Bull. Org. mond. Santé
Bull. Wld Hlth Org. } 1969, **40**, 263-277

Comparative Epidemiological Features of Japanese Encephalitis in the Republic of Korea, China (Taiwan) and Japan

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The epidemiology of Japanese encephalitis in the Republic of Korea from 1949 to 1966 is described and comparisons are made with the situations in Japan and China (Taiwan). Some similarities and some differences are noted. Recent epidemics in Korea coincided with those in southern Japan but the annual fluctuations were more distinct in Korea. The disease mainly affected children in Korea and, in contrast to the situation in Japan, persons in the older age-groups were rarely affected. The authors also discuss the geographical pathology of Japanese encephalitis in Korea.

For many years a disease called "summer encephalitis" has been recognized in Korea (Yoshihara, 1932; Takai, 1933; Shiiba & Chun, 1936), and it is now clear that it is the same disease as Japanese encephalitis (JE). The JE virus was isolated for the first time from an American soldier in 1946 (Sabin et al., 1947) and was also recovered from Korean patients who died in the epidemic in 1949 (Lee & Kim, 1951, Ministry of Health and Social Affairs, Republic of Korea, 1963), when 5616 cases with 2727 deaths were reported. Epidemiological data have been available since that date, because the disease was then registered as one of the notifiable communicable diseases of prime importance in Korea. Thus, the epidemiological record shows that JE has been an annually recurring public health problem in Korea as in the other Western Pacific countries, Japan and China (Taiwan).

This paper will present some epidemiological aspects of JE in Korea in the period from 1949 to 1966; information is also given on the numbers of reported cases and deaths during that period, including details of age, sex, geographical distribution, and times of incidence: comparisons are made with data from Japan and China (Taiwan).

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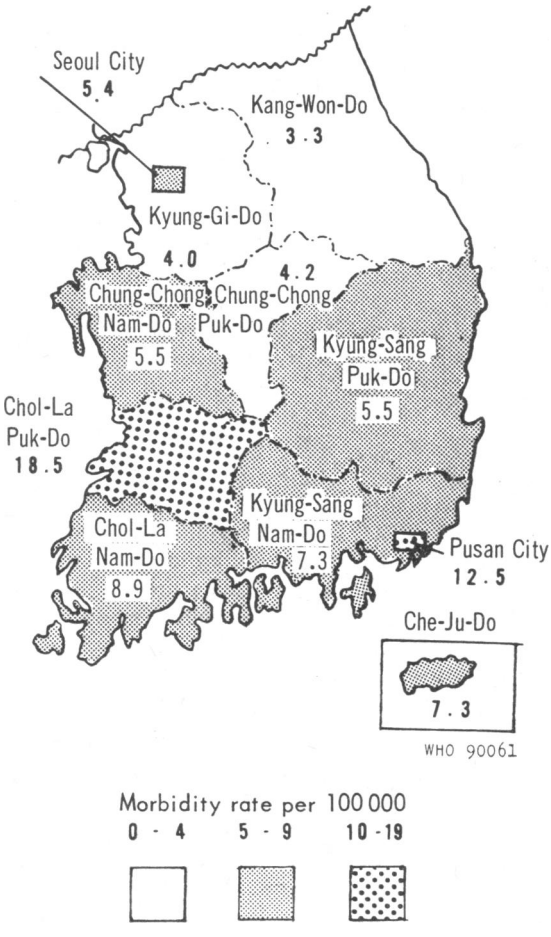
GEOGRAPHICAL DISTRIBUTION

With regard to the geographical distribution of JE in the Republic of Korea during the past 12 years (1955–66) on 6 occasions the highest incidence was recorded in the province of Chol-La Puk-Do where the highest morbidity rate reached 85.5 per 100 000 population in 1958 and its average for 12 years was 18.5 per 100 000 population. This figure is exceedingly high; the next highest occurred in the adjacent southern city of Pusan (12.5) and in the Provinces of Chol-La Nam-Do (8.9) and Kyung-Sang Nam-Do (7.3), as shown in Fig. 1 and 2 and Table 1. From these figures it is clear that the Province of Chol-La Puk-Do is the most important focus of JE in Korea, and that the disease is more prevalent in the south-eastern part of Korea along the borders of the Korean Straits and the Yellow Sea. However, on 1 occasion in 1962, the northern provinces showed higher incidences than those in the south, although the epidemic was not large.

In contrast the areas of high incidence in Japan were scattered, and changed from one district to another every few years; this movement of the focus was also observed in China (Taiwan) (Iimura, 1936; Matsuda, 1961; Wang, 1964).

The south-facing coastline of the Japanese mainland extends approximately from longitude 130°E to longitude 142°E and the part south of latitude 36°N is wider than that of Korea. This geographical

FIG. 1
MORBIDITY RATE OF JAPANESE ENCEPHALITIS PER 100 000 POPULATION IN THE REPUBLIC OF KOREA, 1955–66



difference between the 2 countries is probably one of the reasons for the tendency of the focus of JE to remain fixed or to move from one region to another. If Korea and Japan are considered together, JE tends to have been more prevalent to the south of latitude 36°N with an occasional epidemic in the zone lying between latitude 36°N and latitude 43°N. Fig. 3 depicts the epidemicity of JE by areas in both the Republic of Korea and Japan. The degree of prevalence in each province or prefecture is expressed in terms of an " epidemicity index ", which is calculated by the following formula:

Epidemicity index = [no. of years the prevalence exceeded (the mean annual case rate $+2\sigma$)] / [no. of years of observation]

In the above formula σ is the standard deviation of the mean annual morbidity rate in Japan for 19 years (1948–66): thus the mean annual case rate $+2\sigma$ was calculated as 6.0 per 100 000 population, and this figure was used as the basic figure for comparison of epidemicity indices.

