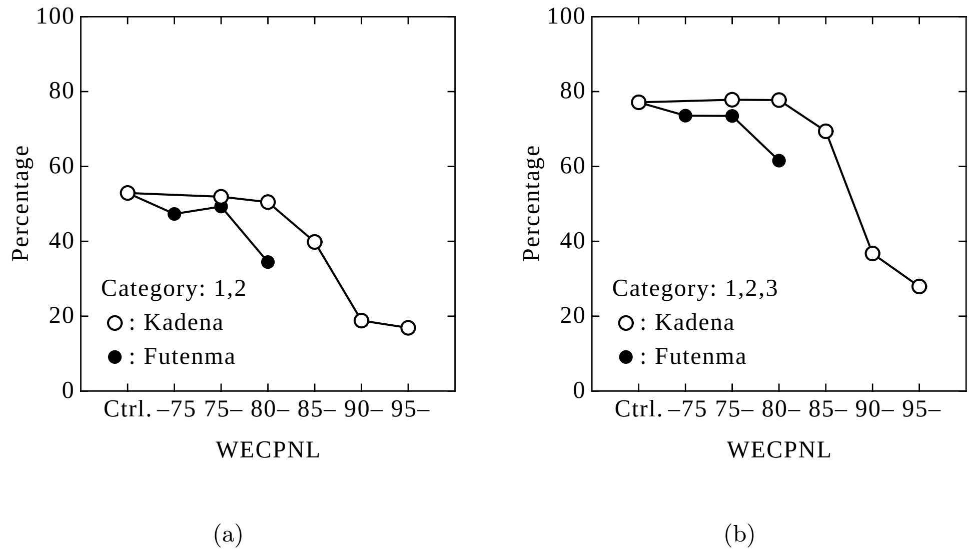


Figure 3.12 Percentage of the responses on the neighbourhood satisfaction *vs.* WECPNL.

(a) Category: "1. Very good to live in." "2. Good to live in."
(b) Category: "1. Very good to live in." "2. Good to live in." "3. Rather good to live in. "

satisfaction is presented in Figure 3.13. The figure illustrates clear dose-response relationship between the odds ratio regarding neighbourhood satisfaction and the level of noise exposure. The decreasing trend of odds ratio is highly significant with the significance level of 0.001 according to the trend test. It should be noted that the odds ratios of the groups with WECPNL of 90 and 95 are very low.

In Figure 3.14 is shown the percentage of the responses to the question asking about the intention of permanent residence. One can see from the figure that the rate of those having marked the answer item 1 decreases as the level of noise exposure increases. The percentage of those who marked the answer items 1 and 2 decreases in the areas with WECPNL 90 and over 95.

In Figure 3.15 is shown the result of logistic regression analysis regarding the intention of permanent residence. The odds ratio of the respondents who expressed their intention of permanent residence by marking the answer item 1 is plotted against WECPNL. Clear and linear dose-response relationship is shown in the figure. The odds ratio of the group of highest noise exposure is as low as about 0.3.

One can see from the figures that there exists a prominent difference in

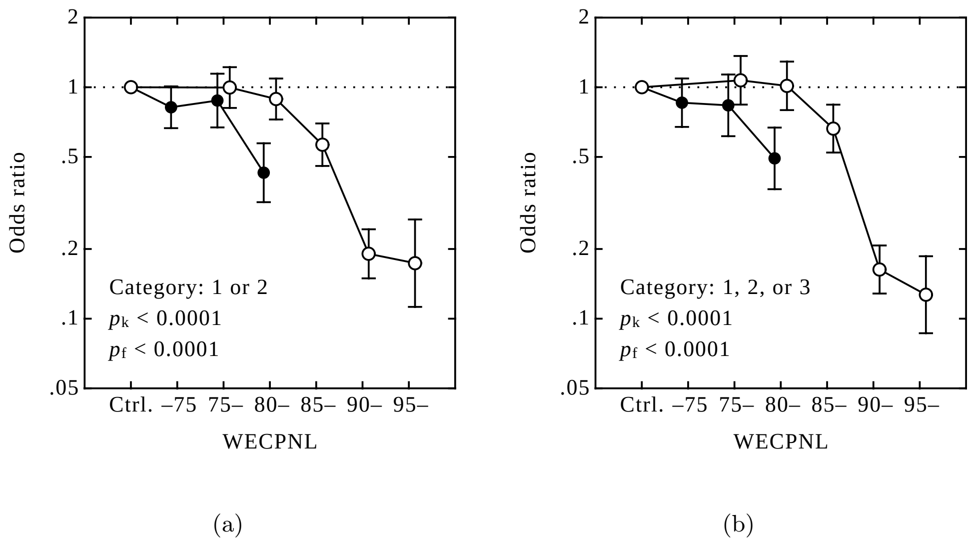
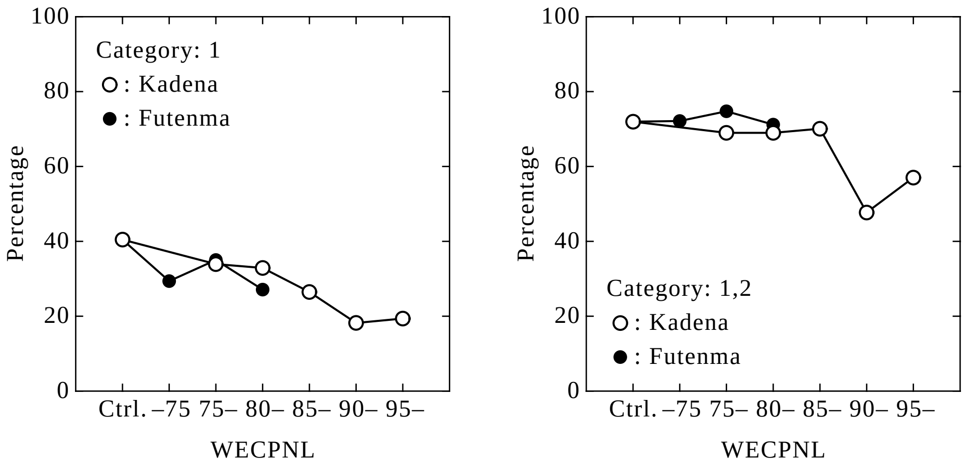


Figure 3.13 Odds ratio of the responses on the neighbourhood satisfaction *vs.* WECPNL.

○ : Around Kadena Air Base. ● : Around Futenma Air Station.
p_{k} and p_{f} are the significance probabilities of trend test around Kadena Air Base and Futenma Air Station, respectively.

(a) Category: "1. Very good to live in." "2. Good to live in."
(b) Category: "1. Very good to live in." "2. Good to live in." "3. Rather good to live in. "



(a) (b)

Figure 3.14 Percentage of the responses on the intention of permanent residence *vs.* WECPNL.

(a) Category: "1. I want to live here throughout my life."
(b) Category: "1. I want to live here throughout my life." "2. I do not want to move out particularly."

the residents' responses between the two bases. The reason of the difference is not very clear but the difference in the state and type of noise exposure could be a factor affecting the residents responses as was discussed in the section 3.2.2. Or one might find some other factors around Futenma Air Station that could give the residents' attitudes negative influence toward the neighbourhood satisfaction and judgement of the quality of area for residence.

From what has been discussed above it would be safe to say that the satisfaction with life reduces in the groups of WECPNL over 90, the neighbourhood satisfaction does in the groups of WECPNL over 85 and the intention of permanent residence does in the groups of WECPNL over 75. The reduction is very likely due to the aircraft noise exposure from Kadena Air Base and Futenma Air Station.

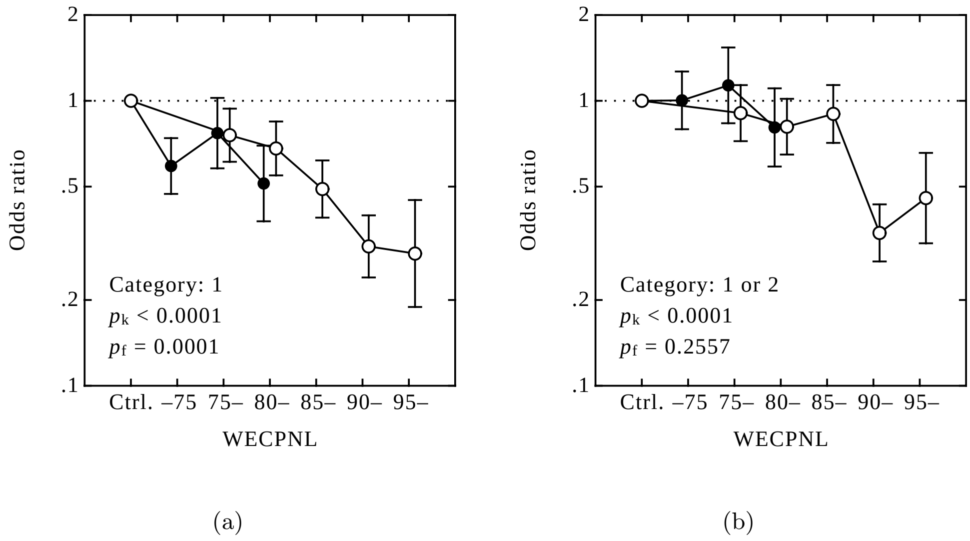


Figure 3.15 Odds ratio of the responses on the intention of permanent residence *vs.* WECPNL.

○ : Around Kadena Air Base. ● : Around Futenma Air Station.
p_k and p_f are the significance probabilities of trend test around Kadena Air Base and Futenma Air Station, respectively.

(a) Category: "1. I want to live here throughout my life."
(b) Category: "1. I want to live here throughout my life." "2. I do not want to move out particularly."

Chapter 4

Residential sound insulation and community response

In the communities surrounding Kadena Air Base and Futenma Air Station, the Japanese government has undertaken sound-insulation programme to mitigate aircraft noise in compliance with an act pertaining to improvements of residential environments adjacent to defence facilities. Homes located in areas where noise contours designated by the DFAA are 75 or higher are eligible for sound insulation under this act. Sound insulation measures to be executed on demand of the residents include sound-proofing of windows and doors, ceiling and wall insulation, and air conditioning. The number of rooms to be sound insulated in a home depends upon the condition of household such as the number of family members.

In this chapter the relationship between residents' responses regarding reported annoyance, interference with conversation, sleep disorder and neighbourhood satisfaction, and the implementation of sound insulation is analysed. The substantial effectiveness of sound insulation against aircraft noise in real-life situations is also discussed.

4.1 Methods

The questionnaire includes questions on the implementation and performance of sound insulation (ref. Appendix A/ Question C8.) For those respondents living in sound insulated houses, the performance of sound insulation was addressed, based on a rating scale with five categories. In addition, the degree of satisfaction regarding the sound insulation was addressed on a rating scale with seven categories.

As the questionnaire items regarding the noise effects such as reported annoyance, communication disturbance, sleep disorder and neighbourhood satisfaction are used for analysis.

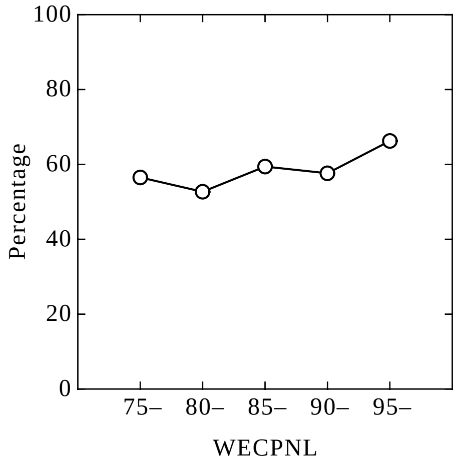


Figure 4.1 Percentage of the response on the implementation of sound insulation *vs.* WECPNL.

4.2 Results

The response rate regarding the implementation of sound insulation supported by the government is presented for the different ranks of noise exposure in Figure 4.1. Contrary to general expectation, the rates are around 60% regardless of the WECPNL rank.

Figure 4.2 shows the rates of the answers in the rating scale to the question regarding the evaluation of the performance of sound insulation as a function of WECPNL. Although the negative evaluation of the performance sound insulation is relatively low to be about 20% in the group with WECPNL of 75, the rate increases as WECPNL increases and reaches up to about 70% in the group with WECPNL of 95.

The response as to the degree of satisfaction with sound insulation is shown in Figure 4.3 as a function of WECPNL. One can see in the figure about 10% of residents with WECPNL of 75 are more or less dissatisfied. The response rate of the satisfied was about 60%. With an increase in the WECPNL, the rate of dissatisfied residents increases and reaches up to about 60% in the group with WECPNL of 95.

The results shown above suggest that damages to the residents caused by aircraft noise might be mitigated by the implementation of sound insulation at least to some extent. The thesis could be examined by comparing the differences of the positive response rates regarding noise effects between sound insulated population and the rest.

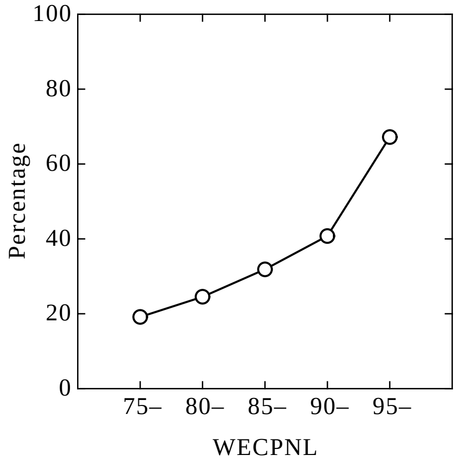


Figure 4.2 Percentage of the response on the evaluation of the performance of sound insulation *vs.* WECPNL.

Category: “4. Not much working.” “5. Not working at all.”

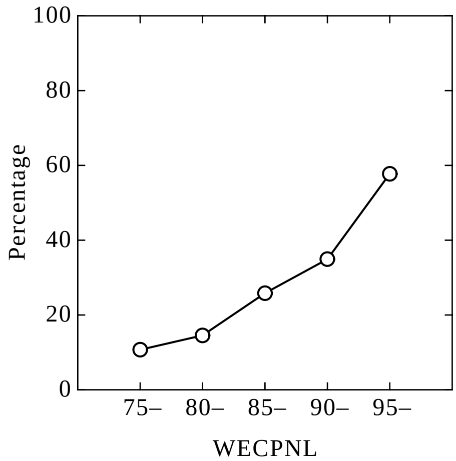


Figure 4.3 Percentage of the response on the satisfaction with sound insulation *vs.* WECPNL.

Category: “6. Dissatisfied.” “7. Very much dissatisfied.”

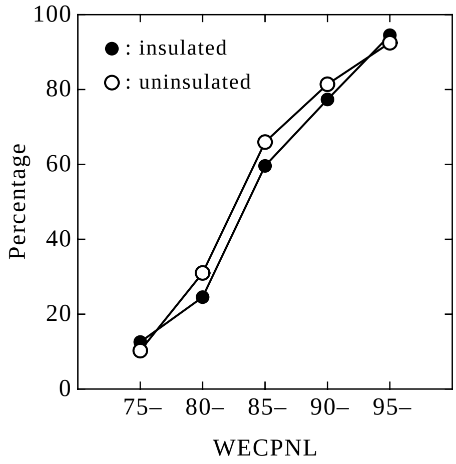


Figure 4.4 Percentage of the response on the annoyance *vs.* WECPNL in relation to sound insulation.

Category: "1. Very annoying." "2. Pretty annoying."

The population are divided into two groups; those whose homes are sound insulated and those whose homes are not. Figure 4.4 illustrates the annoyance reaction rate of those answering the items "very annoying" and "pretty annoying" as a function of WECPNL. Due to the differences in the response rates found between around the two airfields, the response rates are shown as to Kadena Air Base only in this chapter. Solid circles in the figure indicate rates of the population living in the homes sound insulated and open ones not insulated. The rates are adjusted for the different distributions of age and sex between the populations in the areas with different ranks of WECPNL. Surprisingly, the dose-response relationships for both populations manifest very good agreement throughout the range of the level of noise exposure. Reported annoyance, however, might not reflect the annoyance the residents experience inside their homes, although the question asks about the annoyance they experience while staying in the buildings. Doubt cannot be swept out completely, however, if they answered about the overall annoyance impression of the aircraft noise exposure regardless of outside or inside their homes.

In Figure 4.5 is shown the response rate marking the alternative of "always" or "often" concerning the interference with conversation inside the home as a representative of communication disturbance. The response rate of sleep disorder "once or more a month" is plotted against WECPNL in

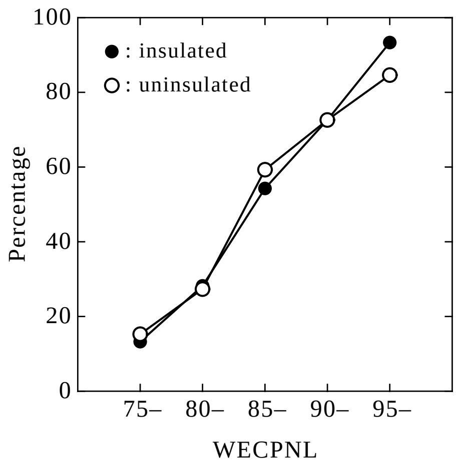


Figure 4.5 Percentage of the response on the interference with conversation *vs.* WECPNL in relation to sound insulation.

Category: “1. Always.” “2. Often.”

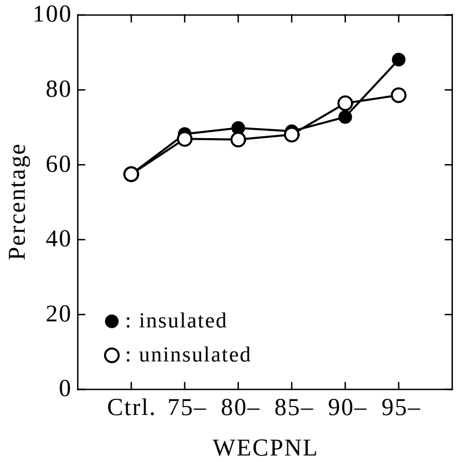


Figure 4.6 Percentage of the scores on the sleep disorders “Once or more a month” *vs.* WECPNL in relation to sound insulation.

Figure 4.6. In both figures there cannot be found any significant difference in the dose-response relationships between the two groups of residents. Since communication disturbance and sleep disorder are considered to occur inside the home basically, the results presented in Figures 4.4 to 4.6 cast a strong doubt about the effectiveness of sound insulation.

