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SOME POSSIBLE ULTRAVIOLET EFFECTS ON THE INCIDENCE OF SKIN CANCER AMONG JAPANESE DUE TO MODIFICATION OF THE OZONE LAYER

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Abstract: An epidemiological analysis was conducted in order to examine possible ultraviolet effects on the incidence of skin cancer among Japanese. Age-adjusted mortality rates (AMRs) and standardized mortality ratios (SMRs) from 1971 to 1977, ratios of cumulative mortality rates (CMRs) from 1950 to 1960 and from 1960 to 1970, and the number of patients from 1975 to 1980 were obtained for skin cancer and malignant melanoma from vital statistics of Japan.

The results indicated that the AMRs of skin cancer and melanoma were much lower than those observed in other countries, and have remained almost unchanged over a long period of time. The SMRs showed a significant correlation with climatological variables; such as latitude and temperature, and socioeconomic income class. However, no significant association was found between the SMRs and the duration of sunshine available. When comparing incidences of the diseases of Japanese with those of Australian and northern Europeans, it seems evident that genetic susceptibility linked to skin colour may be a determinant factor for skin cancer.

1. Introduction

Recent reports of the NATIONAL RESEARCH COUNCIL (NRC) of U. S. A. (1982) dealt with the chemical and physical aspects of potential ozone acts as a shield to screen out much of the short-wavelength ultraviolet (UV) rays in sunlight. The Defense Fund of U. S. A. (DUDEK, 1986) estimated that destruction of the shielding stratospheric ozone layer by gaseous chlorinated carbon compounds, mainly chlorofluorocarbons (CFCs), will cause additional 1.44 million cases of skin cancer in the U. S. A. during the next forty years. We must say that great interest is focussed on some possible UV effects on the incidence of skin cancer. It seems certain that much of skin cancer other than malignant melanoma is associated with solar UV-B rays. There have been many discussion about this problem (SILVERSTONE and SEARLE, 1970; PARRISH *et al.*, 1978; MOLE, 1980; SCOTTO *et al.*, 1981; SCOTTO and FRAUMENI, 1982).

The present study deals with the latest trend of incidences of skin cancer among Japanese due to modification of the ozone layer.

2. Methods

Age-adjusted mortality rates (AMSs) and standardized mortality ratios (SMRs) from skin cancer and malignant melanoma from 1971 to 1977 were obtained from vital statistics collected by the Statistics and Information Department, Japanese Ministry of Health and Welfare. The 1970 population census was used as a standard for the study. Representative samples of the population were taken from cities, towns and villages throughout the country during that period. AMSs and SMRs by sex and prefecture were calculated for those seven years.

Ratios of cumulative mortality rates (CMRs) and ADRs due to skin cancer in 1960, 1970, were compared to those in 1950, 1960 among 23 countries as quoted from SEGI (1979).

The number of patients with skin cancer in the One-day National Patient Survey (the second Wednesday of July each year) from 1975 to 1980 was obtained from the Statistics and Information Department, Japanese Ministry of Health and Welfare. Both observed and anticipated numbers of patients by prefecture were calculated.

A total of 33 explanatory variables such as climatological, socioeconomical and body constitutional was recorded numerically, and the extent of their association with non-melanoma skin cancer was estimated statistically. These data for each prefecture were obtained from OFFICE OF THE PRIME MINISTER (1977) and ASAHI NEWS (1977).

3. Results and Discussion

Table 1 shows the average AMRs of skin cancer and malignant melanoma for each prefecture of Japan from 1971 to 1977. The AMRs of skin cancer and melanoma for both sexes throughout the country are 0.49 and 0.16 per 100000 people, respectively. The mortality from skin cancer and melanoma increases with age and is larger among men than women. The rates were much lower than those observed in any other countries as shown in Fig. 1: out of 50 countries, Japan ranked 41st for men and 44th for women for skin cancer in 1974. Most skin cancers of human beings are of epithelial cell origin. Those most commonly noted are basal cell carcinomas followed in frequency by squamous cell carcinomas. A study of the relative incidence rates of skin cancer in highly pigmented (black) *vs.* lightly pigmented (white) persons indicates more than 90% of skin cancers other than melanoma in the U. S. A. (SCOTTO and FRAUMENI, 1982). Australia, New Zealand and Scandinavia have high mortality due to skin cancer because of their highly susceptible pigments.