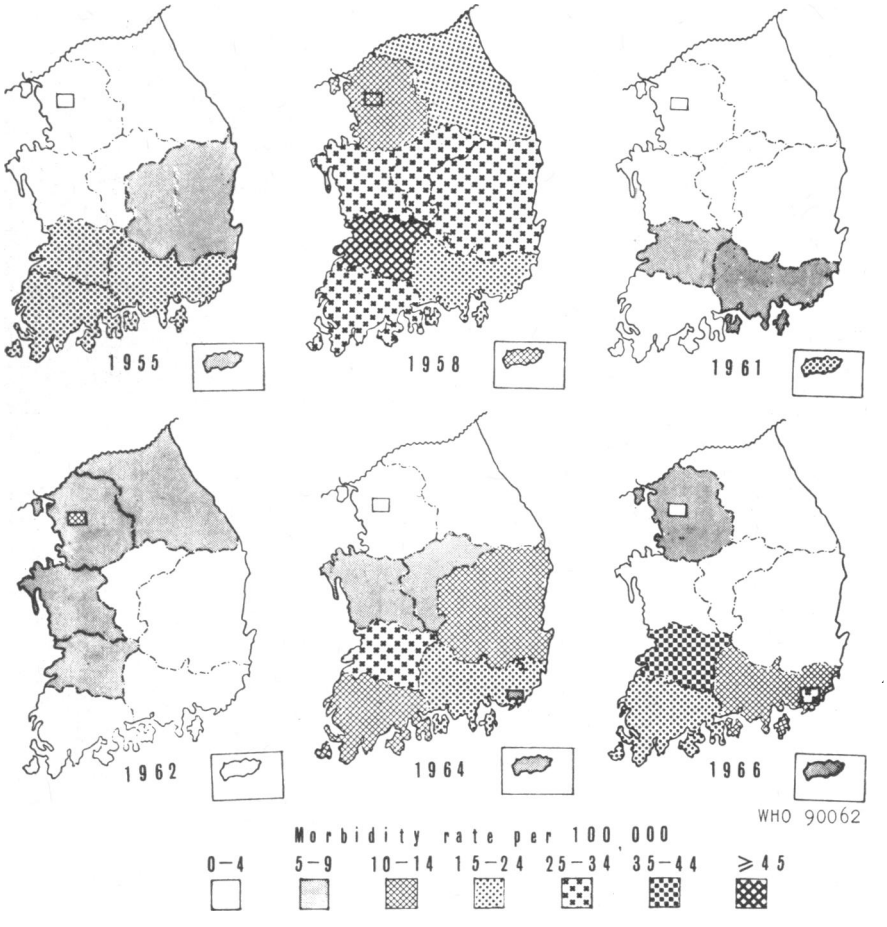
The numbers of years of observation were different in Korea and Japan, being 12 years in Korea (1955–66) and 19 years in Japan (1948–66). As shown in Fig. 3, all the epidemicity indices over 0.4 or 0.5 are found to the south of latitude 36°N and this zone is referred to as the " high epidemic zone ". Since lower epidemicity indices were observed between latitude 36°N and latitude 40°N, but as there were still definite, but less severe, JE epidemics in some summers this zone may reasonably be called the " moderate epidemic zone ". For the Korean peninsula no epidemiological information is available to the north of latitude 38°N, but in the northern part of Japan, particularly in Hokkaido and the northern part of Honshu, JE cases in human-beings were seldom found between latitude 40°N and latitude 43°N, and the disease has never been recorded north of latitude 44°N (Miura et al., 1955). The former zone can thus be designated as a " low epidemic zone " and the latter as a " JE-free zone ". Further, it is of interest to find a zone between latitude 43°N and latitude 44°N where no human cases but many equine cases were found in some years. This zone should therefore be called the non-epidemic–sub-epizootic zone. Thus, Hokkaido was considered by Kanamitsu (1967) as an ecotone in an ecological sense for the epidemiology of JE in Japan. It is probable that the same situation exists in the north of the Korean peninsula and in the maritime district of Siberia.

Of course, such a zonal classification of the epidemicity of JE in this part of the Far East is not considered absolute. Unusual climatic conditions, or the movement of vectors or reservoir animals may have facilitated a spread of JE further northwards perhaps once in several decades, as serological epidemiology showed that 5%–10% of the inhabitants over 40 years old in northern Hokkaido retained neutralizing antibody to JE virus (Kanamitsu, 1967).

ANNUAL INCIDENCE OF REPORTED CASES AND DEATHS

The number of cases and deaths reported during the past 18 years (1949–66) in the Republic of Korea

FIG. 2
MORBIDITY RATES BY AREAS IN THE REPUBLIC OF KOREA IN 6 DIFFERENT YEARS



has shown a rather irregular rise and fall. In 1949 when JE was first listed as a serious, notifiable, communicable disease, the number of cases and deaths reported was 5616 (27.8 per 100 000) and 2729 (13.5 per 100 000) respectively. After that outbreak, over 1000 cases were recorded every 3 years up to 1958, when the largest epidemic so far occurred; in 1958 a total of 6897 cases (29.7 per 100 000) and 2177 deaths (9.4 per 100 000) were reported. From 1959 to 1962 the number of cases steadily decreased, but remained over 1000 per year, and then fell to 19 cases in 1963. The years 1964 and 1966 were again epidemic years whilst in 1965 there were fewer cases (Fig. 4).

In general, large fluctuations in the annual number of cases and deaths are considered to be one of the epidemiological characteristics of JE in Korea in comparison with the more regular annual incidence in Japan. This tendency is shown in Fig. 4 and in Table 1. The small number of cases reported in 1950 and 1951 was probably due to under-reporting during the Korean war, but it is considered fairly certain that there really were few cases in 1957 and 1963, as no similar decrease was observed in these 2 years in other communicable diseases. Therefore, in order to obtain an accurate comparison of the incidence in Korea and Japan we have compared the annual morbidity rates from 1955 to 1966: the figure for

TABLE 1

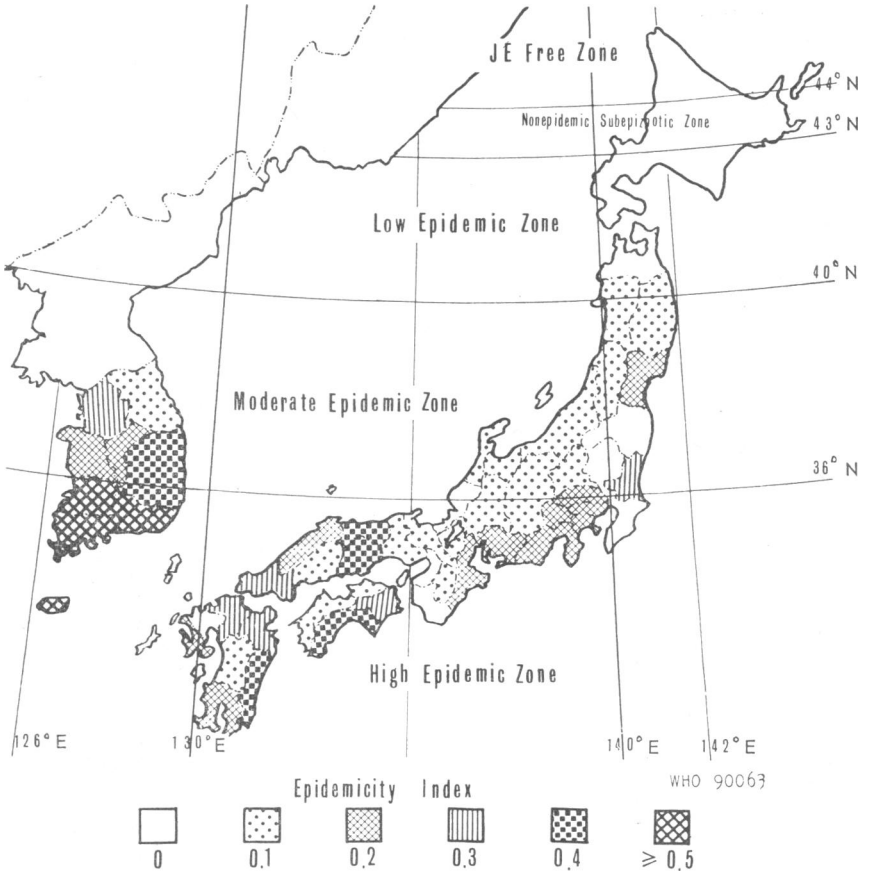
ANNUAL NUMBER OF CASES AND DEATHS, AND THE MORBIDITY AND MORTALITY RATE OF JAPANESE ENCEPHALITIS IN THE REPUBLIC OF KOREA BY AREAS, 1955–66