In Figure 4.7 is shown the response rates of the both groups concerning neighbourhood satisfaction of those marking the items “very good,” “good,” and “rather good” as a function of WECPNL. In the case of neighbourhood

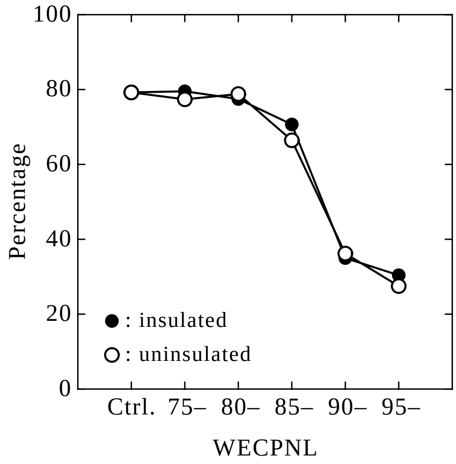


Figure 4.7 Percentage of the responses on the neighbourhood satisfaction *vs.* WECPNL in relation to sound insulation.

Category: “1. Very good to live in.” “2. Good to live in.” “3. Rather good to live in. ”

satisfaction as well is found no difference between the two groups of residents. The fact suggests that the quality of life environment is not improved by the implementation of residential sound insulation.

In order to test the difference in the responses between the two populations, logistic regression analysis is applied with the independent variables of WECPNL, age, sex, sound insulation, occupation, interaction between age and sex and interaction between implementation of sound insulation and WECPNL. According to the results of the analysis, no significant difference is found between the two groups of residents for any items of noise effect, or no contribution of sound insulation is recognised.

4.3 Discussions

4.3.1 Community response as to sound insulation

Despite the evaluation and satisfaction of sound insulation reported by the residents or the physical performance of the sound insulation implemented by the DFAA, the mitigation of the impact of noise exposure on the residents are not at all found according to the results of present survey as presented above. The result is accordant with that reported by Fidell *et al.*(1991) who conducted a social survey to compare the prevalence of noise-induced annoyance in two residential populations with similar aircraft noise exposure in the vicinity of Hartsfield International Airport. One population was composed of the residents of homes that had been sound insulated and the other population was composed of the residents of homes that had not been sound insulated. They found no clear benefit of noise insulation in terms of lowered prevalence of annoyance to aircraft noise exposure.

4.3.2 Physical performance of sound insulation

The sound insulation programme carried out by the DFAA aims to achieve the transmission loss, TL, of 20 dB for the residential homes in the area with WECPNL of 75 to 80 and TL of 25 dB for those in the area with WECPNL of over 80. The noise reduction measured as the difference of sound levels between inside and outside the residential homes which are sound insulated by the DFAA around Kadena Air Base may be considered to be about 30 dB on the basis of the measurements conducted in two ways. In one way of measurement, broadband noise is generated by a loud speaker set outside of a residential house and octave band levels are measured inside of the house. A record of measurement conducted for a most properly sound insulated house indicates the transmission loss is 30 to 50 dB. In another way of measurement was undertaken as on-the-spot inspection of a civil suit case where 906 plaintiffs demanded restriction of nighttime flights and compensation for the damages caused by aircraft noise from Kadena Air Base. In that case both sound levels inside and outside of residential houses are recorded and the difference of the two sound levels is calculated. The result tells the difference is 26 to 29 dB.

The performance of sound insulation, however, is reported to be diverse one home after another and one flight after another. It depends on many factors such as the construction skill, the structural strength and type of the building, the fight path relative to the home, the type of aircraft, etc.(Sharp; 1994) The results of the measurements around Osaka International Airport for over 1,000 homes show that the mean TL of the homes for the same type of aircraft and the flight path are basically constant over the years of measurements from 1975 to 1978 with standard deviations from 2.6 to 4.6 dB. The standard deviations of the measurements are considerable taking the fact that they are of the same types of aircraft flying the same courses of flight path into account (Sato; 1979).

Thus it seems fairly difficult to determine by a simple figure of transmission loss of the buildings the physical performance of sound insulation against aircraft noise.

Table 4.1 Percentage of the response regarding the hours in a day when the respondents close windows

WECPNL	Percentage of the response regarding the hours in a day when the respondents close windows of the room sound insulated (%)				
	Mostly open	< 8 hrs.	8 – 16 hrs.	≥ 16 hrs.	Mostly closed
75–80	31.4	10.7	35.5	10.7	11.8
80–85	34.6	12.8	31.8	11.1	9.7
85–90	33.3	9.3	33.1	11.7	12.6
90–95	31.1	10.8	29.1	12.0	17.1
95–	38.4	7.1	36.4	8.1	10.1
Total	33.0	10.7	32.8	11.1	12.4

4.3.3 Factors detracting the performance of sound insulation

Two factors might be considered which detract the performance of sound insulation in the reality of everyday life. One is window open and the other is the mixture of insulated and uninsulated rooms existing in a home.

Table 4.1 shows the answers of residents to the question asking the hours in a day when they close windows. In the table one can see 40 to 50% of residents close the windows less than 8 hours a day and only about 20% residents close windows more than 16 hours a day. The result presented in the table is understandable because in the semitropical climate as in Okinawa people enjoy breeze in the building in the long summer. With the windows closed they need to operate costly air conditioners all day long for more than six months a year. Imagine the situation. While aircraft noise is off they enjoy quiet and peaceful soundscapes and the noise intrudes at once from time to time. Thus most of residents keep open the windows in the daytime.

From the table it can be seen that 50 to 60% of residents keep windows closed over 8 hours a day, which suggests that more than a half of the population close the windows when they go to bed. If so, it is a kind of mistery that no difference was found in sleep disorder between the two residents of homes with and without sound insulation.

The DFAA's sound insulation programme does not necessarily implement all the rooms of a home. As a result some rooms, say bedrooms and/or living rooms, are primarily insulated and other rooms, say dining room and/or kitchen, are not insulated. The acoustic performance of sound insulation is measured with windows tightly closed and doors between rooms locked up. In daily life, however, it is too unrealistic to force the residents to shut the door between the living room and the dining room every time they get in and out, and moreover to keep tight lock of the door.

They may even keep door of the bedroom open while they are in bed. The performance of sound insulation in this case will be the same as that the TL of ordinary sound insulation without the programme of the DFAA.

4.4 Conclusion

It is clear that the implementation of sound insulation has not led to the responses toward desirable direction regarding both sleep disturbance and interference with television and telephone use regardless of WECPNL grouping. It is very likely that sound insulation does not, in actual context, mitigate some effects of noise in the daily lives of residents — the aforementioned positive responses reflecting its physical performance notwithstanding.

References

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Sato K (1979), On the valuation of noise in the soundproofing houses around Osaka International Airport, Architectural Acoustics and Noise Control, 27/July, 57–62.

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Chapter 5

Effects on children

5.1 Preschool children's misbehaviours

Children in their nature demonstrate misbehaviours more or less. But some factors in their living environment can raise the frequency of misbehaviours. Hattori *et al.* (1986) pointed out aircraft noise was one of the factors reporting that the children around Komatsu Airport in Ishikawa Prefecture showed significantly higher rate of misbehaviours than those of the control.

In this section are reported the results of the survey conducted around the U.S. airfields in Okinawa with respect to children's misbehaviors and the results of their analysis in terms of aircraft noise exposure.

5.1.1 Method

The questionnaire on children's misbehaviour is based on that developed by Kodama *et al.* (1982). It consists of 92 questions regarding "biological function," "social standard," "physical constitution," "movement habit" and "character." The questionnaires were distributed in nursery schools and kindergartens located in the areas with WECPNL over 75 around Kadena Air Base and Futenma Air Station from June to September 1996. The children living around Kadena Air Base were divided into four groups according to WECPNL at their residences of under 75, 75, 80, and over 85 and those around Futenma Air Station into three groups of WECPNL of under 75, 75 and 80.

The subjects were male and female preschool children, 3 to 6 years of age, whose parents and caregivers or teachers answered the questions. The respondents were only explained that the survey was conducted for the sake of the health care of preschool children and were not informed that the survey was a part of the investigation on the effects of aircraft noise. The total number of

Table 5.1 The number of valid answers stratified by WECPNL and age

Age	Control	WECPNL								Total	
		–75		75–80		80–85		85–			
		K	F	K	F	K	F	K	F	K	F
3	48	15	70	43	36	35	20	60	0	153	126
4	79	30	109	88	61	71	27	91	0	280	197
5	106	32	77	127	117	104	65	113	0	376	259
6	75	9	28	37	39	28	16	32	0	106	83
Total	308	86	284	295	253	238	128	296	0	915	665

K: around Kadena Air Base, F: around Futenma Air Station

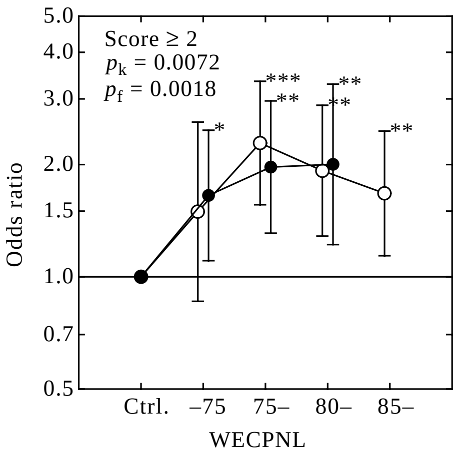
distribution was 2,391 among which the numbers of valid answers were 1,580 from the noise-exposed groups, 915 around Kadena Air Base and 665 around Futenma Air Station, and 308 from the control group. In this survey the control was taken from the southern part of the island where aircraft noise exposure was scarce. Table 5.1 shows the numbers of valid answers stratified by WECPNL and age.

5.1.2 Results and discussion

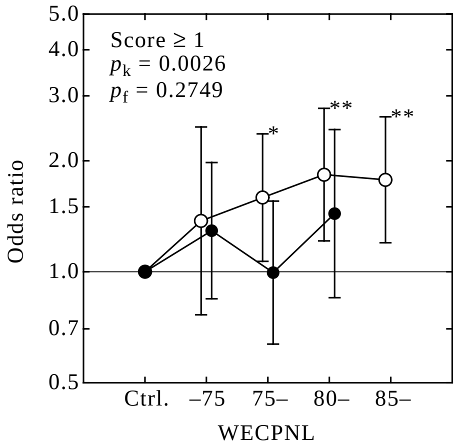
The answers are clustered by means of the cluster analysis into 17 clusters. These clusters are named (1) cold symptoms, (2) skin problem, (3) headache-stomachache, (4) excretory problem, (5) language problem, (6) eating problem, (7) habitual problem A, (8) habitual problem B, (9) injury-sickness, (10) interpersonal tension, (11) passive inclination, (12) fearsome inclination, (13) fatigue inclination, (14) adherence-anxiety, (15) emotional instability, (16) aggressiveness-disobedience, and (17) complaint-discontent.

Multiple logistic regression analysis is conducted taking the each of cluster score as the dependent variable 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 the independent variables. As is shown in Figure 5.1, it is found that the clusters showing the linear relation 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.

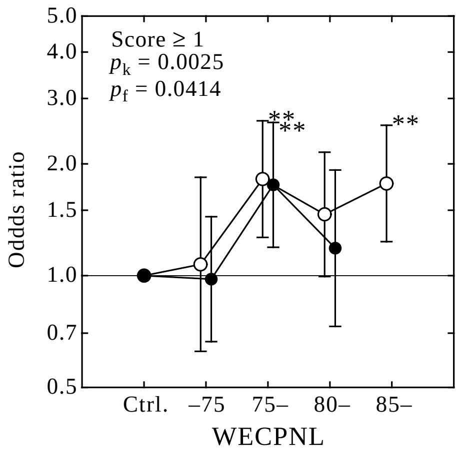
To put the above tersely, children living around airfields and habitually exposed to aircraft noise are likely to have the following inclinations: they easily catch cold, have a poor appetite, and take a long time to make friends.



(a) Cold symptoms.



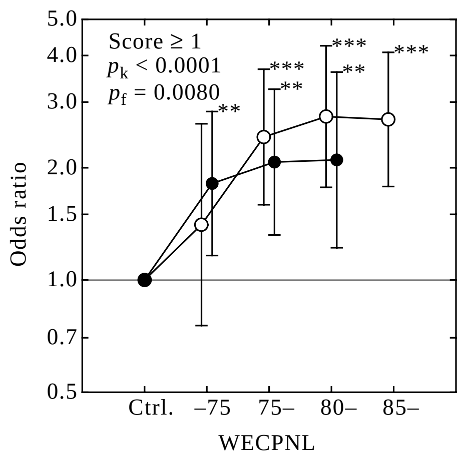
(b) Headache-stomachache.



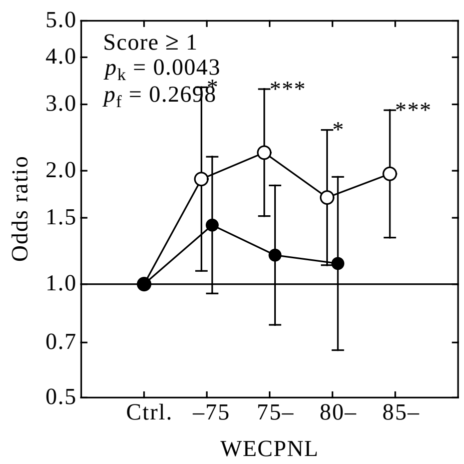
(c) Eating problem.

Figure 5.1 Odds ratio *vs.* WECPNL on the clusters.

Open circles and solid circles show the odds ratios with the 95% confidence intervals around Kadena Air Base and Futenma Air Station, respectively. The symbols p_k and p_f show the significance probabilities of the trend test. The asterisks show the significance probabilities of odds ratios to the control group (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$).



(d) Passive inclination.



(e) Emotional instability.

Figure 5.1 Odds ratio *vs.* WECPNL on the clusters (continued).

Open circles and solid circles show the odds ratios with the 95% confidence intervals around Kadena Air Base and Futenma Air Station, respectively. The symbols p_k and p_f show the significance probabilities of the trend test. The asterisks show the significance probabilities of odds ratios to the control group (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$).

Table 5.2 Number of kindergartens and nursery schools in which interior air quality was measured

Vicinal base	Rate of children with higher score of cold symptoms	Num. of kindergartens and nusery schools
Kadena Air Base	≥25%	8
	<15%	2
Futenma Air Station	≥25%	3
	<15%	1
Control		4
Total		18

5.2 Interior air pollution and cold symptoms

The significance increase of odds ratios in the noise exposed groups found in the previous section might be attributed to possible interior air pollution in the classrooms around the bases where sound insulation programme is carried out by the government, in which case air conditioners are facilitated. It should be noted that, although windows are kept closed during the hours of air conditioning, it does not necessarily cause interior air pollution since well-designed air conditioning would operate ventilation as well.

5.2.1 Method

In the investigation reported in the previous section are found 14 nursery schools and kindergartens in which over 25% of the preschool children showed over 3 points of "cold symptoms." Among the 14, 11 nursery schools and kindergartens, 8 around Kadena Air Base and 3 around Futenma Air Station, accepted the measurement of interior air quality of the classrooms. Measurement is also carried out in 3 nursery schools and kindergartens, two around Kadena air Base and one around Futenma Air Station, in which air conditioning is carried out and the rate of the children showing over 3 points of "cold symptoms" is less than 15%. In the control group four nursery schools and kindergartens, two with air conditioning and two without air conditioning, accepted the measurement. The total number of nursery schools and kindergartens attended the measurement is 18. In Table 5.2 tabulated the number of nursery schools and kindergartens where measurement was conducted.

The items of air quality measured are temperature, humidity, dust, carbon dioxide and carbon monoxide. The devices were composed by the

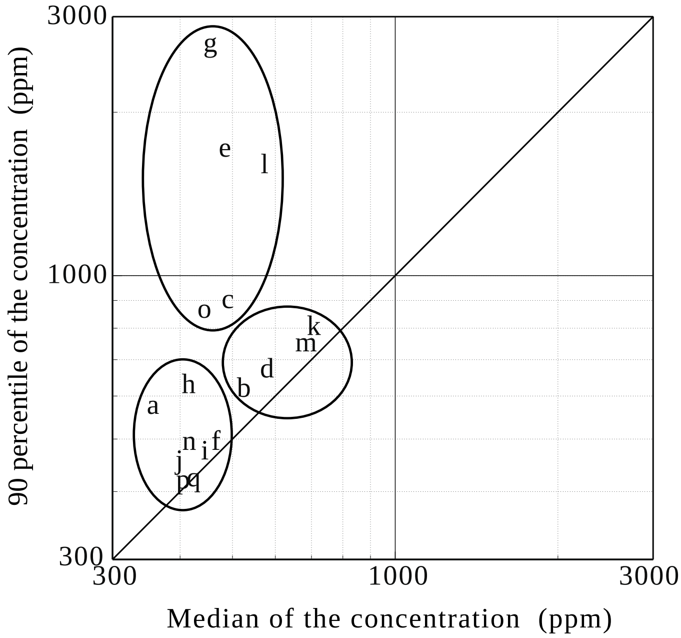


Figure 5.2 Scattergram of the concentration of carbon dioxide
(a–i) Around Kadena Air Base
(j–m) Around Futenma Air Station
(n–q) Control

Institute for Science of Labour and have automatic measuring system.

5.2.2 Results

The result of the concentration of carbon dioxide is presented in Figure 5.2, because carbon dioxide is the standard indicator of air quality when the contamination is wondered due to the human activities. In the figure the result of a nursery school around Kadena Air Base is excluded because of the accident of measurement. The abscissa of the figure is median of the concentration and the ordinate is its 90 percentile. All the measurements plotted in the figure are undertaken during the class hours with the children inside and windows closed. The nursery schools and kindergartens having the median less than 500ppm and 90 percentile less than 850ppm are judged "good ventilation," those having the median over 500ppm and 90 percentile less than 850ppm are judged "slightly poor ventilation" and those having the median over 500ppm and 90 percentile over 850ppm are judged "pretty poor ventilation."