Area [a]		1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Total	Average case and death rates (per 100 000) [b]	Average case-fatality rates (%)
Seoul City	C	11 (0.7)	—	2 (0.1)	286 (13.8)	322 (14.2)	102 (4.1)	43 (1.6)	358 (12.6)	—	150 (4.6)	245 (7.1)	150 (4.1)	1 669	5.4	
	D	5 (0.3)	—	1 (0.0)	107 (5.1)	91 (3.9)	47 (1.9)	27 (1.0)	140 (4.9)	—	69 (2.1)	88 (2.6)	54 (1.5)	629	2.0	37.7
Pusan City	C										128 (9.6)	10 (0.7)	402 (26.6)	540	12.5	
	D										39 (2.9)	2 (0.1)	110 (7.8)	151	3.5	27.9
Kyung-Gi-Do	C	48 (2.0)	—	1 (0.0)	292 (12.2)	183 (6.9)	73 (2.6)	37 (1.3)	176 (6.2)	—	75 (2.6)	167 (5.6)	251 (8.3)	1 303	4.0	
	D	28 (1.2)	—	—	140 (5.4)	81 (3.0)	34 (1.2)	26 (0.9)	71 (2.5)	—	42 (1.4)	81 (2.7)	68 (2.2)	571	1.7	43.8
Kang-Won-Do	C	5 (0.3)	—	—	247 (15.7)	62 (3.9)	15 (0.9)	21 (1.3)	87 (5.2)	3 (0.2)	48 (2.8)	67 (3.8)	88 (4.9)	643	3.3	
	D	5 (0.3)	—	—	119 (7.6)	23 (1.4)	8 (0.5)	14 (0.9)	28 (1.7)	3 (0.2)	25 (1.5)	31 (1.7)	37 (2.1)	293	1.6	45.5
Chung-Chong Puk-Do	C	24 (2.0)	—	—	370 (28.7)	92 (6.9)	10 (0.7)	19 (1.4)	—	—	104 (7.0)	—	73 (4.7)	692	4.2	
	D	10 (0.8)	—	—	92 (7.1)	20 (1.5)	3 (0.2)	3 (0.2)	—	—	31 (2.1)	—	19 (1.2)	178	1.1	25.7
Chung-Chong Nam-Do	C	79 (3.6)	3 (0.1)	1 (0.0)	649 (27.2)	218 (8.9)	108 (4.3)	61 (2.4)	134 (5.0)	—	145 (5.1)	41 (1.4)	123 (4.1)	1 562	5.5	
	D	38 (1.7)	3 (0.1)	1 (0.0)	195 (8.2)	73 (3.0)	53 (2.1)	28 (1.1)	39 (1.5)	—	38 (1.3)	16 (0.6)	31 (1.0)	515	1.8	32.9
Chol-La Puk-Do	C	355 (16.7)	47 (2.2)	43 (1.9)	1 950 (85.5)	358 (15.3)	255 (10.7)	132 (5.5)	168 (6.9)	10 (0.4)	781 (31.5)	106 (4.2)	1 090 (43.1)	5 295	18.5	
	D	122 (5.8)	20 (0.9)	16 (0.7)	414 (18.1)	83 (3.5)	68 (2.8)	37 (1.5)	27 (1.1)	4 (0.2)	230 (9.3)	29 (1.2)	275 (10.9)	1 325	4.7	25.0
Chol-La Nam-Do	C	561 (17.9)	17 (0.5)	26 (0.8)	1 146 (34.2)	303 (8.8)	332 (9.5)	137 (3.8)	56 (1.5)	1 (0.0)	457 (11.7)	—	779 (19.0)	3 815	8.9	
	D	180 (5.8)	5 (0.1)	7 (0.2)	415 (12.4)	107 (3.1)	97 (2.8)	24 (0.7)	12 (0.3)	1 (0.0)	111 (2.9)	—	173 (4.2)	1 132	2.6	29.7
Kyung-Sang Puk-Do	C	317 (9.4)	60 (1.7)	33 (0.9)	965 (26.5)	242 (6.5)	88 (2.3)	173 (4.4)	45 (1.1)	—	558 (12.9)	—	143 (3.1)	2 624	5.5	
	D	166 (4.9)	35 (1.0)	15 (0.4)	355 (9.7)	107 (2.9)	45 (1.2)	61 (1.5)	16 (0.4)	—	209 (4.8)	—	47 (1.0)	1 056	2.2	40.2
Kyung-Sang Nam-Do	C	640 (17.0)	142 (3.7)	25 (0.6)	950 (23.7)	294 (7.2)	237 (5.7)	371 (8.7)	14 (0.3)	—	484 (15.1)	85 (2.6)	469 (14.4)	3 711	7.3	
	D	277 (7.3)	61 (1.6)	16 (0.4)	326 (8.2)	152 (3.7)	92 (2.2)	129 (3.0)	8 (0.2)	—	164 (5.1)	25 (0.8)	139 (4.3)	1 389	2.7	37.4
Che-Ju-Do	C	16 (5.5)	—	1 (0.4)	42 (14.7)	19 (6.7)	28 (9.9)	64 (22.1)	—	5 (0.2)	22 (6.9)	31 (9.5)	29 (8.7)	257	7.2	
	D	6 (2.1)	—	—	14 (4.9)	5 (1.8)	10 (3.5)	26 (9.0)	—	—	8 (2.5)	12 (3.7)	4 (1.2)	85	2.4	33.1
Total	C	2056 (9.6)	269 (1.2)	132 (0.6)	6897 (29.4)	2093 (8.7)	1248 (5.0)	1058 (4.1)	1038 (4.0)	19 (0.1)	2952 (10.6)	752 (2.6)	3597 (12.3)	22 111	7.3	
	D	837 (3.9)	124 (0.6)	56 (0.3)	2177 (9.3)	742 (3.1)	457 (1.8)	375 (1.5)	341 (1.3)	8 (0.0)	966 (3.5)	284 (1.0)	957 (3.3)	7 324	2.4	

[a] C = cases; D = deaths.

[b] The populations for each year were estimated by the graphic method, using the population of Korea 1955, 1960 and 1965 shown in the Republic of Korea, Ministry of Health and Social Affairs, *Year-Book of Public Health and Social Statistics* 1965.

FIG. 3
EPIDEMICITY OF JAPANESE ENCEPHALITIS IN THE REPUBLIC OF KOREA AND JAPAN



Korea varied from 29.7 (1958) to 0.1 (1963) whilst in Japan the morbidity rate varied from 5.0 (1956) to 1.2 (1965). The average attack-rate during the 12 years from 1955 to 1966 was 7.3 per 100 000 population in Korea and 2.5 per 100 000 in Japan. The standard deviations calculated from these data are 8.05 and 1.05 and the coefficients of variance of the annual morbidity rates in Korea and Japan are 110% and 42% respectively. These figures clearly indicate larger annual fluctuations in the occurrence of JE in Korea than in Japan.

In the southern part of Japan, JE is prevalent every summer with little fluctuation in intensity, but in the north the disease occurs irregularly and the morbidity rates are liable to fluctuate considerably. This situation is demonstrated by the 2 districts, Kyushu (south of latitude 34°N) and Tohoku (mainly north of latitude 38°N) in Fig. 4. The north of Japan thus resembles Korea in this respect.

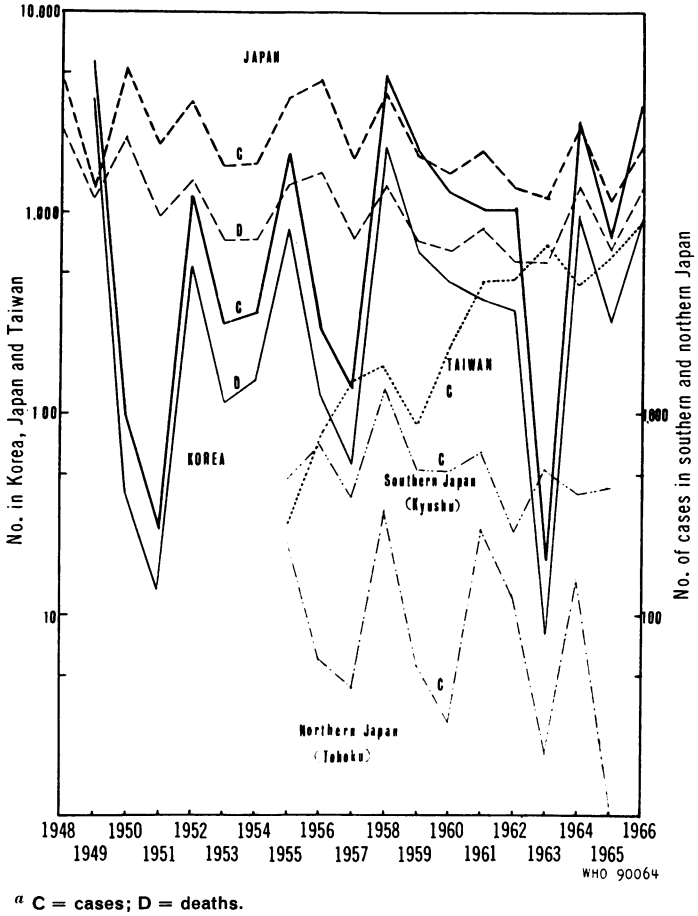
It is also interesting to find that the fluctuations in the incidence of JE in Korea and Japan were similar, particularly after 1957: both countries experienced large epidemics in 1958, 1964 and 1966. During these 10 years the epidemics in Japan mainly affected the south-western part of the country, that is the part adjacent to Korea. On the contrary, it is hard to correlate the incidence of JE in China (Taiwan) with the incidence in the other 2 countries.

AGE AND SEX DISTRIBUTION OF CASES AND DEATHS

An analysis of the age distribution of cases of JE in Korea during the 12 years from 1955 to 1966

FIG. 4

NUMBER OF CASES AND DEATHS FROM JAPANESE ENCEPHALITIS IN THE REPUBLIC OF KOREA, JAPAN AND CHINA (TAIWAN) [a]



[a] C = cases; D = deaths.

shows that 90.1% of the total cases occurred in the age-groups under 14, and that children from 4 to 7 years old were most severely affected (Table 2). In the epidemic of 1966 the morbidity rate was highest in the 5–9-years age-group, at 47.6 per 100 000 population and then decreased with increasing age. This pattern contrasts with the situation in Japan. There the highest percentage of JE patients was in the 5–9-year age-group (30%) in 1956–58, as shown in Fig. 5, but after this the prevalence in this age-group decreased and more cases occurred in persons over 50 years of age. The mean age of patients in Korea and China (Taiwan) was 7.1 years for the period from 1955 to 1966 and 6.6 years from 1957 to 1966 respectively. Recently in Japan the age distribution of JE has been bimodal with peak incidences in the 5–9-year age-group and in the 60–69-year age-group (1962 to 1964).

When compared by age-specific morbidity and mortality rates, the above tendency is much more pronounced. Table 3 shows the figures for the Republic of Korea and Japan. In Korea the age-group 5–9 years showed the highest morbidity and mortality rates, and in Japan both rates were remarkably high among older persons. However, it is possible that the fatality rate in the older age-groups was overestimated in Japan (see p. 271). The differences in age distribution mentioned above are important and interesting phenomena in the epidemiology of JE and should be investigated further.

TABLE 2

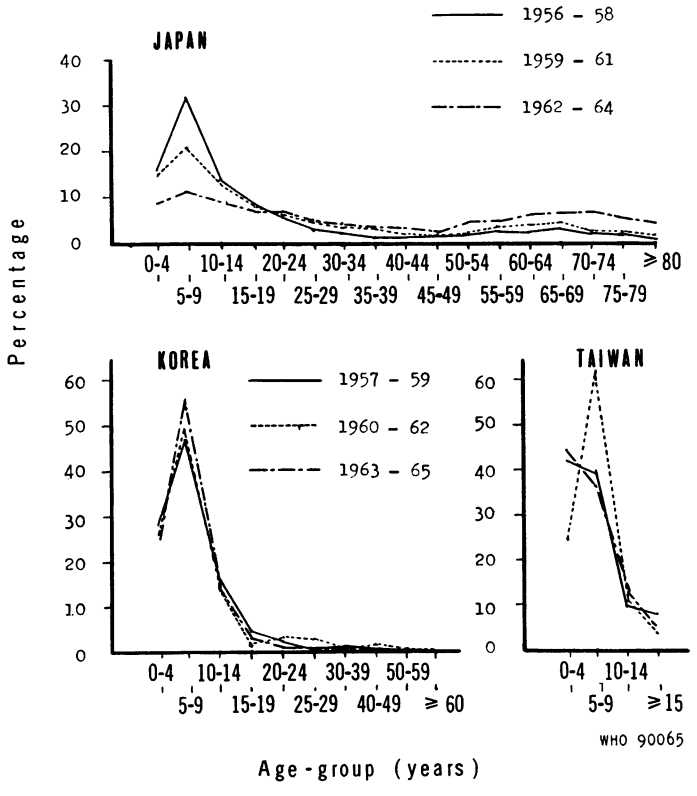
NUMBER OF CASES AND NUMBER OF DEATHS OF REPORTED CASES OF JAPANESE ENCEPHALITIS IN THE REPUBLIC OF KOREA BY AGE, 1955–66 [a]