Multiple logistic regression model is applied with the scale score of "cold symptoms" as the dependent variable and air quality, noise exposure, age and sex as independent variables. The variable of air quality is dummy variable as

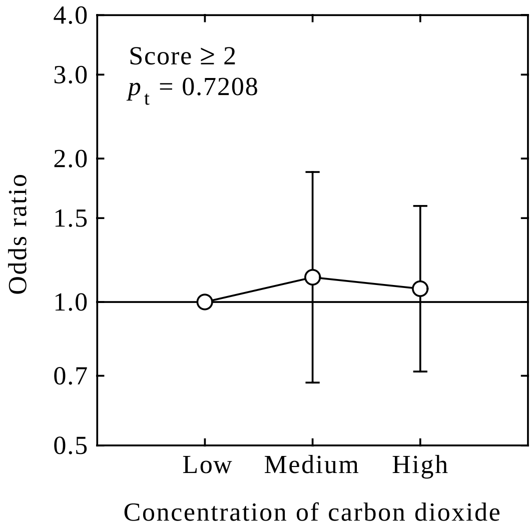


Figure 5.3 Odds ratio *vs.* concentration of carbon dioxide on cold symptoms

Open circles show the odds ratios with the 95% confidence intervals. The symbol p_t is the significance probability of the trend test on the concentration of carbon dioxide.

categorized above. Figure 5.3 illustrates the relation between the odds ratio with respect to "cold symptoms" and the concentration of carbon dioxide adjusted for confounding factors. The vertical bars in the figure indicate the 95% confidence limits of the odds ratios. It is quite clear that the score of "cold symptoms" has little to do with the air quality in the classrooms as represented by the concentration of carbon dioxide or the ventilation of the rooms.

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.

References

Hattori M, Kohno A, Taniguchi T, Morikawa K (1986), Increased incidence of behavior problems of preschool children in a noise polluted area, J Hokuriku Public Health 13(1), 30–38 (in Japanese).

Kodama H, Nakamura T *et al.* (1982), Shouni no Mondai Koudou (Preschool Children's Misbehaviours), Ishiyaku Shuppan, Tokyo (in Japanese).

Chapter 6

General health questionnaire survey: Todai Health Index

Health management is the basis of public health. Collecting precise and minute information on the individuals' health conditions and conducting health management of the individuals might be considered most desirable, but in the realistic conditions it is virtually impossible to carry out health examinations of all the population. It is for this reason that surveys on perceived wellness or subjective health of groups of individuals are widely undertaken by means of personal interview and/or questionnaire survey for the sake of health management.

The basic survey on public health conducted by the Ministry of Health and Welfare of Japan includes the survey of subjective health over the country. It is now recognised that the score of subjective health decreases with age and the average life expectancy is longer in the group of individuals showing higher score of subjective health. It can be said that the correlation between subjective health and objective health is high.

The Todai Health Index, THI, is one of the self-administered questionnaires developed by Suzuki *et al.* in 1974 with the purpose of supplementing the Cornell Medical Index (CMI) — Health Questionnaire(Suzuki *et al.*; 1991). A survey on health effects of aircraft noise on residents living around Kadena Air Base was conducted using the Todai Health Index. This is a report of the analysis of the 12 scale scores concerning perceived physical and mental health in relation to the level of aircraft noise exposure expressed by WECPNL.

6.1 Materials and methods

The THI questionnaire consists of 130 questions regarding vague complaints, mental health, personality, health habits, and so forth. The questions are listed in Appendix B. Based on the answers to 130 questions, twelve scale

Table 6.1 Twelve scale scores of THI

Scale	Abbr.	Content or meaning
Vague complaints	VCOM	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	RESP	Cough up phlegm, sneeze, have a runny nose, cough, have mucus in the throat, irritation or pain in the throat, etc.
Eye and skin	EYSK	Sensitive skin, itchy skin, skin eruptions or rashes, pain or itching in the eyes, inflamed or red eyes, etc.
Mouth and anal	MOUT	Rough or raspy tongue, swelling or inflammation in the mouth, bleeding hemorrhoids, bleeding gums, constipation, etc.
Digestive	DIGE	Stomach problems, stomach pain, discomfort in the stomach, diarrhea, indigestion, etc.
Irritability	IMPU	Easily irritated, lose temper, act without considering the consequences, get upset, etc.
Lie scale	LISC	Like to make people think that one is a better person, social desirability, acquiescence tendency, etc.
Mental instability	MENT	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	DEPR	Hopeless, lonely, unhappy and depressed, less confidence, etc.
Aggression	AGGR	Never become ill, not timid, overweight, no orthostatic dizziness, drink a lot, not sensitive to cold, etc.
Nervousness	NERV	Nervous, sensitive, worry about soil and dirt, worry about everything, etc.
Irregularity of life	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.

scores are calculated to reveal the pattern of complaints. In Table 6.1 is tabulated the 12 scales as well as their contents. In Table 6.2 are presented the question numbers listed in Appendix for the 12 scales.

The survey was undertaken in six municipalities around Kadena Air Base and three around Futenma Air Station from October 1995 to September 1996. As the control three municipalities are selected in the south part of the island where aircraft noise exposure is scarce.

The questionnaire was distributed to 4,840 residents over 15 years of age around Kadena Air Base, 2,213 around Futenma Air Station and 1,031 in Shimajiri district for the control. The total sample size is 8,084. Figure 6.1 illustrates the communities, as indicated by solid small circles, where ques-

Table 6.2 Question numbers for the 12 scale scores

Scale	Num. of questions	Question numbers
VCOM	20	4, 13, 17, 24, 35, 39, 50, 52, 55, 65, 67, 69, 76, 82, 85, 89, 93, 103, 106, 120
RESP	10	5, 18, 30, 48, 62, 84, 89, 97, 106, 117
EYSK	10	6, 19, 31, 49, 63, 85, 88, 99, 108, 118
MOUT	10	3, 16, 27, 42, 56, 70, 80, 94, 104, 114
DIGE	9	7, 20, 33, 51, 64, 86, 101, 111, 127
IMPU	9	8, 21, 29, 44, 58, 72, 96, 115, 125
LISC	10	12, 36, 38, 44, 47, 61, 68, 102, 110, 126
MENT	14	9, 22, 25, 40, 53, 66, 77, 79, 81, 83, 87, 92, 105, 121
DEPR	10	11, 32, 37, 46, 60, 74, 90, 100, 109, 119
AGGR	7	1, 14, 34, 45, 73, 78, 116
NERV	8	10, 23, 41, 54, 75, 107, 112, 124
LIFE	11	2, 15, 28, 43, 57, 71, 82, 91, 95, 113, 122

tionnaires were distributed in the map of middle and south parts of Okinawa Island.

The respondents were sampled from the pole book by means of the stratified random sampling method with respect to WECPNL. 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 to 80, 80 to 85, 85 to 90, 90 to 95 and over 95. The number of residents living in the area of the highest noise exposure with WECPNL over 95 is so limited that the questionnaire was distributed to all the residents over 15 years. The distribution was done by means of the leave-and-pick-up method.

The number of answers collected is 6,695 to make the response rate 82.8%. The valid answers are selected on the following condition where in the individual answer respondent's age and sex are written as well as his or her address so as to identify the noise exposure in WECPNL and the respondent's age is 15 to 74 years. Valid answers thus obtained is 6,480. In Table 6.3 is shown the number of distribution, answers, and valid answers. The 615 answers of the previous survey conducted in Chatan Town in 1992 (Hiramatsu *et al.*; 1997) are added to the valid answers. The number of valid answers stratified by WECPNL are listed in Table 6.4. As a result 7,095 answers are used for analysis. However, since not all the respondents answered all the questions, the number of valid answers varies one scale after another within the range from 6,301 to 6,966.

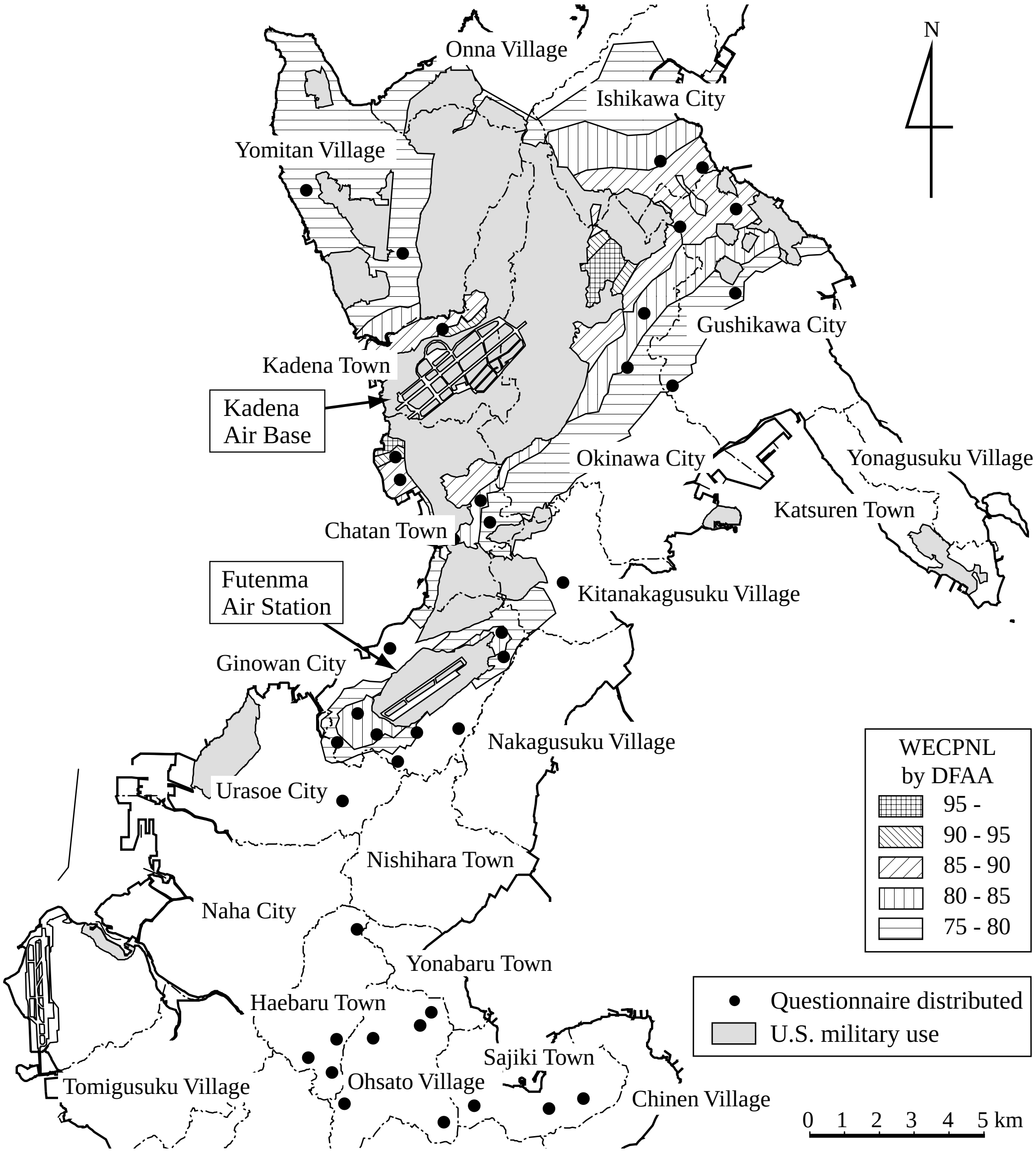


Figure 6.1 Investigated area around Kadena Air Base and Futenma Air Station.

Table 6.3 The number of distribution and valid answers

Address		Present investigation: Sample size	Distri-bution	Collection	Recovery rate (%)	Valid answer	Previous investi-gation	Total
Ishikawa	Mihara	76	63	38	60.3	36		36
City	Maehara	293	244	192	78.7	190		190
	Chuou	180	150	98	65.3	96		96
Gushikawa	Konbu	138	115	84	73.0	83		83
City	Enobi	166	139	138	99.3	133		133
	Nishihara	209	174	174	100.0	170		170
	Esu	127	106	102	96.2	101		101
Okinawa	Ikehara	150	124	75	60.5	73		73
City	Noborikawa	500	415	372	89.6	362		362
	Matsumoto	150	127	103	81.1	101		101
Yomitan	Iramina	337	281	232	82.6	226		226
Village	Namihei	424	380	372	97.9	357		357
Kadena	Higashi	1,014	986	810	82.2	760		760
Town	Nishihama	382	334	271	81.1	264		264
Chatan	Sunabe	297	297	224	75.4	217	237	454
Town	Miyagi	340	283	190	67.1	186	56	242
	Eiguchi	301	251	220	87.6	203	55	258
	Ujihara	227	189	169	89.4	157	31	188
	Jagaru	218	182	172	94.5	172	69	241
	Other						167	167
Subtotal		5,529	4,840	4,036	83.4	3,887	615	4,502
Kitanakagusuku								
Village	Chunjun	70	60	60	100.0	59		59
Ginowan	Nodake-1	294	245	203	82.9	197		197
City	Futenma-2	54	45	36	80.0	35		35
	Kakazu	166	150	147	98.0	146		146
	Maehara	457	381	213	55.9	209		209
	Ueohjana	113	94	82	87.2	80		80
	Ohyama	376	313	235	75.1	225		225
	Ganeko	443	369	350	94.9	337		337
	Ginowan	275	229	190	83.0	182		182
	19-Ku	170	142	127	89.4	123		123
Urasoe City	Nakama	230	185	156	84.3	152		152
Subtotal		2,648	2,213	1,799	81.3	1,745		1,745
Sajiki	Niisato	117	100	99	99.0	99		99
Town	Sajiki	103	90	88	97.8	87		87
	Tetone	108	90	89	98.9	88		88
Ohsato	Haebaru	43	41	41	100.0	41		41
Village	Hirara	53	50	39	78.0	38		38
	Touma	77	65	60	92.3	58		58
	Inamine	106	90	51	56.7	51		51
	Ohshiro	103	90	87	96.7	86		86
Haebaru	Miyagi	125	105	81	77.1	78		78
Town	Kyamu	141	120	86	71.7	85		85
	Yamakawa	105	90	70	77.8	68		68
	Kamisato	118	100	69	69.0	69		69
Subtotal		1,199	1,031	860	83.4	848		848
Total		9,376	8,084	6,695	82.8	6,480	615	7,095

Table 6.4 Number of valid answers stratified by WECPNL

WECPNL	Control	Kadena Air Base	Futenma Air Station	Total
Control	848			848
70–75			1,020	1,020
75–80		1,268	417	1,685
80–85		1,129	308	1,437
85–90		936		936
90–95		969		969
95–		200		200
Total	848	4,502	801	7,095

6.2 Results and discussion

6.2.1 An analysis of the 12 scale scores

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 dependent variable and WECPNL, age, sex, occupation and the interaction of age and sex as the independent variables is conducted.

In Tables 6.5 and 6.6 are shown the significance probabilities for twelve scales scores obtained in the multiple logistic regression analysis observed for the residents around Kadena Air Base and Futenma Air Station, respectively. In the column of WECPNL of the table, the significance probabilities of trend test are given in which linear dose-response relationships are assumed between WECPNL and logarithmic values of odds ratio. As can be seen in the table 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 Air Station significant dose-response relationships are found in the scale scores of EYSK ($p = 0.0201$) and NERV ($p = 0.0014$).

The odds ratios of the seven scale scores significant dose-response relationships are found about are plotted against WECPNL in Figure 6.2. As to VCOM, odds ratios of subjects with the scale score of over 39 inclusive were statistically significant in Group 90 and Group 95 as can be seen in the figure. As to RESP and NERV, significant increases of odds ratio are observed even in the groups with lower noise exposure such as Groups 75, 80 and 85 as well as Groups 90 and 95. As to EYSK, the trend of increase of odds ratio is not

Table 6.5 Siginificance probabilities of the independent variables in the logistic regression analysis of 12 scale scores (Kadena Air Base)

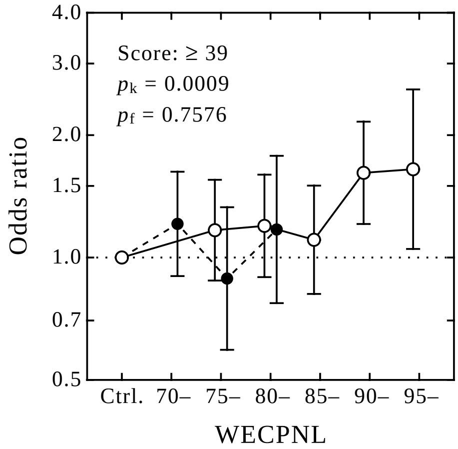
Scale	Threshold	WECPNL	Age	Sex	Age*Sex	Occupation
VCOM	≥ 39	0.0009***	0.0086**	0.8121	0.0904	0.2648
RESP	≥ 18	0.0000***	0.0112*	0.0000***	0.8999	0.2863
EYSK	≥ 19	0.2258	0.5602	0.3721	0.0000***	0.1569
MOUT	≥ 16	0.0666	0.0000***	0.7007	0.0060**	0.3086
DIGE	≥ 16	0.0004***	0.0000***	0.0000***	0.0000***	0.5826
IMPU	≥ 23	0.1356	0.0011**	0.0000***	0.0318*	0.1729
LISC	≤ 14	0.8510	0.0000***	0.0032**	0.9613	0.1111
LISC	≥ 22	0.4461	0.0000***	0.0182*	0.0843	0.3775
MENT	≥ 30	0.0085**	0.0761	0.0000***	0.0462*	0.0509
DEPR	≥ 20	0.0724	0.0015**	0.4475	0.0127*	0.1616
AGGR	≤ 12	0.0124*	0.0666	0.0000***	0.0078**	0.0000***
AGGR	≥ 18	0.4040	0.0024**	0.0000***	0.2431	0.0216*
NERV	≤ 11	0.1487	0.0063**	0.0048**	0.3946	0.0694
NERV	≥ 20	0.0005***	0.0000***	0.4469	0.7192	0.2057
LIFE	≥ 24	0.1094	0.0000***	0.0479*	0.5840	0.0000***

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

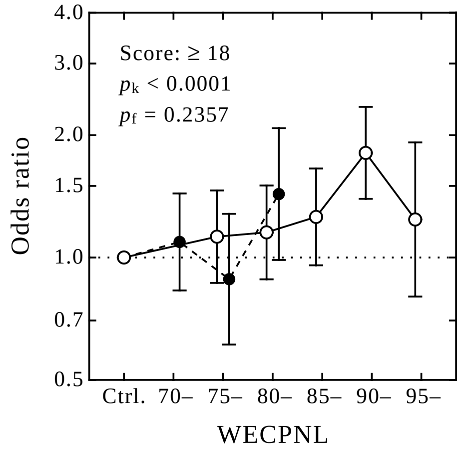
Table 6.6 Siginificance probabilities of the independent variables in the logistic regression analysis of 12 scale scores (Futenma Air Station)

Scale	Threshold	WECPNL	Age	Sex	Age*Sex	Occupation
VCOM	≥ 39	0.7576	0.8704	0.2322	0.2929	0.9373
RESP	≥ 18	0.2357	0.0269*	0.0174*	0.9005	0.5148
EYSK	≥ 19	0.0201*	0.0081**	0.0383*	0.3320	0.1569
MOUT	≥ 16	0.1209	0.0054**	0.7798	0.6860	0.3171
DIGE	≥ 16	0.8686	0.0000***	0.0081**	0.0179*	0.0202*
IMPU	≥ 23	0.8736	0.1564	0.3842	0.0709	0.3394
LISC	≤ 14	0.0576	0.0000***	0.0234*	0.6434	0.8180
LISC	≥ 22	0.0927	0.0000***	0.0426*	0.6563	0.4979
MENT	≥ 30	0.7803	0.1996	0.0000***	0.7758	0.1281
DEPR	≥ 20	0.9907	0.3792	0.5326	0.4365	0.9167
AGGR	≤ 12	0.9292	0.2210	0.0007***	0.4577	0.0815
AGGR	≥ 18	0.1711	0.0034**	0.0000***	0.0535	0.1421
NERV	≤ 11	0.2323	0.3333	0.9680	0.5019	0.2501
NERV	≥ 20	0.0014**	0.0013**	0.1400	0.1594	0.0749
LIFE	≥ 24	0.8190	0.0000***	0.1983	0.8960	0.3844

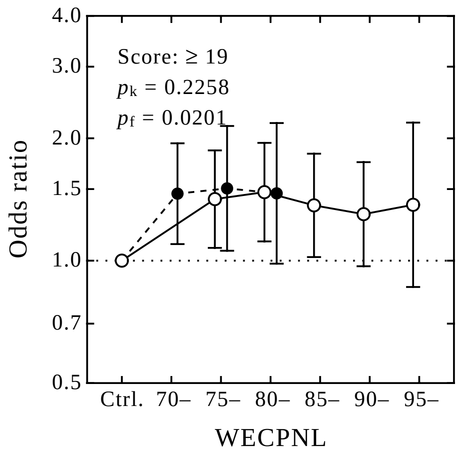
*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$



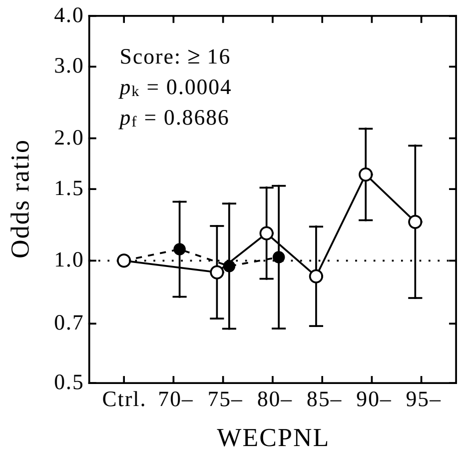
(a) Vague complaints (VCOM).



(b) Respiratory (RESP).



(c) Eye and skin (EYSK).

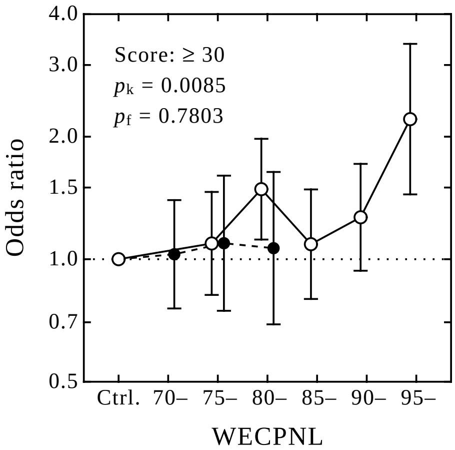


(d) Digestive (DIGE).

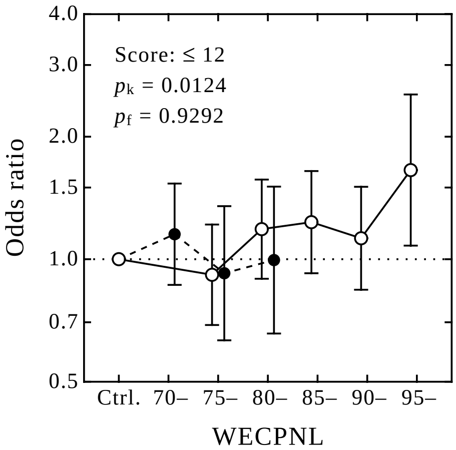
Figure 6.2 Odds ratio *vs.* WECPNL on 12 scale scores.

Open circles and solid circles show the odds ratios with the 95% confidence interval around Kadena Air Base and Futenma Air Station, respectively.

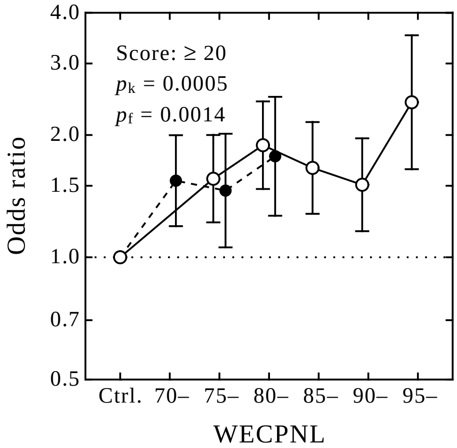
significant. However, the odds ratios of the respondents in the noise-exposed groups are more or less around 1.5. As to DIGE, odds ratio of subjects with the scale score of over 16 is elevated for the Groups of WECPNL of 90 and 95. Odds ratio regarding MENT increases as WECPNL is higher and that with scale score of over 30 inclusive exceeds 2.0 in Group 95. As to AGGR, odds ratio with scale score of less than 13 inclusive was significant in Groups 85, 90 and 95.



(e) Mental instability (MENT).



(f) Aggression (AGGR) (low score).



(g) Nervousness (NERV) (high score).

Figure 6.2 Odds ratio *vs.* WECPNL on 12 scale scores (cont.)

Open circles and solid circles show the odds ratios with the 95% confidence interval around Kadena Air Base and Futenma Air Station, respectively.

Table 6.7 Siginificance probabilities of the independent variables in the logistic regression analysis of DF values (Kadena Air Base)

DF value	WECPNL	Age	Sex	Age*Sex	Occupation
Psychosomatic	0.0000***	0.4329	0.0000***	0.4501	0.0080**
Neurosis	0.2159	0.0064**	0.0177*	0.0333*	0.0593

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

6.2.2 Analysis of DF values

The discriminant function (DF) values for psychosomatics and neurosis are calculated as is proposed by Suzuki *et al.* (1991). The dichotomous variables converted from the DF values are applied as the dependent variables in the logistic regression analysis with the independent variables of WECPNL, age, sex, occupation and the interaction of age and sex. The conversion of the variables is done with the threshold of null of the DF value.

Tables 6.7 and 6.8 are the lists of significance probabilities obtained in the trend test of odds ratio of DF values of the residents around Kadena Air Base and Futenma Air Station regarding the different variables used in the logistic regression analysis. The probability of psychosomatics for WECPNL around Kadena Air Base is very low indicating that the trend of increase of odds ratio with the increase of the level of noise exposure is highly significant. In Figure 6.3 is shown the results of the analysis of the DF values of psychosomatics, where the odds ratio is plotted as a function of the level of noise exposure expressed by WECPNL. The vertical bars indicate 95% confidence limits of the odds ratio and p_{k} and p_{f} indicate confidence probabilities of trend test for Kadena Air Base and Futenma Air Station. The clear dose-response relationship is found and the trend of increase is statistically significant for Kadena Air Base. The odds ratio of the area of WECPNL over 95 is over 2.0. The result of the analysis of DF value of neurosis is also shown in Figure 6.3. From the figure it can be seen that the odds ratio is significantly high in the area of WECPNL 95.

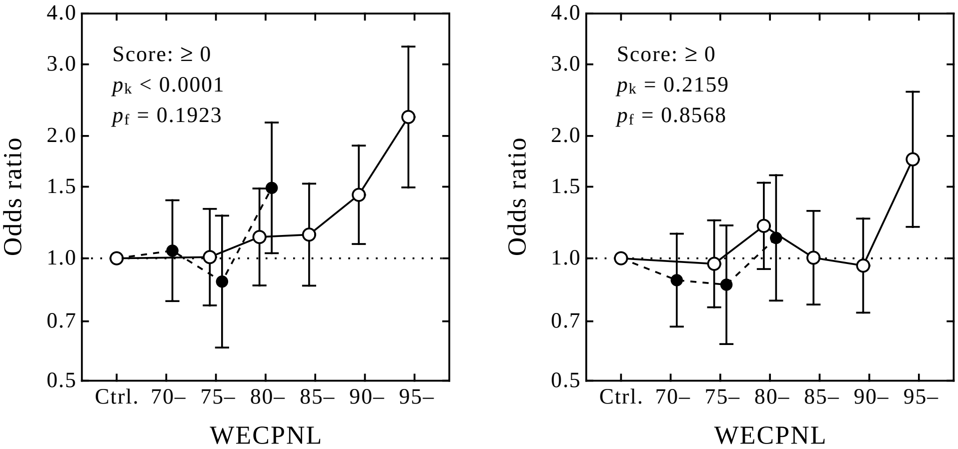
6.2.3 Analysis of factor scores

In this section principal factor analysis is applied and then Oblimin rotation is carried out using the 12 scale scores.

Table 6.9 is the factor pattern matrix of two factors extracted by the factor analysis by means of principal factor method with Oblimin rotation.

Table 6.8 Siginificance probabilities of the independent variables in the logistic regression analysis of DF values (Futenma Air Station)

DF value	WECPNL	Age	Sex	Age*Sex	Occupation
Psychosomatic	0.1923	0.8130	0.0662	0.2828	0.2207
Neurosis	0.8568	0.6624	0.0803	0.1872	0.4425



(a) Psychosomatic. (b) Neurosis.

Figure 6.3 Odds ratio *vs.* WECPNL on DF value.

Open circles and solid circles show the odds ratios with the 95% confidence interval around Kadena Air Base and Futenma Air Station, respectively.

Table 6.9 Patern matrix of factor analysis with Oblimin rotation

Scale	Abbr.	Somatic factor	Mental factor
Vague complaints	VCOM	0.871*	0.034
Respiratory	RESP	0.730*	−0.066
Eye and skin	EYSK	0.700*	−0.001
Mouth and anal	MOUT	0.587*	0.072
Digestive	DIGE	0.689*	−0.003
Irritability	IMPU	0.003	0.718*
Lie scale	LISC	0.084	−0.601*
Mental instability	MENT	−0.018	0.908*
Depression	DEPR	0.178	0.655*
Aggression	AGGR	−0.144	−0.384
Nervousness	NERV	0.034	0.506*
Irregularity of life	LIFE	0.425	0.265

* : ≥ 0.5

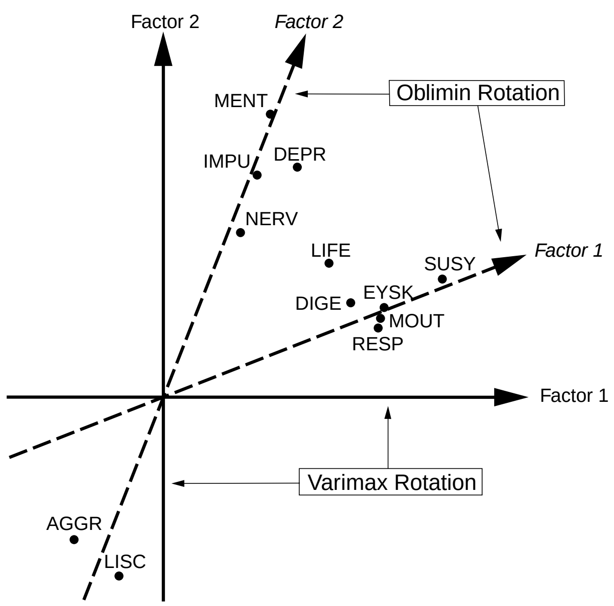
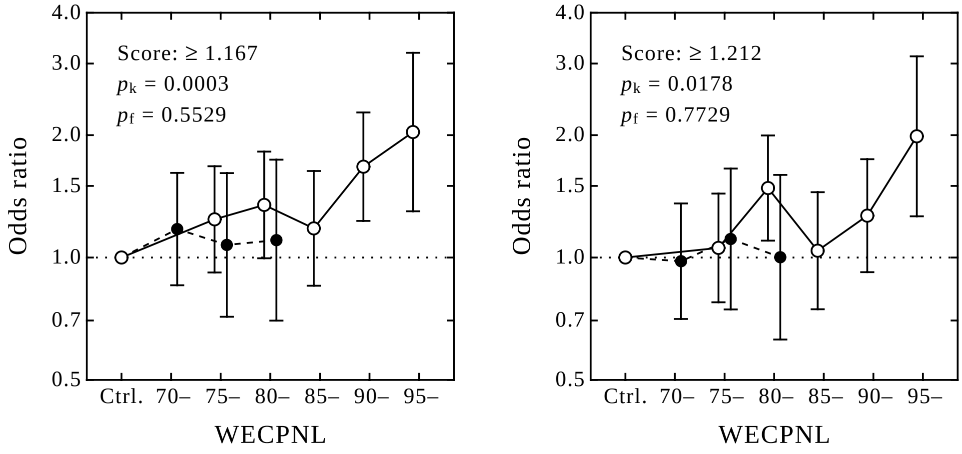


Figure 6.4 Comparison of Oblimin rotation and Varimax rotation.

The factor showing strong relation with somatic symptoms is named as somatic factor and the other related with mental symptoms as mental factor. Oblimin rotation is applied in the present analysis since the factors extracted are considered to correlate with each other. In Figure 6.4 is illustrated the comparison of Oblimin rotation and Varimax rotation.

The dichotomous variables converted from the factor scores are applied as the dependent variables in the logistic regression analysis with the independent variables of WECPNL, age, sex, occupation and the interaction of age



(a) Somatic factor.

(b) Mental factor.

Figure 6.5 Odds ratio *vs.* WECPNL on factor scores.

Open circles and solid circles show the odds ratios with the 95% confidence interval around Kadena Air Base and Futenma Air Station, respectively.

and sex. The factor scores of 90 percentile of the control are taken as the thresholds in the conversion of the variables of factor scores.

Figure 6.5 show the odds ratios of somatic factor and mental factor plotted as a function of WECPNL, respectively. Clear dose-response relationship is found for Kadena Air Base in Figure 6.5 where the trend of increase of odds ratio regarding somatic factor starts from comparatively lower level of WECPNL of 75. Although in the case of mental factor the dose-response relationship shown in Figure 6.5 is not as clear as in the case of somatic factor, higher odds ratio is observed in the area of highest noise exposure. Odds ratio is over 2.0 in the area where WECPNL is over 95.

In Tables 6.10 and 6.11 is listed the significance probabilities obtained in the trend test of odds ratio of factor scores of the residents around Kadena Air Base and Futenma Air Station regarding the different variables used in the logistic regression analysis.

6.3 Conclusions

As a non-specific biological stressor, noise can influence the entire body system via both autonomic nervous system and neuroendocrine system (Morrell *et al.*; 1997). In this sense, it would be reasonable to consider that pro-

Table 6.10 Siginificance probabilities of the independent variables in the logistic regression analysis of factor scores (Kadena Air Base)

Factor score	Threshold	WECPNL	Age	Sex	Age*Sex	Occupation
Somatic factor	≥ 1.167	0.0003***	0.1771	0.0864	0.0108*	0.0460*
Mental factor	≥ 1.212	0.0178*	0.0018**	0.2380	0.0055**	0.1802

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

Table 6.11 Siginificance probabilities of the independent variables in the logistic regression analysis of factor scores (Futenma Air Station)

Factor score	Threshold	WECPNL	Age	Sex	Age*Sex	Occupation
Somatic factor	≥ 1.167	0.5529	0.1040	0.3567	0.7865	0.7222
Mental factor	≥ 1.212	0.7729	0.2028	0.0010***	0.1276	0.9476

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

longed and repeated exposure of aircraft noise may adversely affect health and well-being of individuals around Kadena Air Base, making allowance for the serious noise exposure level in the residential area (Chapter 2) and the high community responses (Chapter 3) regarding sleep disturbance, disturbance of rest, fear of possible danger as well as annoyance. In addition, it was denied that sound insulation as a measure against aircraft noise and air conditioning which reduces ventilation might cause the spread of air borne infections and thus increase the complaints regarding respiratory organs (RESP). Finally, it should always be borne in mind that physical health effects of noise may manifest in susceptible subgroup within a population and the sites where various symptoms appear are different among individuals even in the same conditions of noise exposure.

References

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Morrell S, Taylor R & Lyle D (1997), A review of health effects of aircraft noise, Aust N Z J Public Health 21: 221–236.

Suzuki S *et al.* (1991), Methods and Applications in Mental Health Surveys : The Todai Health Index, The University of Tokyo Press, Tokyo.

Chapter 7

Analysis of the data obtained in general health examination

7.1 Introduction

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 from the health examination conducted by the local authorities for the years of 1994 and 1995 were analysed with respect to systolic blood pressure and diastolic blood pressure, the numbers of red and white blood cells and the concentration of serum uric acid. Logistic regression analysis was applied to analyse the data acquired.