Age (years)	1955		1956		1957		1958		1959		1960		1961		1962		1963		1964		1965		1966		Total	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D	C	D
0	7	5													1	1			3	1	2	1	4		17	8
1	19	3	11	8	7	5	210	37	50	16	24	7	33	8	16	5	1		50	17	11	6	80	18	512	130
2	89	32	11	6	8	5	368	106	102	28	86	19	59	22	34	11	1	1	107	33	27	9	134	34	1 026	306
3	108	45	14	6	11	5	628	181	150	48	114	35	110	38	84	28	2	1	216	71	38	15	277	64	1 752	537
4	255	95	29	15	14	8	803	256	220	69	127	42	89	29	108	34	2		361	108	88	36	459	118	2 555	810
0–4	478	180	65	35	40	23	2 009	580	522	161	351	103	291	97	243	79	6	2	737	230	166	67	954	234	5 862	1 791
5	214	88	28	11	11	6	866	286	267	109	183	83	113	49	125	40	4	2	464	146	111	40	513	139	2 899	999
6	261	107	26	11	15	6	696	221	236	83	180	74	121	42	121	42	2	2	423	136	81	34	544	163	2 705	921
7	231	88	28	13	8	2	697	227	169	65	142	51	108	41	95	30			336	110	67	21	477	133	2 358	781
8	211	87	22	6	11	1	521	169	185	64	74	29	71	20	94	34	1	1	234	83	85	31	302	75	1 811	600
9	146	57	13	6	9	3	433	123	120	42	73	26	76	27	62	18	1		180	58	58	22	232	49	1 403	431
5–9	1 063	427	117	47	54	18	3 213	1 026	977	363	652	263	488	179	497	164	8	5	1 637	533	402	148	2 068	559	11 176	3 732
10	115	41	13	3	8	3	308	114	98	38	41	16	59	20	63	26			126	54	43	10	162	54	1 036	379
11	65	26	14	10	4	1	257	79	86	31	22	7	31	11	43	16	1		95	28	23	7	99	30	740	246
12	66	24	11	2	4	1	237	79	82	29	38	17	25	6	27	5			87	25	22	11	76	22	675	221
13	52	26	12	5	3	2	142	30	60	15	27	7	23	3	28	7			42	12	18	6	52	9	459	122
14	38	13	6	3	4		95	30	45	18	23	9	14	3	23	7	1	1	33	9	10	2	46	12	338	107
10–14	336	130	56	23	23	7	1 039	332	371	131	151	56	152	43	184	61	5	1	383	128	116	36	435	127	3 248	1 075
15–19	96	51	11	6	6	3	300	103	97	34	34	11	44	18	41	17	2		89	30	29	13	79	15	828	301
20–24	30	21	6	4	3	2	156	46	38	12	24	9	51	19	19	4	1		24	11	12	6	28	6	392	140
25–29	9	7	8	5	3	1	30	10	26	13	11	3	8	5	8	2			19	9	8	5	11	3	141	63
30–39	20	9	2				77	41	21	8	12	6	10	7	19	5			18	9	6	1	10	7	195	93
40–49	13	7	1	1	1	1	37	20	13	9	7	3	8	5	6	2			12	5	3	2	7	2	108	57
50–59	4	3	1	1			17	8	15	7	3	1	2	1	4	2			3	1	3	1	4	4	57	29
⩾60	4	2					19	11	6	4	3	2	4	1	10	1			2	2	2		1		51	23
Unknown	3		2	2	2	1			7						7	4			28	8	5	5			54	20
Total	2 056	837	269	124	132	56	6 897	2 177	2 093	742	1 248	457	1 058	375	1 038	341	19	8	2 925	966	752	284	3 597	957	22 111	7 324

[a] C = cases; D = deaths.

FIG. 5

AGE DISTRIBUTION AMONG JAPANESE ENCEPHALITIS PATIENTS IN THE REPUBLIC OF KOREA, JAPAN AND CHINA (TAIWAN)



Studies of the sex distribution of cases of JE in Korea show that males are more often affected than females. In Japan in the middle and older age-groups the morbidity rate of females is higher than that of the males. This trend was not clear in Korea, as there were few cases of JE among older persons.

SEASONAL DISTRIBUTION

Table 4 shows the seasonal distribution of the reported cases of JE in the period from 1956 to 1960 and in 1966. The main epidemic period was between mid-August and mid-September (94.9% of the total number of cases) regardless of the epidemic size.

The first cases were usually reported in late July or early August, and the epidemics ceased in late October. This seasonal pattern was similar to that observed in the central part of Japan, at approximately the same latitude as the high-epidemic regions of Korea.

It is known that in Japan the JE epidemic usually starts in the south-western part of the country and moves towards the north-east during the epidemic season: Mitamura, Kitaoka & Miura (1947) called this the "northward advancing phenomenon". Hence, it is of interest to know whether the same thing happens in Korea. Fig. 6 illustrates the seasonal pattern of JE in 9 Provinces and 2 large cities of Korea, in 1966. As far as the 1966 epidemic was concerned in these 11 areas, the largest outbreak occurred in Chol-La Puk-Do and the beginning and peak (week no. 34) of the outbreak were also earliest in this province (Fig. 6). The peak incidence in Chol-La Nam-Do occurred 1 week later and that in Kang-Won-Do (in the north-east) 3 weeks later.

TABLE 3

AGE-SPECIFIC MORBIDITY AND MORTALITY RATES OF JAPANESE ENCEPHALITIS PER 100 000 POPULATION AND THEIR SEX RATIO IN THE REPUBLIC OF KOREA AND JAPAN

Age-group (years)	Japan, 1964							Korea, 1966						
	Total [a]		Male [a]		Female [a]		Sex ratio of morbidity [b]	Total [a]		Male [a]		Female [a]		Sex ratio of morbidity [b]
	C	D	C	D	C	D		C	D	C	D	C	D	
0–4	2.1	0.7	2.3	0.6	2.0	0.8	1.15	20.8	5.1	23.2	4.7	18.1	5.4	1.28
5–9	3.2	0.9	3.9	1.0	2.3	0.8	1.70	47.6	12.8	56.0	14.3	36.8	11.3	1.52
10–14	2.0	0.4	2.6	0.4	1.5	0.4	1.73	14.2	4.1	17.7	5.1	10.5	3.0	1.68
15–19	1.9	0.5	2.4	0.6	1.5	0.3	1.60	3.0	0.6	3.3	0.7	2.6	0.5	1.26
20–24	2.0	0.6	2.1	0.6	1.9	0.6	1.10	1.1	0.2	1.0	0.1	1.2	0.3	0.83
25–29	1.8	0.5	1.9	0.5	1.7	0.6	1.12	0.5	0.1	0.6	0.1	0.3	0.2	2.0
30–34	1.3	0.5	1.5	0.6	1.1	0.4	1.36	0.2 [c]	0.1 [c]	0.3 [c]	0.1 [c]	0.1 [c]	0.1 [c]	3.0 [c]
35–39	1.4	0.5	1.6	0.6	1.1	0.5	1.45							
40–44	1.3	0.8	1.4	0.9	1.2	0.6	1.17							
45–49	1.6	0.9	1.6	0.8	1.7	1.1	0.94							
50–54	2.4	1.4	2.1	1.2	2.7	1.7	0.78							
55–59	3.5	2.2	3.2	2.2	3.8	2.1	0.86							
60–64	5.3	3.3	5.9	3.6	4.9	3.0	1.25							
65–69	8.5	7.3	9.1	7.8	8.0	6.9	1.14							
70–74	12.1	8.6	12.1	7.7	12.2	9.3	0.99							
75–79	17.7	15.3	17.2	15.4	18.0	15.1	0.96							
80–84	18.3	17.3	16.1	14.5	19.4	18.8	0.83							
⩾85	19.1	15.8	17.3	18.3	19.4	14.7	0.89							

[a] C = morbidity rate; D = mortality rate.
[b] Male/female.
[c] 30 years of age or over.

Therefore, the " northward advancing phenomenon " was not so distinct as in Japan, probably because of differences in the geography and summer climate, but there was a tendency of the JE epidemic to occur later in the north-eastern provinces.

CASE-FATALITY RATE

The case-fatality rate, which has been calculated from the reported numbers of cases and deaths, is referred to as the crude case-fatality rate hereafter, since it gives only a rough estimate: the true case-fatality rate should be based on the number of cases confirmed at the bedside. In Korea the crude case-fatality rate was about 40% until 1957, then decreased to 26.6% in 1966. The decrease may have been due to better reporting or to improvements in treatment.

The crude fatality rate in Japan, as shown by Table 5, remained at about 40% until 1962, then increased after 1963, reaching 66.8% in 1966. There seem to be 2 plausible explanations for this increase, (1) the recent increasing involvement of the older age-groups which show higher fatality rates, and (2) the tendency since 1963 to report only serologically confirmed cases whilst the reporting of JE deaths is still based on clinical diagnosis, because the deaths often come in the early days of the illness when a rise in antibody is hard to detect: the number of reported deaths may thus include some deaths not due to JE. Thus the crude fatality rate should not be accepted at its face value, the true figure probably being about half the reported figure. According to the result of an elaborate survey of JE in Japan in 1965, the true fatality rate was 32.1% of the

TABLE 4

SEASONAL DISTRIBUTION OF JAPANESE ENCEPHALITIS CASES AND DEATHS IN THE REPUBLIC OF KOREA IN 1956–60 AND 1966 [a]

Time of year		1956 [b]		1957 [b]		1958 [b]		1959 [b]		1960 [b]		1966 [b]		Total no. of cases [c]	Percentage of total no. of cases
		C	D	C	D	C	D	C	D	C	D	C	D		
July	1–10														
	11–20							2				8	4	10	0.07
	21–31							3				39	7	42	0.30
Aug.	1–10					42	4	11	6	5	1	38	7	96	0.67
	11–20	13		4		1 390	188	192	47	99	18	742	120	2 440	17.14
	21–31	63		27	5	3 131	937	553	141	449	103	1 229	361	5 452	38.30
Sept.	1–10	77		61	18	1 558	589	871	234	466	157	1 065	284	4 098	28.78
	11–20	90		35	23	539	263	337	185	163	109	357	121	1 521	10.68
	21–30	18		4	6	208	129	111	87	51	49	27	19	419	2.95
Oct.	1–10	5		1	4	27	20	11	25	12	9	92	34	148	1.04
	11–20	2					27	1	12	3	10			6	0.04
	21–31	1				2	20	1	5		1			4	0.03
Total		269		132	56	6 897	2 177	2 093	742	1 248	457	3 597	957	14 236	100.00 %

[a] No cases occurred in November.
[b] C = cases; D = deaths.
[c] In the 6 years quoted.

confirmed cases in all age-groups. As shown in Table 6, the fatality rates were lower for the younger patients and higher for the older ones. The figures for the confirmed cases in Taiwan show fatality rates almost identical with those of children in the 0–4 age-group in Japan. However, the over-all fatality rate in Taiwan is about half that in Japan, and this is clearly because of the greater involvement of older patients in Japan. From the above figures it seems probable that the case fatality rate of confirmed JE cases would be considerably lower than the crude fatality rate mentioned above, probably as low as that in Taiwan.

DISCUSSION

The importance of JE from the public health point of view was first recognized during the outbreak in 1949 in Korea, and thereafter, further serious epidemics recurred in 1955, 1958, 1964 and 1966.

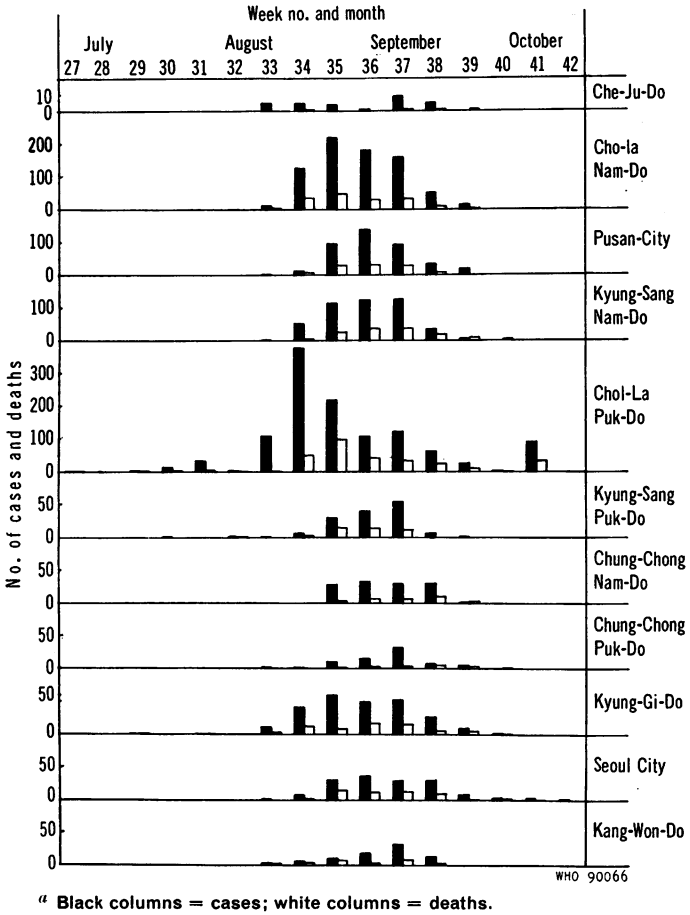
There are many studies of the epidemiology of JE in Korea (Sabin et al., 1947; Duel et al., 1950; Hullinghorst et al., 1951; US Army, 1958; Chang, Han & Lee, 1959; Lee, 1962; Chun, 1965), but only a few of them (Mitamura, Kitaoka & Miura, 1950; Scherer, 1966) treat of the problem from the broader aspects of geographical pathology. In this paper we have presented some of the epidemiological features of JE in Korea and have compared the patterns in Japan and in China (Taiwan), attempting to regard it as a problem common to this part of the Far East. Since our analysis depends mostly on reported cases and deaths it is not considered perfect. However, our survey gives an over-all picture of JE in this part of the Far East and has drawn attention to points of similarity and points of difference.