7.2 Effect on systolic and diastolic blood pressure

Sample size of the subjects concerning systolic and diastolic blood pressure stratified in the ranks of WECPNL is shown in Table 7.1. In order to adjust various confounding factors possibly influencing the blood pressure,

Table 7.1 Sample size of systolic and diastolic blood pressure

Year	Mucipality	WECPNL						Total
		–75	75–80	80–85	85–90	90–95	95–	
1994	Okinawa City	2,938	4,337	1,006	189			8,470
	Kadena Town				1,556	155		1,711
	Chatan Town		441	923	437	15	93	1,909
	Kitanakagusuku Village	1,190	2					1,192
1995	Ishikawa City	338	905	642	101			1,986
	Gushikawa City	2,066	1,627	247	213			4,153
	Ginowan City	2,140	1,750	1,061				4,951
	Okinawa City	80	85	1				166
	Yomitan Village		4,021	222				4,243
Total		8,752	13,168	4,102	2,496	170	93	28,781

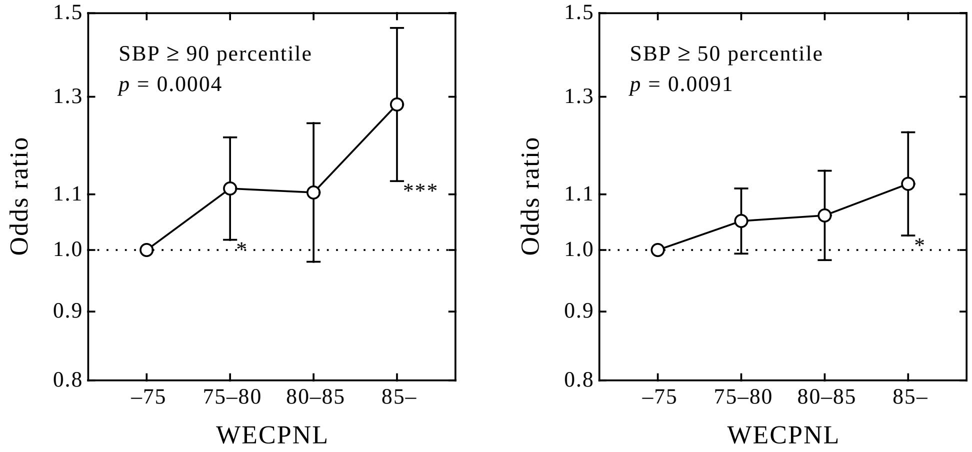

Figure 7.1 Odds ratio *vs.* WECPNL on higher systolic pressure.

*:$p < 0.05$, **:$p < 0.01$, ***:$p < 0.001$

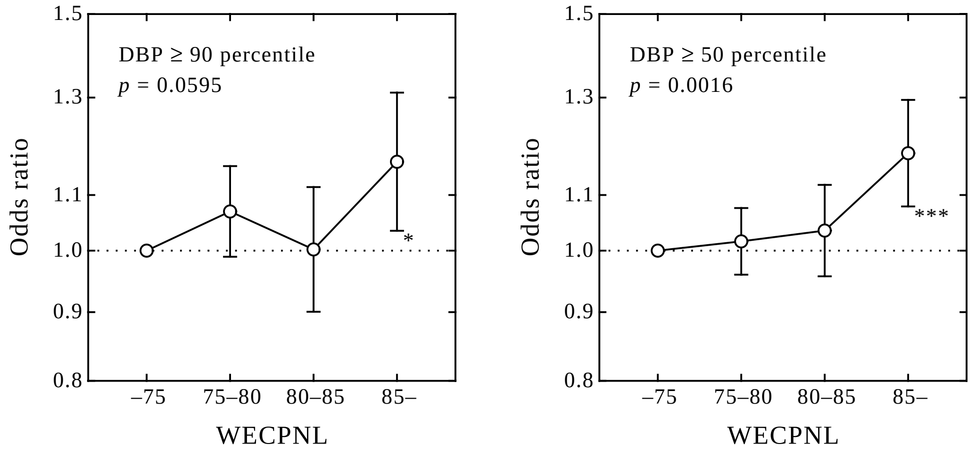

Figure 7.2 Odds ratio *vs.* WECPNL on diastolic blood pressure.

*:$p < 0.05$, **:$p < 0.01$, ***:$p < 0.001$

multiple logistic regression analysis was applied. Since there is close correlation between blood pressure and age, the rates of those with systolic blood pressure and diastolic blood pressure exceeding 90 percentile or 50 percentile for age groups stratified in the bands of 10-years were taken as the dependent variable. Noise exposure in WECPNL, age (20–79 years, 6 categories), sex, Body Mass Index (5 categories) and the interaction of age and sex were applied as the independent variables.

Relation between odds ratios and WECPNL on systolic and diastolic blood pressures are shown in Figure 7.1 and Figure 7.2 with 95% confidence

Table 7.2 Sample size of the concentration of serum uric acid

Year	Municipality	WECPNL				Total
		–75	75–80	80–85	85–90	
1994	Okinawa City	2,934	4,321	1,005	189	8,449

intervals. On systolic blood pressure, 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. The results of the trend test tell that the trend of increase of odds ratio with the increase of WECPNL are significant with the significance probability, $p = 0.0004$, as shown in the figure, which suggests that significant dose-response relation is very likely to exist between the rate of the higher blood pressure and the noise exposure.

7.3 Effect on the numbers of white blood cells and red blood cells

Sample size of the subjects concerning white blood cells is 28,692, and that of white blood cells is 13,404. No significant dose-response relationship was found as to the numbers of white blood cells and red blood cells.

7.4 Effect on the concentration of serum uric acid

Sample size of the subjects concerning serum uric acid stratified in the ranks of WECPNL is shown in Table 7.2. Since there is close correlation between uric acid and sex, the rate of those with the concentration of uric acid exceeding 90 percentile or 50 percentile for male and female groups was taken as the dependent variable. Noise exposure in WECPNL, age (20–79 years, 6 categories), sex, Body Mass Index (5 categories), the concentration of creatinine (5 categories) and the interaction of age and sex were applied as the independent variables.

Relation between odds ratios and WECPNL on uric acid is shown in Figure 7.3 with 95% confidence intervals. The odds ratio of those exceeding the threshold corresponding 50 percentile of the population is 0.8 in the noise exposed group with WECPNL over 80. The results of the trend test tell that the trend of decrease of odds ratio with the increase of WECPNL is significant

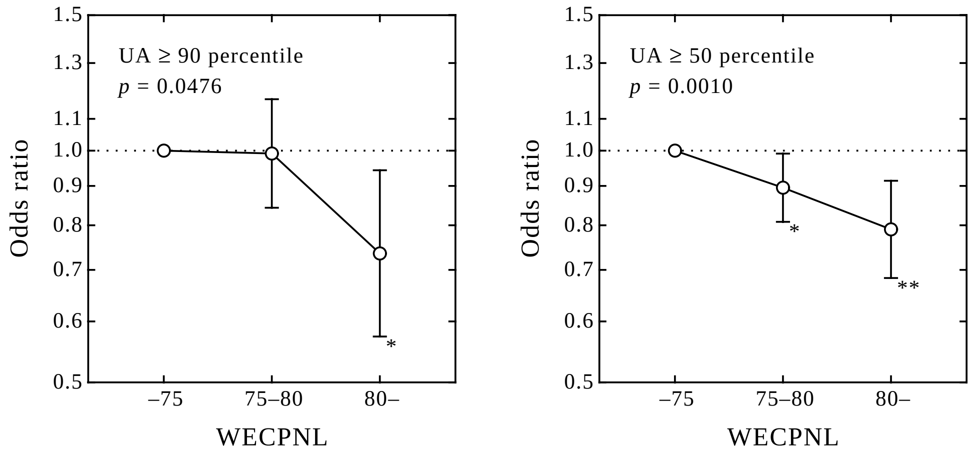

Figure 7.3 Odds ratio *vs.* WECPNL on the concentration of serum uric acid.

*:$p < 0.05$, **:$p < 0.01$, ***:$p < 0.001$

with the significance probability, $p = 0.0010$, as shown in the figure, which suggests that significant dose-response relation is likely to exist between the rate of the lower concentration of serum uric acid and the noise exposure.

Chapter 8

Higher rate of low birth-weight infants

It is generally recognized that the mental stress possibly causes through the endocrine and nervous systems various physical impact upon human beings. Noise can be a stresser to cause such stress reactions as many mental stresses might do to human bodies.

Many papers have been published to report the results of animal experiments and epidemiological researches suggesting the effect of noise on pregnancy; that is the noise exposure is a factor reducing birth weight and/or shortening the term of pregnancy. For example, it is reported that the rate of low birth weight of infants was found higher in the vicinity of Osaka International Airport (Ando & Hattori; 1973) than the average rate of non-noise exposed area in Japan and that the aircraft noise exposure could be a factor of raising the rate.

Taking the high level of noise exposure around the U.S. airfields in Okinawa, particularly in the vicinity of Kadena Air Base, into account, there would be a good reason to investigate whether the higher rate of low birth weight infants are observed.

8.1 Materials and methods

Japanese government accumulates for every municipality all over the country 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 20 years from 1974 to 1993 was 356,549 among which 164,028 records of 15 municipalities around Kadena Air Base and Futenma Air Station filed up for the 20 years are used for the analysis in the present investigation.

The 15 municipalities are shown in the map of Figure 8.1. In the map

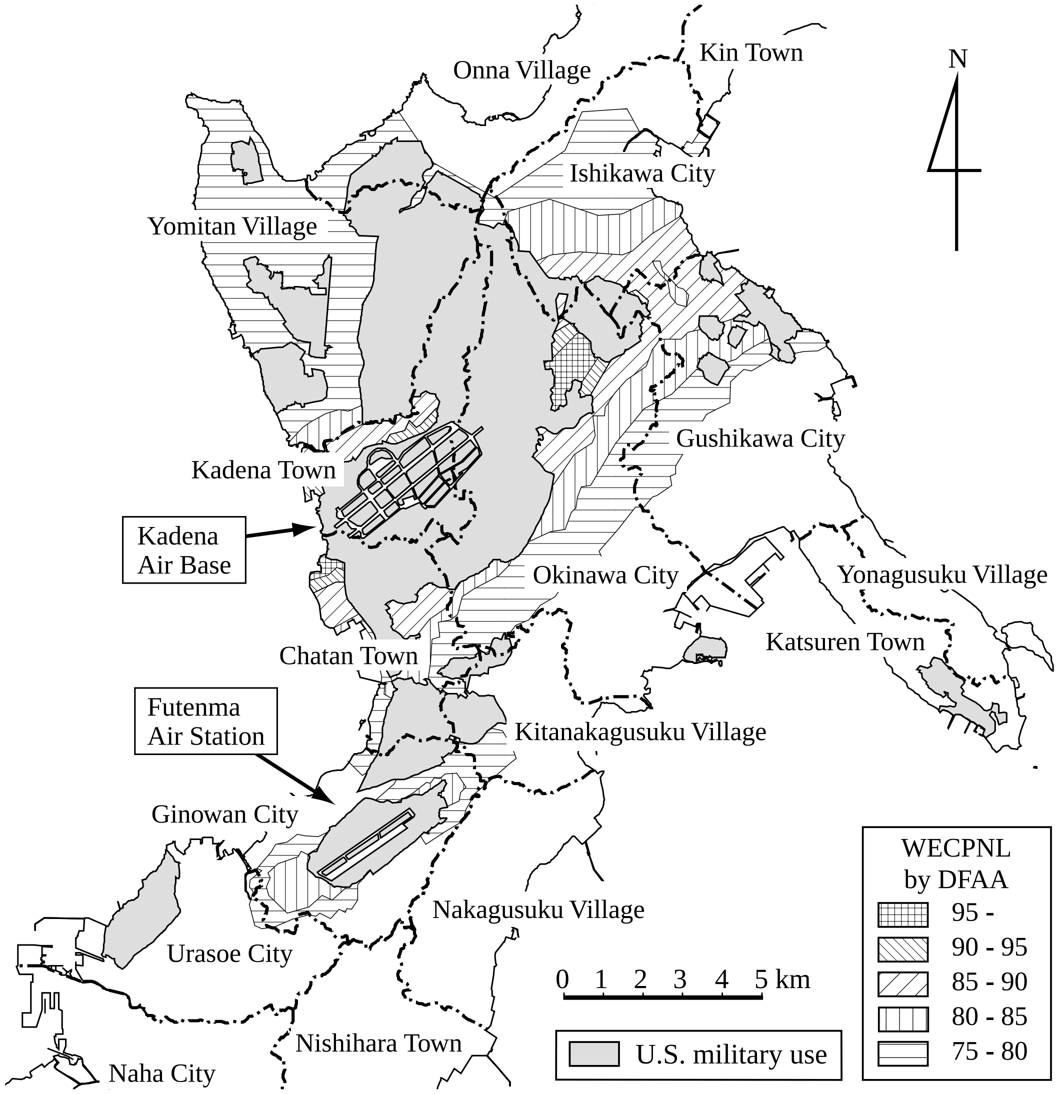

Figure 8.1 Municipalities around Kadena Air Base and Futenma Air Station.

Ishikawa City, Gushikawa City, Okinawa City, Kadena Town, Chatan Town, Yomitan Village and Ginowan City are the nearest municipalities surrounding the bases and have over 30% of the population within the noise contour of WECPNL of 75 designated by the DFAA. Onna Village, Kin Village, Yonagusuku Village, Katsuren Town, Kitanakagusuku Village, Nakagusuku Village, Urasoe City and Nishihara Town are the outer surrounding municipalities of the above ones.

The birthplace is recorded as the name of the municipality only and no direct information is available such as the postal address of birthplace on which one could estimate the noise exposure the mother would have been exposed to during pregnancy. In order to make a rule of thumb estimation of the

Table 8.1 Population stratified in the ranks of WECPNL

Municipality	WECPNL							Average†
	–75	75–80	80–85	85–90	90–95	95–	Total	WECPNL
Kadena Town				12,777	1,265		14,042	88.0
Chatan Town		6,884	6,064	10,229	317	237	23,731	83.5
Okinawa City	47,612	50,070	14,974	2,412			115,068	76.3
Gushikawa City	37,618	14,309	3,256	2,926			58,109	75.0
Ishikawa City	5,398	10,596	4,727	1,254			21,975	77.9
Ginowan City	39,561	24,997	17,258				81,816	76.1
Yomitan Village		31,791	2,263				34,054	77.8
Onna village	8,422	672					9,094	72.9
Kin Town	10,040						10,040	72.5
Katsuren Town	14,112						14,112	72.5
Yonagusuku Village	13,629						13,629	72.5
Kitanakagusuku Village	11,697	2,519					14,216	73.4
Nakagusuku Village	13,497						13,497	72.5
Urasoe City	94,014	2,434					96,448	72.6
Nishihara Town	28,710						28,710	72.5
Total	324,310	144,272	48,542	29,598	1,582	237	548,541	75.6

†'Average WECPNL' is calculated as population weighted average of WECPNL.

noise exposure, population weighted WECPNL is calculated in such a way as follows; firstly, populations in the ranks of WECPNL in every municipality are estimated based on the community population available as of June 1, 1995, and secondly, the average of noise exposure weighted for the population is calculated for the municipalities. In Table 8.1 are tabulated the population stratified in the ranks of WECPNL. In the following analysis the 8 municipalities with average WECPNL under 75 are treated as the control, the 5 municipalities with average WECPNL from 75 to 80 are treated as "lower noise exposed group." Chatan Town and Kadena Town are independent groups.

The weight of the new infant under 2,500g is categorized as low birth-weight. Birth rate of low birth-weight infants are analysed in relation to noise exposure. The data of multiple pregnancy and/or the records of the mothers having experience of stillbirth are excluded from the analysis.

8.2 Results

8.2.1 Birth rate of low birth-weight infants

In Table 8.2 are presented the numbers of births and the birth rates of low birth-weight infants for different ranks of noise exposure. Clearly the higher birth rates of low birth-weight infants are found in the municipalities with higher noise exposure. The birth rate of low birth-weight infants of

Table 8.2 Rate of low birth weight infants

Municipalities	Num. of births	<2,500g
Kadena Town	4,425	366 (8.3%)
Chatan Town	6,066	423 (7.0%)
Okinawa City, etc.	92,332	6,439 (7.0%)
Control	57,637	3,667 (6.4%)

† The samples with multiple pregnancy and/or stillbirth experience are excluded from the analysis.

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.

In order to adjust various confounding factors possibly influencing the birth rate of low birth-weight infants, multiple logistic regression analysis is applied with the birth rate as the dependent variable and sex, mother's age, live birth order, occupation of householder, legitimacy of the infant, year of birth and the interaction of mother's age and live birth order as the independent variables. Table 8.3 is the results of the analysis where p-value indicates the significance probability of odds ratio. In the table 'factor' indicates independent variable for the logistic regression model. Here odds ratio is nearly equal to relative risk. They are plotted in Figure 8.2 as a function of WECPNL. Vertical bars in the figure indicate 95% confidence intervals of odds ratios and the asterisks do the odds ratios are significantly higher to the control. The result of the trend test tells that the trend of increase of odds ratio with the increase of WECPNL is significant with the significance probability p less than 0.0001 as shown in the figure, which suggests that significant dose-response relation exists between the birth rate of low birth-weight infants and the noise exposure.

8.2.2 Rate of preterm infants

Birth weight and period of pregnancy are highly correlated with each other. In this section the rate of preterm births is analysed as done for the birth rate of low birth-weight infants in the previous section.