The seasonal pattern of incidence in Korea is similar to that found in the middle and north-east part of the Japanese mainland, and the annual epidemic waves are fairly consistent with those found in the south-western part of Japan.

A second interesting point about the epidemiology of JE in Korea is that Chol-La Puk-Do has always constituted the focus of the epidemics. The area must offer special advantages for the development of

FIG. 6

SEASONAL AND GEOGRAPHICAL DISTRIBUTION OF JAPANESE ENCEPHALITIS CASES AND DEATHS IN THE 1966 EPIDEMIC IN THE REPUBLIC OF KOREA [a]



[a] Black columns = cases; white columns = deaths.

the JE virus and the reasons for this must be investigated. However, in 1962 and probably in 1949, JE was more prevalent in the northern districts rather than the southern provinces (Hullinghorst et al., 1951). Whether this was due to climatic conditions in the north being more favourable for the spread of JE in these years remains to be elucidated.

If Korea and Japan are considered together, the high and moderate epidemic zones can be separated approximately along the 36°N parallel: in the former zone epidemics occur annually, whilst in the latter they occur irregularly, probably when climatic conditions favour the vector–reservoir relationship which allows the spread of the JE virus.

The most striking difference is that of age distribution: in Korea and Taiwan, JE has been almost entirely a disease of young children, whereas in Japan greater numbers of older people have been affected and fatality rates among these older people have been extremely high.

Serological surveys in Taiwan and Korea showed that 90%–100% of the adult population maintained antibodies to the JE virus (Sabin et al., 1947). Sero-epidemiological studies in Japan also showed more positive antibody titres among adults than children (Sabin et al., 1947), although a recent survey (Committee of Surveillance of Communicable Disease, Osaka Municipality, 1967) suggests that the numbers

TABLE 5

CASE-FATALITY RATES CALCULATED ON THE BASIS OF REPORTED CASES AND DEATHS

Year	Republic of Korea	Japan
1955	40.7	37.1
1956	46.1	35.3
1957	42.4	41.5
1958	31.6	34.6
1959	35.4	36.5
1960	36.6	40.4
1961	35.4	40.2
1962	32.8	41.7
1963	42.1	47.0
1964	32.7	50.8
1965	37.7	55.6
1966	26.6	66.8

may be rather lower in Japan than in Korea and Taiwan. Matsuda (1961) tried to explain the decrease in the number of younger patients as being a result of the wide use of JE-virus vaccine among schoolchildren in Japan, but it is not so simple as that, as this phenomenon is observed irrespective of past vaccination. For instance, the morbidity and mortality rates of JE in Japan were lower in the population under 30 years of age during the period from 1921 to 1933, and then increased sharply in the younger generation in the 1940s and 1950s (Iimura, 1936; Mutsuda, 1961). There has been a suggestion that age distribution is partly determined by the geographical location of the epidemic focus, the patients being younger in the north-east and older in the south-west (Iimura, 1936; Matsuda, 1961). According to the 1965 survey a U-shaped age-distribution curve resulted from the greater involvement of children in the north-east and of older people in the south-west of Japan (Okuno et al., 1967). Such a tendency has never been observed in Korea and Taiwan where older patients are extremely rare. It is very hard to believe that the older JE patients in Japan had never been exposed to JE virus until they succumbed to the disease, when one considers the wide dissemination of the JE virus in nature. Ishii, Matsunaga & Kono (1968) reported serological evidence which suggested that some of those patients had been previously exposed to the JE virus before suffering from the disease. It is conceivable that improvements in environmental sanitation have decreased the chances of exposure to the JE virus, thus lowering the level of immunity in the population. The inhabitants of Korea and Taiwan, however, have been more exposed to the JE virus, and retain a higher level of immunity which would be sufficient to prevent involvement of the central nervous system on subsequent exposure to the virus. In these circumstances it is understandable that the disease is confined to children. This hypothesis should be confirmed by laboratory tests in 3 areas in which the ecology of the human hosts is different and in which different reservoir animals and insect vectors are present.

The question still remains, however, whether there really are few JE patients in the older age-groups in Korea and Taiwan. Therefore, it is important that an elaborate surveillance of each JE case should be carried out in Korea and Taiwan based on both clinical diagnosis and laboratory confirmation.

Since the efficacy of JE vaccine was clearly shown in a field trial in Taiwan (Wei et al., 1966), there is hope that the outbreaks of JE among children in Korea and Taiwan may be controlled by vaccination.

Domestic pigs are one of the main reservoirs, or amplifiers, for human epidemics in Japan (Oya, 1967). We could not find a direct relationship between human morbidity rates and pig population densities in the provinces of Korea, although there have been many reports (Lee et al., 1955) which suggest that pigs and other domestic animals might serve as reservoirs or amplifiers of the JE virus in Korea.

In the Japanese mainlands, environmental contamination by the JE virus is demonstrated by the positive conversion of neutralizing antibody in almost all newly-born piglets, by the first exposure to the JE virus during the summer, even though human cases of JE are rare. It is probable that the same thing happens in Korea, which is at a similar latitude to the middle or northern regions of Honshu, Japan, as domestic animals which could serve as natural amplifiers of the JE virus are abundant. The fact that the human morbidity rate is higher in Korea than in Japan, in epidemic years, is probably a reflection of heavier human exposure to the virus in Korea than in Japan. In other words, the vectors which transmit JE may be more abundant in Korea and may be more efficient in transmitting the disease to man. Further support for this hypothesis is

TABLE 6

NUMBER OF CASES OF JAPANESE ENCEPHALITIS RESULTING IN COMPLETE RECOVERY, RECOVERY WITH SEQUELAE, OR DEATH, IN JAPAN AND CHINA (TAIWAN) IN 1965

Age-group (years)		Japan				China (Taiwan)		
		Recovered completely	Recovered with sequelae	No. of deaths	Total no. of cases	No. recovered	No. of deaths	Total no. of cases
0–4	No.	25	21	11	57	135	30	165
	%	(43.8)	(36.9)	(19.3)		(81.2)	(18.8)	
5–9	No.	48	15	12	75	54	4	58
	%	(63.9)	(20.0)	(16.0)		(93.1)	(6.9)	
10–14	No.	27	9	5	41	13	7	20
	%	(65.9)	(21.9)	(12.2)		(65.0)	(35.0)	
15–19	No.	48	9	17	74	6	1	7
	%	(64.8)	(12.2)	(22.9)		(85.7)	(14.3)	
20–29	No.	74	14	12	100	2	2	4
	%	(74.0)	(14.0)	(12.0)		(50.0)	(50.0)	
30–39	No.	39	10	14	63	1	1	2
	%	(61.8)	(15.9)	(22.2)		(50.0)	(50.0)	
40–49	No.	23	8	16	47	0 [a]	2 [a]	2 [a]
	%	(48.9)	(17.0)	(34.1)		(0.0)	(100.0)	
50–59	No.	28	14	34	76			
	%	(36.8)	(18.4)	(44.7)				
60–69	No.	53	26	71	150			
	%	(35.3)	(17.3)	(47.3)				
⩾70	No.	31	26	67	124			
	%	(25.0)	(20.9)	(54.0)				
Total	No.	396	152	259	807	211	47	258
	%	(49.1)	(18.8)	(32.2)		(81.8)	(18.2)	

[a] Over 40 years of age.

provided by the fact that tertian malaria, which was completely eradicated in Japan, is still endemic in some parts of Korea.

Many interesting observations and findings have been accumulated by workers in Korea, China (Taiwan) and Japan, and it is necessary to collate these results and to undertake further collaborative research, not only in these 3 countries but in all the nations of the Western Pacific, in order to control this important viral infection.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Dr M. W. Hong, Director, and Dr C. S. Lee, Vice-Director, of the National Institute of Health of Korea, for encouraging this study. Also it is a pleasure for the authors to acknowledge a special debt of gratitude to Dr Y. Ashihara and Mr C. T. Chang for giving information on the epidemiology of Japanese encephalitis in Taiwan.

RÉSUMÉ

ASPECTS ÉPIDÉMIOLOGIQUES COMPARÉS DE L'ENCÉPHALITE JAPONAISE DANS LA RÉPUBLIQUE DE CORÉE, EN CHINE (TAÏWAN) FT AU JAPON

Depuis l'épidémie de 1949, l'encéphalite japonaise est tenue en Corée pour l'une des plus importantes maladies à déclaration obligatoire. C'est un grave problème de santé publique auquel doivent également faire face d'autres pays du Pacifique occidental. Le présent article expose quelques-uns des aspects épidémiologiques de l'affection en Corée entre 1949 et 1966 et établit une comparaison avec les données similaires recueillies au Japon et en Chine (Taïwan).

L'étude de la répartition géographique de l'encéphalite japonaise en Corée montre l'existence d'un foyer principal, la province de Chol-La Puk-Do, où l'on a relevé, lors de l'épidémie de 1958, un taux de morbidité de 85,5 pour 100 000; le taux moyen de morbidité, de 1955 à 1966, a atteint 18,5 pour 100 000. L'affection est particulièrement fréquente dans les provinces du sud-est, le long des côtes du détroit de Corée et de la mer Jaune. Les foyers sont remarquablement stables, à l'opposé de ce qui est observé en Chine (Taïwan) et au Japon, où les régions de forte incidence sont dispersées et varient fréquemment. Si l'on considère l'ensemble des territoires japonais et coréen, on peut distinguer une « zone d'hyperépidémicité » au sud du 36e degré de latitude N, une « zone d'épidémicité moyenne » entre le 36e et le 40e degré de latitude N et une « zone de faible épidémicité » entre le 40e et le 43e degré de latitude N. Au Japon, les territoires situés au nord du 44e degré de latitude N, où aucun cas d'encéphalite japonaise n'a été signalé, représentent une « zone indemne », tandis qu'on peut délimiter une « zone non épidémique et modérément épizootique », comprise entre le 43e et le 44e degré de latitude N, où seuls ont été rapportés des cas d'infection équine par le virus de l'encéphalite japonaise.

La Corée a connu de graves épidémies d'encéphalite japonaise en 1949, 1958, 1964 et 1966. En 1958, on a enregistré 6897 cas (29,7 pour 100 000) et 2177 décès (9,4 pour 100 000). De 1955 à 1966, le taux moyen de la morbidité a été en Corée de 7,3 et au Japon de 2,5 par 100 000 habitants. L'épidémiologie de l'affection est caractérisée en Corée par de fortes variations annuelles des taux de morbidité et de mortalité: les premiers atteignaient 29,7 en 1958 et 0,1 seulement en 1963; au Japon, les chiffres extrêmes étaient de 5,0 en 1956 et de 1,2 en 1965. Depuis 1957, on note cependant un certain parallélisme des fluctuations de l'incidence de la maladie en Corée et au Japon.

En Corée et en Chine (Taïwan), l'encéphalite japonaise atteint surtout les enfants. L'âge moyen des malades a été de 7,1 ans pour la période 1955-1966 en Corée et de 6,6 ans pour la période 1957-1966 en Chine (Taïwan). En revanche, au Japon, elle frappe de plus en plus fréquemment des personnes âgées de plus de 50 ans. De 1962 à 1964, la courbe de la répartition selon l'âge a pris au Japon une allure bimodale, avec deux clochers correspondant aux groupes d'âge 5-9 ans et 60-69 ans. En 1965, le taux de létalité a été de 32,1 % au Japon et de 18,2 % en Chine (Taïwan).

La répartition saisonnière de l'encéphalite japonaise est très semblable en Corée et dans la partie centrale du Japon. Les premiers cas font généralement leur apparition à la fin de juillet et au début d'août, les derniers à la fin d'octobre. Les épidémies débutent habituellement dans les régions méridionales et s'étendent ensuite vers le nord.

Les auteurs mettent l'accent sur les aspects très différents de la répartition des cas selon les groupes d'âge dans les trois pays. L'hypothèse la plus vraisemblable pour expliquer la forte incidence de l'encéphalite japonaise parmi les personnes âgées au Japon, contrastant avec l'atteinte quasi exclusive des enfants en Corée et en Chine (Taïwan), leur semble être l'affaiblissement marqué du niveau de l'immunité au sein de la population japonaise moins exposée au virus en raison des progrès de l'urbanisation.

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