In Table 8.4 are shown the rates of preterm births for different ranks of noise exposure. In the table, preterm, term and postterm mean the period of pregnancy to be less than 37 weeks, from 37 to 41 weeks inclusive and over 41 weeks, respectively. The classification of the term of pregnancy in this

Table 8.3 Results of the logistic regression analysis (<2,500 g)

Factor	Category	N	Odds ratio	95% CI	p-value
Noise exposure	Kadena Town	4,425	1.32	1.18–1.48	<0.0001
	Chatan Town	6,066	1.09	0.98–1.21	0.1232
	Okinawa City, etc.	92,332	1.09	1.04–1.13	0.0001
	Control	57,637	1.00		
Sex	Male	82,777	1.00		
	Female	77,683	1.16	1.11–1.20	<0.0001
Mother's age	≤ 19	5,584	2.14	1.70–2.69	<0.0001
	20–24	36,634	1.39	1.29–1.51	<0.0001
	25–29	59,942	1.00		
	30–34	39,879	0.95	0.89–1.02	0.1376
	$35 \leq$	18,421	1.19	1.10–1.28	<0.0001
Live birth order	1st	58,773	1.42	1.33–1.52	<0.0001
	2nd or after	101,687	1.00		
Interaction of mother's age and live birth order	≤ 19 and 1st	4,840	0.71	0.56–0.92	0.0082
	20–24 and 1st	22,522	0.73	0.66–0.81	<0.0001
	25–29 and 1st	21,478	1.00		
	30–34 and 1st	7,315	1.16	1.03–1.31	0.0118
	$35 \leq$ and 1st	2,618	1.13	0.97–1.32	0.1253
Legitimacy	Legitimate infants	155,421	1.00		
	Illegitimate infants	5,039	1.67	1.52–1.82	<0.0001
Occupation of householder	White-collar worker	51,843	1.00		
	Blue-collar worker	60,005	1.18	1.12–1.24	<0.0001
	Full-time farmer	2,179	1.12	0.94–1.33	0.2050
	Farmar with a side Job	4,727	1.13	1.00–1.27	0.0569
	Self-employed	18,349	1.11	1.03–1.19	0.0041
	Other	22,970	1.24	1.17–1.32	<0.0001
	Unknown	387	1.18	0.80–1.74	0.3983
Period	1974–1978	43,732	1.00		
	1979–1983	38,501	0.96	0.90–1.01	0.1156
	1984–1988	40,422	1.10	1.04–1.16	0.0011
	1989–1993	37,805	1.27	1.21–1.34	<0.0001

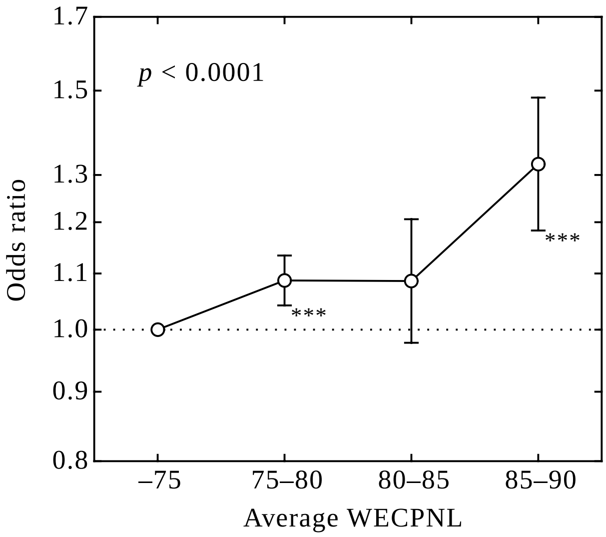

Figure 8.2 Odds ratio *vs.* WECPNL ($< 2,500\,$g).

*:$p < 0.05$, **:$p < 0.01$, ***:$p < 0.001$

Table 8.4 Rate of preterm infants

Municipalities	Preterm infants	Term infants	Postterm infants	Total
Kadena Town	234 (7.7%)	2,745 (89.9%)	76 (2.5%)	3,055
Chatan Town	308 (6.7%)	4,193 (90.8%)	118 (2.6%)	4,619
Okinawa City, etc.	4,398 (6.6%)	60,438 (91.0%)	1,562 (2.4%)	66,398
Control	2,651 (6.2%)	38,997 (91.3%)	1,065 (2.5%)	42,713

† The samples with multiple pregnancy and/or stillbirth experience are excluded from the analysis.

report is in accordance with the definition proposed by WHO. Since Japan used the classification on month basis before adopting the definition in 1979 for statistics, the records before the year of 1979 are excluded in the following analysis.

Clearly the 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 1.5% 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.

In order to adjust various confounding factors possibly influencing the birth rate of preterm births, multiple logistic regression analysis is applied with the birth rate as the dependent variable and the same independent variables

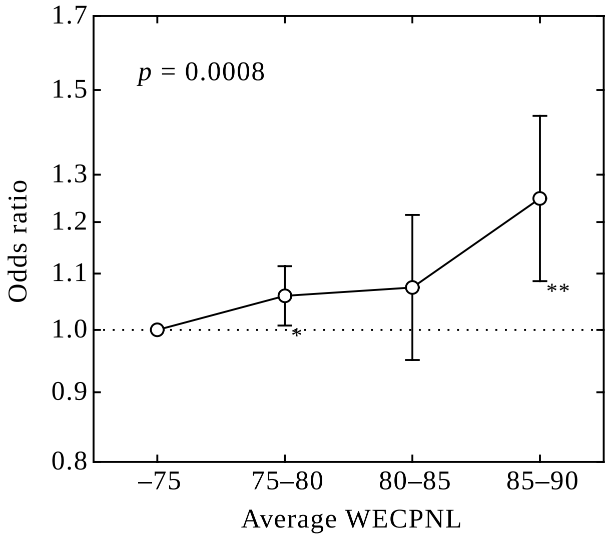

Figure 8.3 Odds ratio *vs.* WECPNL (preterm infants).

*:$p < 0.05$, **:$p < 0.01$, ***:$p < 0.001$

as used in the previous section. The odds ratios of different ranks of noise exposure are shown in Figure 8.3 as a function of WECPNL. As was found in the case of low birth-weight, the trend of increase of odds ratio with the increase of WECPNL is clear and significant according to the trend test.

As have been seen above the dose-response relations between the birth rate of low birth-weight infants and the rate of preterm birth and the noise exposure are significant under the adjustment of confounding factors. But unfortunately strong confounding factors such as smoking habit and some other habits of life style are not used as the independent variables in the present analysis due to the lack of information. In fact, epidemiologists report that smoking habit raises the birth rate of low birth-weight infants by 50 to 100% (Cnattingius *et al.*; 1993, Behrman; 1985, Maruoka *et al.*; 1998). In that sense one cannot draw a firm conclusion based on the present analysis. Suppose, however, the odds ratio of the birth rate due to smoking habit is 2.0 and the higher birth rate of low birth-weight infants in Kadena Town is attributed to the smoking habit solely, then the smoking rate of females in Kadena Town needs to be by 40% higher than the control. That is quite unrealistic.

In conclusion, it would be safe to say that it is fairly likely that the aircraft noise exposure might cause the higher birth rate of low birth-weight infants obsereved in Kadena Town.

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Chapter 9

Hearing loss

9.1 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.

The past noise exposure during the Vietnam War era was estimated in the previous section using measurements recorded at the residential areas in the vicinity of Kadena airfield in 1968 and 1972. The estimated WECPNL was around 105, and the equivalent continuous sound pressure level, L_{Aeq}, for averaging time of 24 hours came to 83 dB. These values are serious when compared with the permissible criteria of 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 years under 20 dB for the test frequency of 4 kHz.

9.1.1 Estimation of TTS due to aircraft noise

A method of computation of average temporary threshold shift (TTS) (Takagi K, Hiramatsu K & Yamamoto T; 1988) is available if the temporal and spectral features 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 method consists of two stages. One is the critical band theory with respect to TTS, which deals with the spectral aspect of the exposure noise. The other is the application of unit-step-function to simulate the temporal

Table 9.1 Critical band width in dB and its center frequency (Yamamoto *et al.*; 1970)

Test frequency (kHz)	Center frequency (Hz)	Bandwidth and its 95% CI (dB)
0.5	490	21.3 ± 1.5
0.8	600	23.8 ± 1.3
1	730	23.8 ± 1.6
1.5	1010	24.0 ± 1.3
2	1400	26.0 ± 0.8
3	2620	29.7 ± 0.9
4	3040	30.5 ± 0.8
6	3840	29.9 ± 1.0
8	4950	33.3 ± 0.8

Table 9.2 Constants included in the equation for TTS (Ito *et al.*; 1987)

Frequency (Hz)	a (dB)	b (dB^{-1})	T_1 (min)	m (–)	T_2 (min)
500	0.016	0.102	15.7	2.00	105.0
800	0.037	0.101	62.0	1.77	257.4
1000	0.115	0.090	94.1	1.62	617.3
1500	1.347	0.054	44.8	1.47	352.0
2000	0.063	0.102	13.4	1.61	179.9
3000	0.118	0.103	41.8	1.16	182.7
4000	0.106	0.114	31.8	1.04	337.6
6000	0.261	0.098	14.8	1.07	412.0
8000	0.110	0.112	17.0	1.41	458.6

change of the level of exposure noise and the formula of TTS growth is applied to the local steady part of the noise.

The critical bandwidth and centre frequency of TTS at 9 test frequencies are given in Table 9.1. The formulae of TTS growth are given by the following equation, the constants in the equation are shown in Table 9.2.

$$TTS_\tau(S,t) = TTS_0(S,t+\tau) - TTS_0(S,\tau),$$
$$TTS_0(S,t) = a\exp(bS)\frac{1-\exp(-t/T_1)}{1+m\exp(-t/T_2)}$$

The unit-step-function method expresses the temporal pattern of the level fluctuation of the exposure noise in Figure 9.1 by means of the unit step function $U(t)$ ($= 0$ for $t \leq 0$, $= 1$ for $t > 0$), as follows;

$$S_1[\mathrm{U}(t) - \mathrm{U}(t-T_1)] + S_2[\mathrm{U}(t-T_1) - \mathrm{U}(t-T_1-T_2)] + \cdots$$
$$+ S_i[\mathrm{U}(t-T_1-T_2-\ldots-T_{i-1}) - \mathrm{U}(t-T_1-T_2-\ldots-T_i)] + \cdots$$

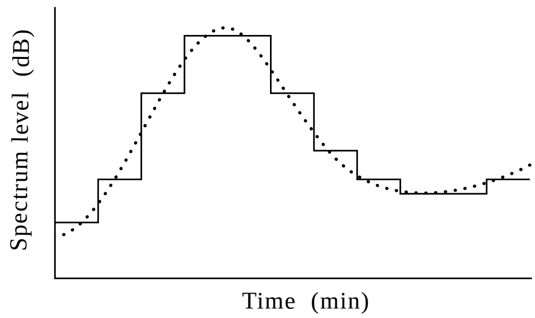


Figure 9.1 Temporal pattern of the level fluctuation and aproximation by unit step functions.

Here S_i is the level of the exposure noise. With this supposed to be the input, the output then is

$$\begin{aligned}&f_{S_1}(t) - \mathrm{U}(t-T_1)f_{S_1}(t-T_1)\\&+ \mathrm{U}(t-T_1)f_{S_2}(t-T_1) - \mathrm{U}(t-T_1-T_2)f_{S_2}(t-T_1-T_2) + \cdots\\&- \mathrm{U}(t-T_1-T_2-\cdots-T_i)f_{S_i}(t-T_1-T_2-\cdots-T_i)\end{aligned}$$

The notation $f_{S_i}(t)$ denotes *TTS* produced by steady state noise at the level S_i.

The time history of sound level during 24 hours is estimated from the recorded data 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 threshold shift due to aircraft noise exposure at that time is calculated from the time history of critical band level by means of the method described above.

The result of calculation is presented in Figure 9.2. It indicates the noise exposure around Kadena airfield causes TTS in excess of 20 dB. This is an average estimation for the exposed populations and further hearing loss could be possible for some highly susceptible individuals.

Temporary threshold shift measured at 2 min after the cessation of daily noise exposure is regarded as approximately equal to the permanent threshold shift induced by habitual exposure to the same noise over 10 years (Glorig *et al.*; 1961). There should be some possibility that the noise exposure in the vicinity of Kadena Air Base might cause the residents permanent hearing loss.

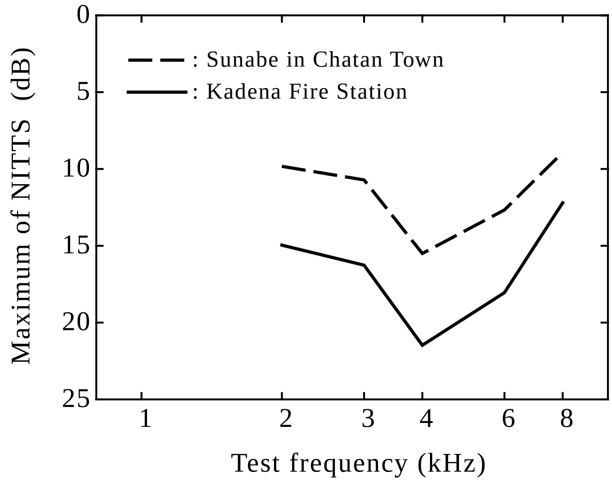


Figure 9.2 Maximum of calculated NITTS.

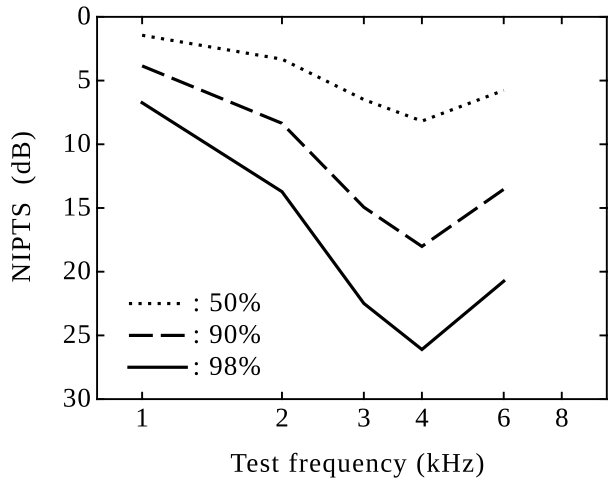


Figure 9.3 Percentiles of calculated NIPTS.

9.1.2 Estimation of NIPTS due to aircraft noise

Robinson among other workers who have proposed methods to estimate permanent hearing loss due to prolonged noise exposure proposes a method to give the percentile of the subjects suffering from noise induced hearing loss (Robinson; 1971). Noise induced permanent threshold shift (NIPTS) due to the noise exposure observed around KAB is calculated according to his method. Note that his method gives comparatively conservative calculation.

Figure 9.3 shows the NIPTS estimated by Robinson's method with 83 dB in L_{Aeq} for 10 years. In the figure, 50, 90 and 98 percentiles of NIPTS are illustrated as functions of test frequency. The 98 percentile of NIPTS is over 20 dB at the test frequency of 4 kHz.

The results of the calculation of possible hearing loss strongly suggest that there exist some residents in the vicinity of Kadena Air Base who suffer from hearing loss due to the noise exposure from aircraft landing and taking off on the runways of Kadena Air Base.

9.2 Hearing tests

9.2.1 Primary test

Hearing test was conducted three times from May 1996 to July 1998, at three wards in Chatan Town and Kadena Town, where WECPNL ranged from 85 to 95 and more. The subjects to receive the test were limited to the individuals aged between 25 and 69 years inclusive. The number of residents living in the area to receive the test was 2,035.

Inquiry

Before going through audiometry, subjects were asked about hearing, tinnitus, otological anamnesis, past experience of noise exposure in occupation, service and/or hobbies.

Audiometry

Tests were carried out by an experienced medical researcher and a trained clinical technician of Otorhinolaryngology Department of Okinawa Chubu Hospital in audiometric booths (DANA Japan, SILENT CABIN) installed in public halls using two audiometers (Rion, AA-67N, AA-62). The public halls are sound insulated on the basis of the DFAA's mitigation programme around military bases. The sound pressure levels of the background noise measured in the booths were 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 of 0.5, 1, 2, 3, 4, 6, and 8 kHz.

Results

Three hundred 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 a secondary examination held at the Otorhinolaryngology Department. In the selection of the 40 individuals, those having medical history of chronic tympanitis and/or occupational noise exposure are excluded and in the judgement of noise induced hearing loss the hearing levels of the individuals are adjusted for presbyacusis using the hearing levels presented in ISO 7029-1984(E).

9.2.2 Secondary test

In the secondary test are conducted pure tone audiometry with 1 dB step at test frequencies of 0.125, 0.25, 0.5, 1, 2, 3, 4, 6 and 8 kHz, Short Increment Sensitivity Index (SISI) test using the sensation level of 20 dB at every test frequency, tympanometry by means of impedance audiometer (RION, RS-20) and audioscan audiometry by means of the device (ESSILOR, Audioscan) with the frequency scanning speed 20 s/oct.

Hearing losses are broadly classified as follows;

1) Conductive Hearing loss, caused by impediments to the external auditory meatus, tympanic membrane or the middle ear;
2) Sensorineural Hearing Loss, caused by impediments to the inner ear or auditory nerve;
   - a: Cochlear Hearing Loss, caused by impediments to the cochlear, especially the inner and outer hair cells and the stria vascularis;
   - b: Retrocochlear Hearing Loss, caused by impediments to auditory nerve and its vast network of central connections within the brainstem.

Since noise induced hearing loss is sensorineural hearing loss, otological examinations of those selected from the first examination were conducted to confirm that their hearing losses were the type of sensorineural hearing loss.

First, the external and middle ears were checked by visual inspection of tympanic membrane and tympanometry. Secondly, air-bone gap of hearing acuity was checked; whether hearing losses observed by air conduction and bone conduction are equal within the margin of measurement error. From the above examination, the subjects' hearing losses were judged non-conductive. Thirdly, SISI test was conducted in order to check for inner ear hearing loss. The subjects showing positive recruitment phenomena, under Jerger's classification, are presumed to have cochlear hearing loss, but no retrocochlear hearing loss. Audiograms of a few subjects suggest they have more progressive hearing loss judging from a dip at higher frequencies.

Thus 12 subjects are chosen, 10 from Chatan Town and 2 from Kadena Town, who have a decline of hearing ability in the frequency range of 3 to 6 kHz, which strongly suggests the hearing losses are due to excessive noise exposure. In Table 9.3 are tabulated the results of hearing tests of the 12 individuals whose audiograms are presented in Figure 9.4. Hearing level by pure tone audiometry is plotted with open circle and cross. Solid line and broken line show the results of audioscan audiometry, and arrows indicate the 90 percentile of presbyacusis defined by ISO 7029-1984 (E): Database A (screened population).

9.2.3 Causation between hearing loss and aircraft noise

The result of hearing test alone cannot specifically determine that aircraft noise is the direct cause of their hearing loss. The following 7 reasons can be raised why their hearing losses are likely to be due to the aircraft noise from Kadena Air Base.

1) Audiogram

As a typical pattern of audiogram of noise induced hearing loss c^5-dip and its progressive pattern are observed. Recruitment positive is another symptom to support the diagnosis.

2) Geographical concentration

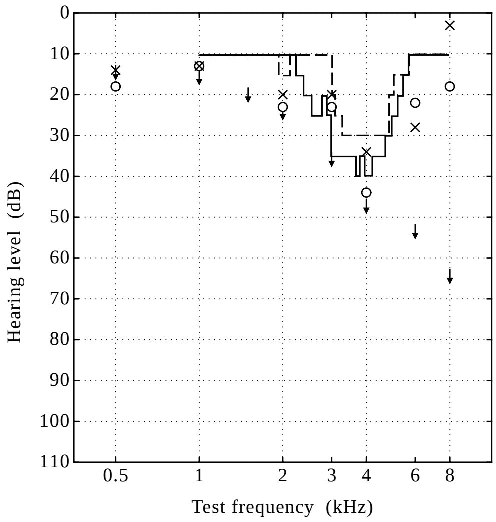
The individual judged noise induced hearing loss are concentrated the vicinal area of the base. The 12 subjects dwell in the closest part in the ward to either of the runways of Kadena Air Base. In Figure 9.5 are plotted the locations of the residences of the subjects living in Sunabe relative to the base. In the

Table 9.3 Twelve cases of the sensorineural hearing loss in which the aircraft noise exposure seems to be primary cause.

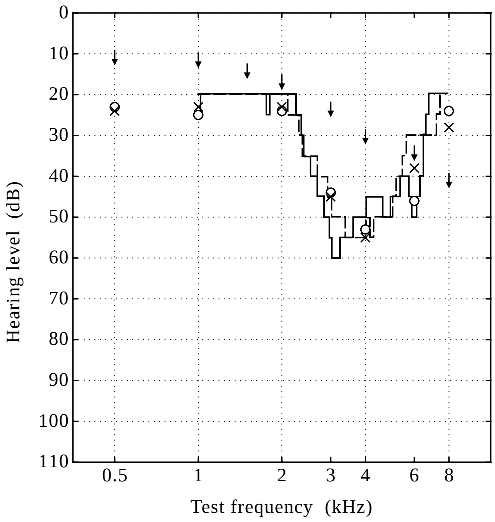
No.	Sex	Age	WECPNL by DFAA	Year of residence	Anamnesis[1)]	Noise exposure[2)]	Inspection of eardrum
1	Male	57	95–100	40	None	None	Normal
2	Male	47	90–95	19	None	None	Normal
3	Male	57	95–100	40	None	None	Normal
4	Female	52	95–100	39	None	None	Normal
5	Male	48	95–100	32	None	None	Normal
6	Male	68	90–95	21	None	None	Normal
7	Male	44	95–100	40	None	None	Normal
8	Male	59	95–100	35	None	3)	Normal
9	Male	63	90–95	38	None	None	Normal
10	Male	64	90–95	43	None	None	Normal
11	Male	68	85–90	40	None	None	Normal
12	Male	33	90–95	33	None	None	Normal

No.	Tympanometry	Air-bone gap	SISI test (L/R) 1 kHz	SISI test (L/R) 4 kHz	Hearing level (dB) R–4 kHz	Hearing level (dB) L–4 kHz
1	A[4)]	None	+−/−	+/+	44	34
2	A	None	−/−	+/+	53	55
3	A	None	−/−	+/+	48	53
4	A	None	−/−	+/+−	29	51
5	A	None	+/−	+/+	57	58
6	A	None	−/−	+/+	75	75
7	A	None	−/−	+/+	55	55
8	A	None	+/−	+/+	68	95
9	A	None	−/−	+/+	65	63
10	A	None	−/−	+/+	67	64
11	A	None	+−/−	+/+	46	52
12	A	None	−/−	+/+	55	47

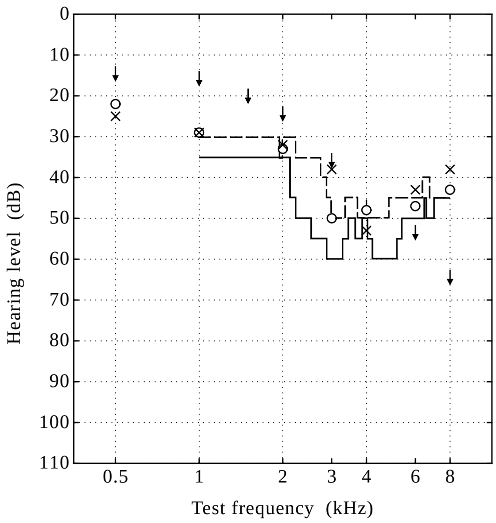
1) Disease possibly causing hearing loss
2) Occupational noise exposure
3) Watchman in the base (Sunabe) for a few years around 56 years old
4) Normal (No abnormality in the sound conductive system of the middle ear)



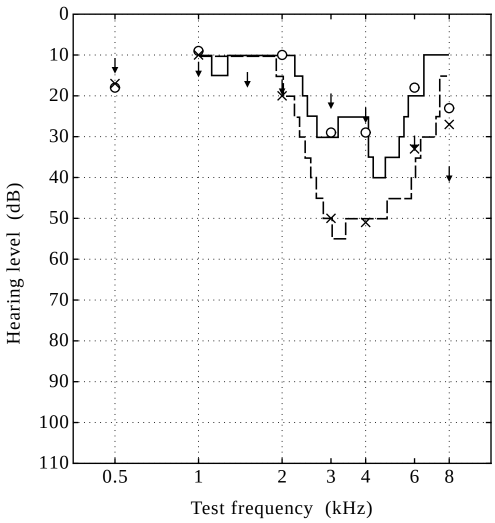
(a) Case 1.



(b) Case 2.



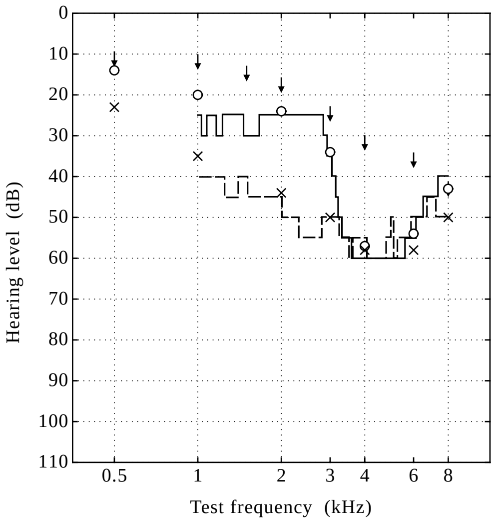
(c) Case 3.



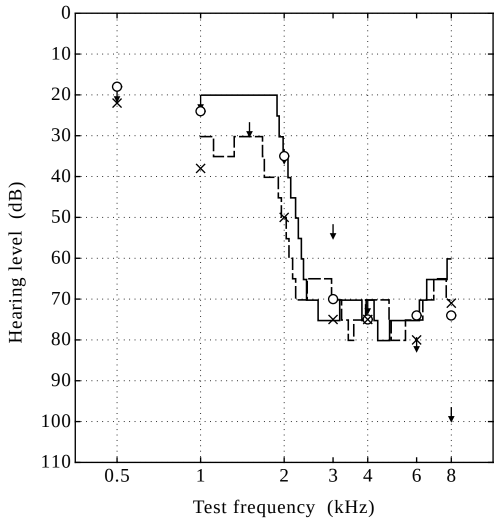
(d) Case 4.

Figure 9.4 Audiograms of the twelve cases; (1) No. 1–4.

Hearing level by pure tone audiometry is plotted with open circle and cross. Solid line and broken line show the results of audioscan audiometry, and arrows indicate the 90 percentile of presbyacusis defined by ISO 7029-1984 (E): Database A (screened population).



(e) Case 5.



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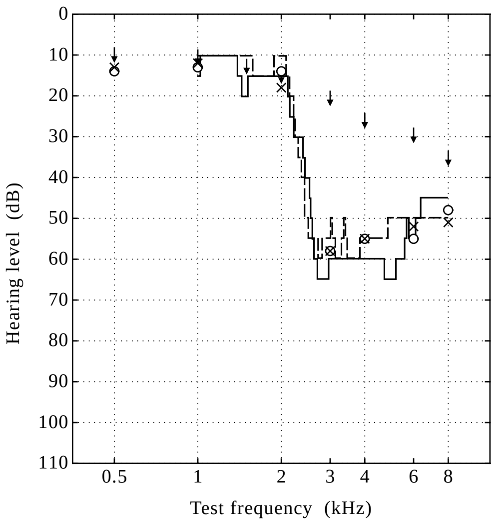

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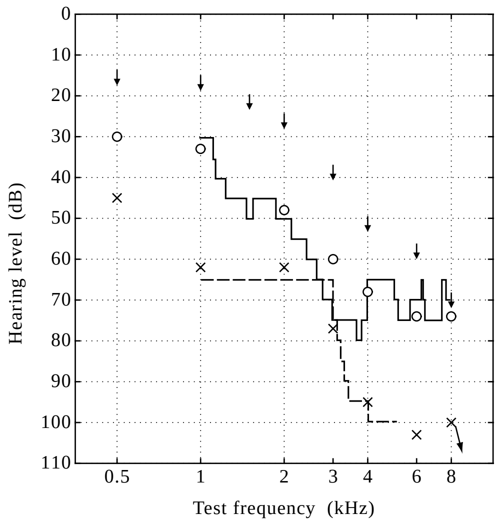
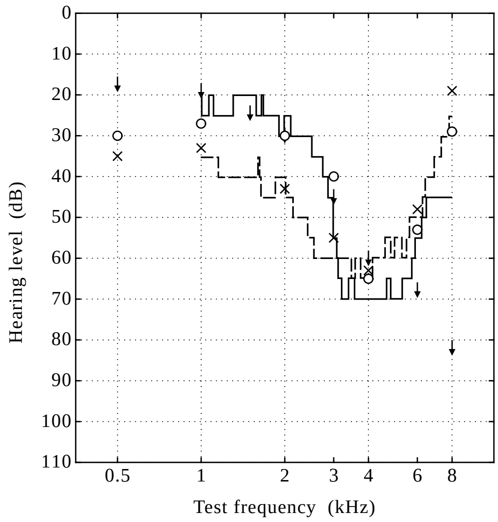


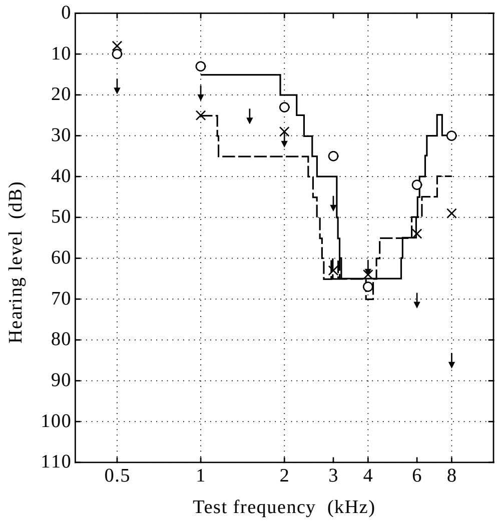
(h) Case 8.

Figure 9.4 Audiograms of the twelve cases; (2) No. 5–8.

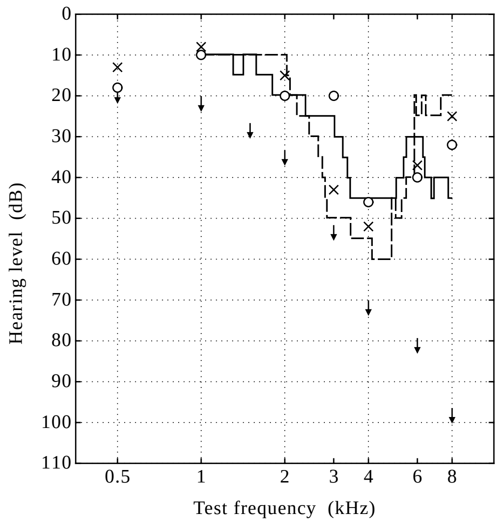
Hearing level by pure tone audiometry is plotted with open circle and cross. Solid line and broken line show the results of audioscan audiometry, and arrows indicate the 90 percentile of presbyacusis defined by ISO 7029-1984 (E): Database A (screened population).



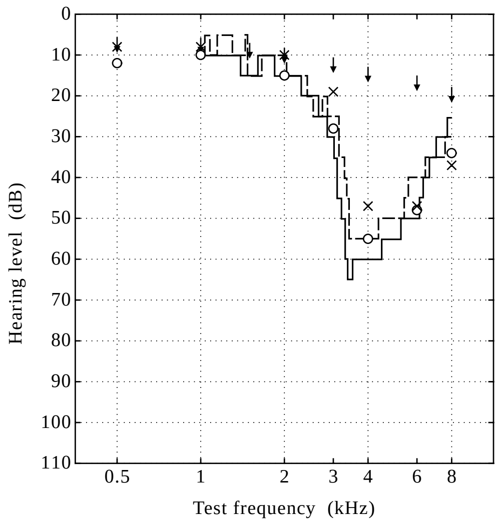
(i) Case 9.



(j) Case 10.



(k) Case 11.



(l) Case 12.

Figure 9.4 Audiograms of the twelve cases; (3) No. 9–12.

Hearing level by pure tone audiometry is plotted with open circle and cross. Solid line and broken line show the results of audioscan audiometry, and arrows indicate the 90 percentile of presbyacusis defined by ISO 7029-1984 (E): Database A (screened population).

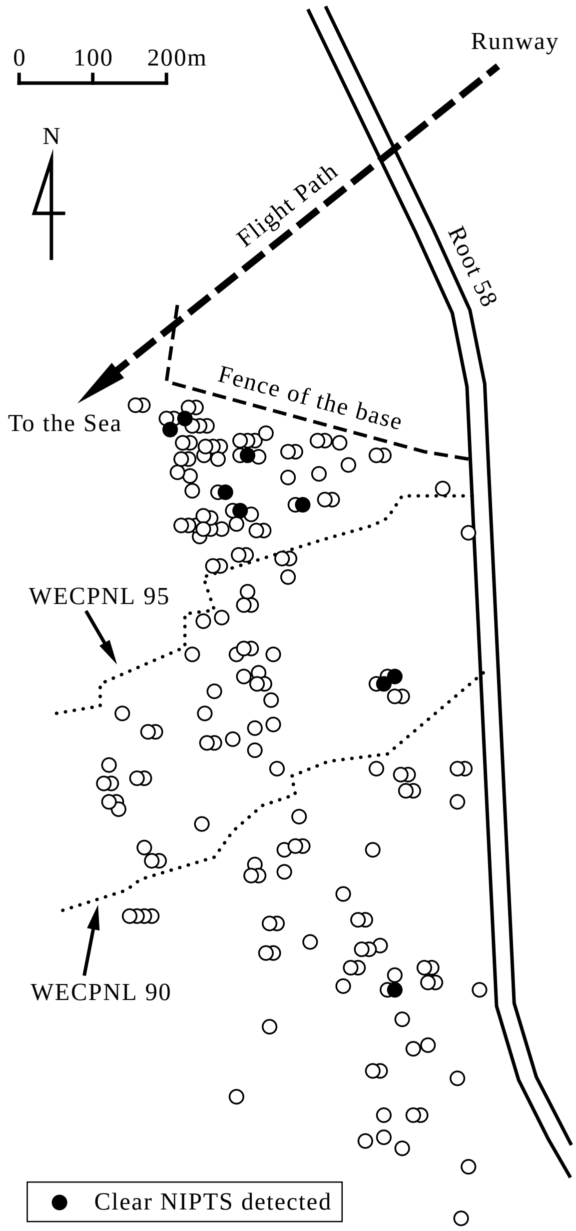


Figure 9.5 Locations of the homes of the residents who received the hearing test in Sunabe, Chatan Town.

map circles indicate the individuals who went through the hearing test, and among them 9 individuals over 40 years of age were judged to suffer from noise induced hearing loss. There resided 6 individuals in the area of WECPNL over 95, 2 in WECPNL 90–95 and 1 in WECPNL 85–90. Statistical test tells that the increasing trend of the number of individuals having NIPTS with the increase of WECPNL is significant ($p = 0.0402$, one-tailed Mantel extension method with exact test).

3) Intense noise exposure

Noise exposure past and present is extremely intense so as to be comparable to damage risk criteria for occupational noise exposure.

4) Estimated NITTS/NIPTS

The NITTS at 4 kHz estimated on the basis of the past noise exposure reaches about 20 dB on average and the NIPTS at 4 kHz of one chance in ten individuals is calculated to be about 20 dB.

5) Occupational noise exposure

The examiners interviewed the subjects to confirm that they had not experienced repeated intense noise exposure at their residence or workplace other than aircraft noise that might have caused their hearing loss.

6) Long term of residence

The individuals had resided in the area for 19 to 43 years.

7) High odds ratio for subjective hard of hearing

In the THI questionnaire besides the 130 THI questions was included a question asking if she/he had hard of hearing. Result of the analysis by means of logistic regression model is presented in Figure 9.6. Open circles indicate the odds ratios adjusted by age, sex, occupation and interaction of age and sex with 95% confidence intervals. It is clearly shown that the residents living in the area with WECPNL over 95 appeals hard of hearing and the increase of odds ratio is statistically significant.

These seven reasons strongly supports one to draw a conclusion that the cause of the individuals' hearing losses are most likely the exposure from the past to the present or a certain period in the past to the intense noise from aircraft take-off, landing and tune-up on Kadena Air Base.

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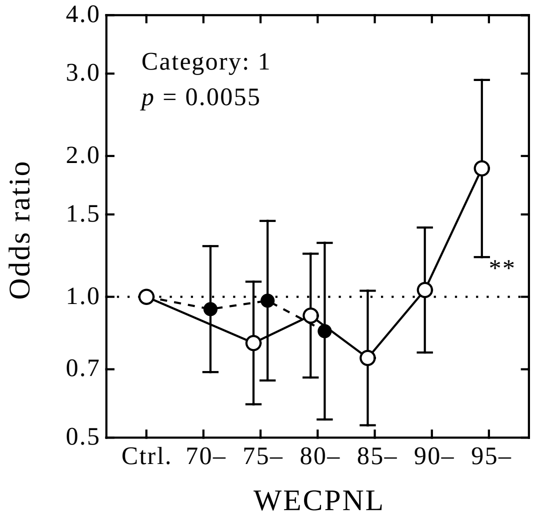

Figure 9.6 Odds ratio *vs.* WECPNL on subjective hard of hearing.

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Yamamoto T, Takagi K, Shoji H & Yoneda H (1970), Critical band with respect to temporary threshold shift, J. Acoust. Soc. Am. 48, 978–987.

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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 day-time, 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 dependent 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 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 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, legitimacy 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 hundred 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.

Acknowledgements

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Appendix A

Questionnaire of the survey on the life and local environment

A: Life satisfaction

A1. Generally speaking, are you satisfied with your present life? Please put a circle on only one item.

1. Highly satisfied. 2. Satisfied. 3. Slightly satisfied. 4. Neither satisfied nor dissatisfied 5. Slightly dissatisfied. 6. Dissatisfied. 7. Highly dissatisfied.

A2. What do you find of your health condition? Please put a circle on only one item.

1. I find myself very fine. 2. I find myself rather fine. 3. I do not find myself very fine. 4. I do not find myself fine.

A3. Answer the following questions on your content with your present life. Please put a circle on the only one figure in the option.

1) domestic life
2) economic situation
3) job (including domestic duties)
4) companionship with your friends, neighbours and relatives
5) leisure activities
6) participation to community activities like PTA, town association, volunteer activities

Option: 1. Highly satisfied. 2. Satisfied. 3. Slightly satisfied. 4. Neither satisfied nor dissatisfied 5. Slightly dissatisfied. 6. Dissatisfied. 7. Highly dissatisfied.

A4. Answer the following questions. Please put a circle on one figure in each option.

1) How often do you have a chat with your neighbours?

1. Very frequently. 2. From time to time. 3. Scarcely. 4. Not at all.

2) How often do you enjoy travelling, festivals, sports etc. with your neighbours as a group activity?

1. Very frequently. 2. From time to time. 3. Scarcely. 4. Not at all.

3) Have you anybody who makes you at ease and relaxed?

1. Yes. 2. Neither yes nor no. 3. No.

4) Have you anybody who agrees to your ideas and behaviour, and supports you?

1. Yes. 2. Neither yes nor no. 3. No.

5) Have you anybody whom you can share your most private feelings with?

1. Yes. 2. Neither yes nor no. 3. No.

6) Do you think you are a useful member of the society and needed by others?

1. Yes. 2. Neither yes nor no. 3. No.

7) Do you make efforts for reducing wastes and recycling used goods?

1. Yes. 2. Neither yes nor no. 3. No.

8) Do you feel low recently?

1. Yes. 2. Neither yes nor no. 3. No.

9) Do you find your life dreary and hopeless?

1. Yes. 2. Neither yes nor no. 3. No.

10) Are you without self-confidence in something or other?

1. Yes. 2. Neither yes nor no. 3. No.

A5. This is for those over 40 years old inclusive. If you are younger than 40 years, please go to the question B.

Here are some statements about life in general that people feel differently about. Would you read each statement in the list and answer every question on the list?

1) As I grow older, things seem worse than I thought they would be.
2) I have got more of the breaks in life than most of the people I know.
3) This is the dreariest time of my life.
4) I am just as happy as when I was younger.
5) These are the best years of my life.
6) Most of the things I do are boring or monotonous.
7) The things I do are as interesting to me as they ever were.
8) As I look back on my life, I am fairly well satisfied.
9) I have made plans for things I'll be doing a month or a year from

now.

10) When I think back over my life, I have got most of the important things I wanted.
11) Compared to other people, I get down in the dumps too often.
12) I've got pretty much what I expected out of life.
13) In spite of what people say, the lot of the average man is getting worse, not better.

1. Agree. 2. Neither agree nor disagree. 3. Disagree.

B: Neighbourhood and local environment

B1. As a resident do you find the place you live in now is a good place and are you satisfied with your neighbourhood?

1. Very good to live in. 2. Good to live in. 3. Rather good to live in. 4. Neither good, nor bad. 5. A little bad to live in. 6. Bad to live in. 7. Very bad to live in.

Respondents from 1 to 3.

In what sense do you find the place is a good place and are you satisfied with your neighbourhood? Please put circles on all the items you find appropriate.

Because

1. it is a convenient place.
2. I can find kind neighbours.
3. the area is full of life.
4. there is a full of green
5. the educational environment is good.
6. I can find a lot of good jobs.
7. there are good medical institutions.
8. the facilities of local office are well organised.
9. I have lived long and am familiar with the place.
10. of other reasons ( )

Respondents from 5 to 7.

In what sense do you find the place is not a good place and are you not satisfied with your neighbourhood? Please put circles on all the items you find appropriate.

Because

1. it is not a convenient place.
2. I cannot find kind neighbours.
3. the area is short of life.
4. there is a short of green.
5. the educational environment is bad.
6. I cannot find a lot of good jobs.
7. there are not good medical institutions.
8. the facilities of local office are not well organised.
9. the area is noisy.
10. the area is malodorous.
11. the air is dirty.
12. of other reasons ( )

B2. Do you want to keep on living in the area from now on? Or do you wish to move out if you can? Please put a circle on one of the answers from the point of view of your residential area, not of your residence. This does not mean that you really do it.
1. I want to live here throughout my life. 2. I do not want to move out particularly. 3. I want move out if possible. 4. I want move out as soon as possible. 5. No idea. 6. Others.

(B2-1) Why is that? Please write freely.

C: U.S. bases and their problems

C1. When you are at home, how do you find the noises from the U.S. bases such as aircraft noise? Are they annoying? Please put a circle on the only one figure in the option.
1. Very annoying. 2. Pretty annoying. 3. A little annoying. 4. Not very annoying. 5. Not annoying.

C2. When you are at school or in the college, how do you find the noises from the U.S. bases such as aircraft noise? Are they annoying? Please put a circle on the only one figure in the option.
1. Very annoying. 2. Pretty annoying. 3. A little annoying. 4. Not very annoying. 5. Not annoying.

C3. Is there any place where you hear aircraft noise and other noise from US bases more frequently in your daily life than at home, at school or in the office? Please put a circle on the only one figure in the option.

1. Yes, there is. (Go to the following questions.)
2. No, there is not. (Go to the question C4)

Questions to those who put a circle on "yes".

1) Where is it? (   )
2) How loud is the noise from bases? Please put a circle on the only one figure in the option.
   1. very loud. 2. pretty loud. 3. a little loud. 4. not very loud. 5. not loud.

C4. To what extent are you disturbed by aircraft noise and noise from bases? Please put a circle on the only one figure in the option of the items of disturbance.

Noises

1) disturb sleep.
2) jam conversation.
3) jam telephone use.
4) jam listening to TV, radio and CD etc.
5) interrupt watching TV.
6) interfere with work.
7) interrupt reading and thinking.
8) disturb rest.
9) is annoying.

I am

10) scared by aircraft noise.
11) scared because the noise reminds me of the war.
12) afraid of danger of traffic accident because the noises mask alarm-whistles

Write freely if there are some others.

Option:

1. Always. 2. Often. 3. Occasionally. 4. Seldom. 5. Never.

C5. When is the time of a day you are disturbed much by the aircraft noise from the bases? Please put circles on all the items you think appropriate. 1. Early in the morning, 0–7 hours. 2. Morning, 7–9 hours. 3. Daytime, 9–17 hours. 4. Late afternoon, 17–19 hours. 5. Evening, 19–22 hours. 6. Nighttime, 22–24 hours. 7. Not disturbed.

C6. What are the noises from the bases you are annoyed by? Please put single circles on the items you find annoying and put double circles on the items you find especially annoying.

Noise source

1. Jet fighter. 2. Jet transport aircraft. 3. Propeller transport aircraft. 4. Tanker transport. 5. Helicopter. 6. Others. 7. Not identified. 8. Nothing annoying.

Manoeuvres

9. Taking off. 10. Landing. 11. Over flight. 12. Engine adjustment and test. 13. Touch-and-go manoeuvre. 14. Turning flight. 15. Taxing. 16. Others. 17. Not identified. 18. Nothing annoying.

C7. To what extent you life is damaged by the noise from bases. Please put a circle on only one item.

1. Intolerably damaged. 2. Very much damaged. 3. Pretty damaged. 4. Slightly damaged. 5. Not damaged.

C8. Is your house sound-insulated according to the state programme? Please put a circle on yes or no.

1. Yes. (Go to the following questions.)

2. No. (Go to the question C9.)

Questions to those who put a circle on "yes".

1) How many rooms are insulated?

_______ rooms in _______ rooms of the house.

2) To what extent the sound-insulation works? Please put a circle on only one.

1. Sufficiently working. 2. Pretty working. 3. Somewhat working. 4. Not much working. 5. Not working at all.

3) Do you open the windows or shut them, when you are in the room sound-insulated? Please put a circle on only one.

1. I keep windows open in most cases. 2. I keep windows closed in most cases. 3. I sometimes open and sometimes close windows.

Questions to those who put a circle on 3.

a) How many hours in 24 hours of a day do you keep windows closed?

About ( ) hours.

b) In which occasion do you shut the windows? Please put a circle on as many items as appropriate.

1. When in bed. 2. When in a family circle. 3. When enjoying TV or radio. 4. When working or studying. 5. When letting children go to bed. 6. Others. ( )

4) As a whole, are you satisfied with the sound-insulation programme? Please put a circle on only one.
   1. Very much satisfied. 2. Satisfied. 3. Slightly satisfied. 4. Neither satisfied nor dissatisfied. 5. Slightly dissatisfied. 6. Dissatisfied. 7. Very much dissatisfied.

C9. Do you have the following anxiety? Please put a circle on one category of each item.
   1) Aircraft crash accident: 1. Very much. 2. Pretty much. 3. A little. 4. Not very much. 5 Not at all.
   2) Drop of objects from aircraft: 1. Very much. 2. Pretty much. 3. A little. 4. Not very much. 5 Not at all.
   3) Explosion of explosives and combustibles such as fuel tank in the base: 1. Very much. 2. Pretty much. 3. A little. 4. Not very much. 5 Not at all.
   4) Involvement in war: 1. Very much. 2. Pretty much. 3. A little. 4. Not very much. 5 Not at all.

D: Sleep

The followings are questions about your "sleep in the last one month."

D1. Have you kept regular hours of rising and bed-time on weekdays in the last one month? Please put a circle on one for each hour.
   - Hour of rising 1. Regular. 2. Slightly irregular. 3. Pretty irregular. 4. Very irregular.
   - Bed-time 1. Regular. 2. Slightly irregular. 3. Pretty irregular. 4. Very irregular.

D2. Do you habitually feel sleepy when you wake up in the morning? Please put a circle on only one.
   1. I don't feel sleepy. 2. I feel sleepy a little. 3. I feel pretty sleepy. 4. I feel very sleepy.

D3. Do you sometimes find difficulty in going to sleep in bed? Please put a circle on only one.
   1. I do more than three times a week. 2. I do once or twice a week. 3. I do once or twice a month. 4. I scarcely do. 5. I don't at all.

D4. Do you sometimes wake up in the night and find difficulty in going to sleep afterwards? Please put a circle on only one.
   1. I do more than three times a week. 2. I do once or twice a week. 3. I do once or twice a month. 4. I scarcely do. 5. I don't at all.

D5. Do you sometimes wake up too early in the morning? Please put a circle on only one.

1. I do more than three times a week. 2. I do once or twice a week. 3. I do once or twice a month. 4. I scarcely do. 5. I don't at all.

D6. Do you sometimes feel in the morning that you did not sleep well all night long? Please put a circle on only one.

1. I do more than three times a week. 2. I do once or twice a week. 3. I do once or twice a month. 4. I scarcely do. 5. I don't at all.

D7. Before you go to bed, do you sometimes get anxious worrying "Don't I sleep well tonight also?" Please put a circle on only one.

1. I do more than three times a week. 2. I do once or twice a week. 3. I do once or twice a month. 4. I scarcely do. 5. I don't at all.

D8. Sometimes you might not go to sleep easily or you might wake up in the night or you might feel in the morning you did not sleep well in the previous night. What is your condition after you get up when you didn't sleep well?

1. Different from usual. (Please put a circle on any items appropriate listed below.)

2. Same as usual. (Go to the question D9)

List of items:

1. I don't find any particular problem. 2. I make more mistakes than usual when I study and work. 3. As I feel sleepy, I cannot do anything with dispatch. 4. I am apt to take an unintentional siesta or a nap. 5. I don't feel better. 6. I feel heavy in the system. 7. Others. ( )

D9. How many times do you usually visit the toilet in a night (after going to bed till rising)? Please put a circle on only one.

1. None. 2. 1 or 2 times. 3. More than 3 times.

D10. Is your sleep sometimes disturbed during night due to the following noises? Please put a circle on one category appropriate for each item.

1) Noises made by the person(s) sleeping in the same room.
2) Voice of animals like dogs, fowls etc.
3) Road traffic noise.
4) Aeroplane noise and/or helicopter noise.
5) Noise of engine tuning and testing of aircraft.
6) Noises from bars and restaurant and karaoke sounds.
7) Construction noise.

Please write any noises or sounds disturbing your sleep.
( ) ( )
1. I am disturbed many times a week. 2. I am disturbed once or twice a week. 3. I am disturbed once or twice a month. 4. I am scarcely disturbed. 5. I am not disturbed at all.

E: About yourself

Please fill in the list.
Name ______________________ Male / Female
Date of birth ______________________ Age ______________________
Height ______________________ Weight ______________________
Address ____
Phone number ____
Occupation ______________________
Work place ______________________
Marriage (unmarried / married / divorced / separation by death)
Length of residence in the present place _____ years
Type of residential house (reinforced concrete / wooden / prefabricated / blocks & wood)
Year of building (19)

F: Free statement

Would you write anything whatever you might think about which is related to the contents of this questionnaire?

Appendix B

The Todai Health Index; a general health questionnaire English version 1991

Please answer the questions listed below. Your answer should be selected from the three (1,2,and3) answers prepared, by putting a circle as follows:
For example,

1 Do you eat sweets?
Often, 2 Sometimes, 3 Hardly ever or Never.

This Indicates that you eat sweets often.
Please circle the answer that you feel describes you best from among the three choices.

1. Do you eat sweets?
2. Do you go to bed early and get up early?
3. Has the inside of your mouth been rough, irritated or sore?
4. Do you have headaches?
5. Have you experienced coughing?
6. Is your skin sensitive?
7. Do you have indigestion?
8. Do things in your daily life irritate you?
9. Does your face flush?
10. Are you a perceptive person?
11. Do you feel blue ?
12. Do you envy people who are richer than you?
13. Do you experience feelings of dizziness?
14. Are you very sensitive to the cold?
15. Do you eat between meals?
16. Has your tongue been rough or raspy?

17. Have you experienced a sense of dullness or a heavy feeling in your head?
18. Do you sneeze?
19. Do your eyes get tired?
20. Do you belch or burp?
21. Do you feel irritated when someone makes you wait?
22. Do you worry about the past?
23. Do you think before you act?
24. Have you experienced a sense of dullness or a heavy sensation in your legs?
25. Do you think your character is easily misunderstood by others?
26. Are you calm and in control of yourself?
27. Do your gums look unhealthy?
28. Have you been told that your face looked pale?
29. Do you lose your temper when things don't go your way?
30. Do you feel like there is something in your throat?
31. Do you get abscesses or rashes?
32. Do you feel that your life is hopeless?
33. Do you have stomach pain?
34. How do you think of your body weight?
35. Do you have pains in various parts of your body?
36. Do you dislike a few of your acquaintances?
37. Do you lose interests in things you usually enjoy?
38. Do you find it easy to give your opinion in public?
39. Does your head feel "heavy" or "dull"?
40. Do you worry about what people think of you?
41. Do you worry about trivial or small things?
42. Do you have bad breath?
43. Do you have a poor appetite?
44. Do you become unfriendly or distant when you meet an impolite person?
45. Do you feel slightly faint or light headed when you stand up?
46. Do you feel lonely even when you attend a meeting or are in a group?
47. Do you read books on philosophy and classical literature?
48. Do you have difficulty in coughing up phlegm?
49. Do you have inflamed or red eyes?
50. Does your mouth " water " a lot ; that is, produce a lot of saliva?
51. Do you suffer from diarrhea?
52. Do you have any stiffness or pain in your neck or shoulders?

53. Do you have cold sweats?
54. Do you worry about soil or dirt on your clothes and hands?
55. Do you have blurred vision?
56. Are you bothered by bleeding gums?
57. Did a doctor ever say your blood pressure is?
58. Do you complain about things a lot?
59. Do you smoke more than 20 cigarettes a day?
60. Do you feel lonely?
61. Do you gossip about other people?
62. Do you have a runny nose?
63. Do you have hives or urticaria?
64. Do you feel queasy or nauseous when you brush your teeth in the morning?
65. Do you have low back pain?
66. Do you get mentally tired?
67. Do you feel flushed or feverish?
68. Do you finish your work on schedule?
69. Do you have high back pain?
70. Do you have constipation?
71. Do you feel your work load is too much?
72. Do you act without considering the consequences?
73. Do you drink a lot of alcoholic beverages?
74. Do you sometimes feel like not seeing other people?
75. Are you sensitive to the surroundings?
76. Does your heart pound or beat faster when you walk in a hurry?
77. Do you perspire when you have to reply to your boss or superior or while taking an examination?
78. Do you ever become ill?
79. Do you feel uneasy when in a strange place?
80. Do you have pain when you have a bowel movement?
81. Do you have periods of both mania and depression?
82. Do you feel languid or less energetic?
83. Are you bothered by trivial or small things?
84. Do you catch colds?
85. Do you feel pain of itching in your eyes?
86. Do you have stomach problems?
87. Do you get nervous and shaky when approached by your boss or superior?

88. Do your eyelids feel heavy?
89. Is your nose stuffy?
90. Do you feel inferior?
91. Do you find it hard to get up in the morning?
92. Do you tremble or feel weak whenever someone shouts at you?
93. Do you have heart burn?
94. Do you ever have bleeding hemorrhoids?
95. Do you skip breakfast?
96. Do you lose your temper over trivial things?
97. Do you have wheezing in your chest?
98. Do you get into violent rages?
99. Do you have skin eruptions or rashes?
100. Are you depressed?
101. Do you have discomfort in your stomach?
102. Do you read the newspaper editorial pages?
103. Are there times when you would like to take a rest or lie down in bed during the day?
104. Do you have swelling or inflammation in your mouth?
105. Do you become scared at sudden movements or noises at night?
106. Do you feel irritation or pain in your throat?
107. Are you nervous?
108. Do you have discharge from your eyes?
109. Do you feel your life is going badly?
110. Do you like to make people think that you are a better person than you are?
111. Do you have stomach pains after points a meal?
112. Are you inclined to worry about everything?
113. Have you been sleeping less lately?
114. Do you have swelling in your gums?
115. Are you upset when you are told to do something by others?
116. Are you timid?
117. Do you have phlegm or mucus in your throat?
118. Do you have itchy skin?
119. Have you had less confidence lately?
120. Do you have hot flashes?
121. Do you feel difficulty to continue in your work when your work is observed by others?

122. Are your meals irregular?
123. Do you feel like saying or doing things to impress people?
124. Are you a very particular person?
125. Do you feel angry when you are made to hurry by others?
126. Do you feel able to handle many tasks in a brief period of time?
127. Does your stomach hurt when it is empty?
128. Do you have pain in your lower abdomen?
129. Do you have difficulty climbing stairs?
130. Do you get short of breath when you walk in a hurry?