The incidence of skin cancer on a worldwide basis appears to depend largely on latitude (NRC, 1982). Epidemiological studies have found direct and statistically significant relationships between UV-B dosage and skin cancer. The lifestyle of spending time outdoors in the sunlight is worth noting (MAGNUS, 1973). To assess the influences of certain confounding variables, we analysed the mortality data of Japan in relation to several indexes. Figure 2 shows that the SMRs for skin cancer for both sexes were not found to be so clearly associated with latitude in Japan. However, the SMRs were highest in Okinawa and Kagoshima in southern, and Iwate in northern Japan in comparison with the other prefectures. The result of the correlation analysis of the SMRs with 33 climatological variables of Japan is shown in Table 2. The SMRs showed a significant correlation ($p<0.01$) with climatological factors: the correlation coefficient for latitude is -0.47, that for mean temperature is 0.39, and that for forest area is 0.43. No statistically significant correlation was found with the

Table 1. Averaged annual age-adjusted mortality rate of skin cancer and malignant melanoma per 100000 population from 1971 to 1977 in Japan for male and female, and each prefecture.

Prefecture	Skin cancer			Malignant melanoma		
	Total	Male	Female	Total	Male	Female
Hokkaido	0.54	0.53	0.55	0.18	0.17	0.19
Aomori	0.43	0.47	0.40	0.16	0.13	0.19
Iwate	0.71	0.51	0.91	0.25	0.23	0.28
Miyagi	0.39	0.33	0.45	0.21	0.27	0.16
Akita	0.49	0.49	0.50	0.18	0.21	0.16
Yamagata	0.46	0.52	0.40	0.13	0.19	0.07
Fukushima	0.57	0.67	0.49	0.15	0.17	0.13
Ibaraki	0.55	0.60	0.51	0.16	0.19	0.13
Tochigi	0.54	0.64	0.44	0.15	0.13	0.13
Gunma	0.52	0.48	0.55	0.19	0.20	0.18
Saitama	0.43	0.48	0.37	0.14	0.10	0.18
Chiba	0.48	0.48	0.47	0.14	0.19	0.09
Tokyo	0.41	0.43	0.39	0.17	0.18	0.16
Kanagawa	0.32	0.37	0.26	0.17	0.20	0.14
Niigata	0.46	0.45	0.47	0.19	0.25	0.14
Toyama	0.52	0.40	0.64	0.13	0.18	0.09
Ishikawa	0.47	0.58	0.37	0.18	0.23	0.14
Fukui	0.67	0.60	0.74	0.10	0.07	0.12
Yamanashi	0.41	0.44	0.38	0.15	0.17	0.13
Nagano	0.50	0.57	0.42	0.24	0.27	0.21
Gifu	0.48	0.51	0.45	0.13	0.18	0.09
Sizuoka	0.42	0.52	0.32	0.18	0.22	0.13
Aichi	0.48	0.53	0.42	0.19	0.18	0.20
Mie	0.37	0.37	0.37	0.16	0.28	0.04
Shiga	0.52	0.65	0.40	0.16	0.14	0.17
Kyoto	0.47	0.48	0.46	0.09	0.13	0.06
Osaka	0.47	0.61	0.35	0.16	0.15	0.18
Hyogo	0.45	0.51	0.40	0.15	0.18	0.13
Nara	0.49	0.63	0.37	0.14	0.13	0.15
Wakayama	0.58	0.53	0.63	0.09	0.16	0.02
Tottori	0.43	0.53	0.34	0.18	0.20	0.18
Shimane	0.63	0.65	0.60	0.14	0.12	0.15
Okayama	0.47	0.61	0.32	0.10	0.11	0.09
Hiroshima	0.45	0.43	0.47	0.18	0.22	0.14
Yamaguchi	0.46	0.48	0.44	0.15	0.17	0.14
Tokushima	0.42	0.44	0.41	0.08	0.06	0.11
Kagawa	0.64	0.69	0.59	0.14	0.15	0.12
Ehime	0.43	0.35	0.52	0.27	0.36	0.18
Kochi	0.53	0.64	0.44	0.20	0.24	0.16
Fukuoka	0.47	0.55	0.40	0.13	0.13	0.13
Saga	0.59	0.55	0.63	0.15	0.11	0.18
Nagasaki	0.58	0.67	0.50	0.18	0.17	0.19
Kumamoto	0.57	0.59	0.56	0.19	0.25	0.14
Oita	0.59	0.71	0.47	0.15	0.19	0.12
Miyazaki	0.67	0.82	0.53	0.18	0.22	0.14
Kagoshima	0.87	0.86	0.89	0.17	0.14	0.19
Okinawa	0.75	1.04	0.54	0.10	0.12	0.10
Total	0.49	0.53	0.45	0.16	0.18	0.15

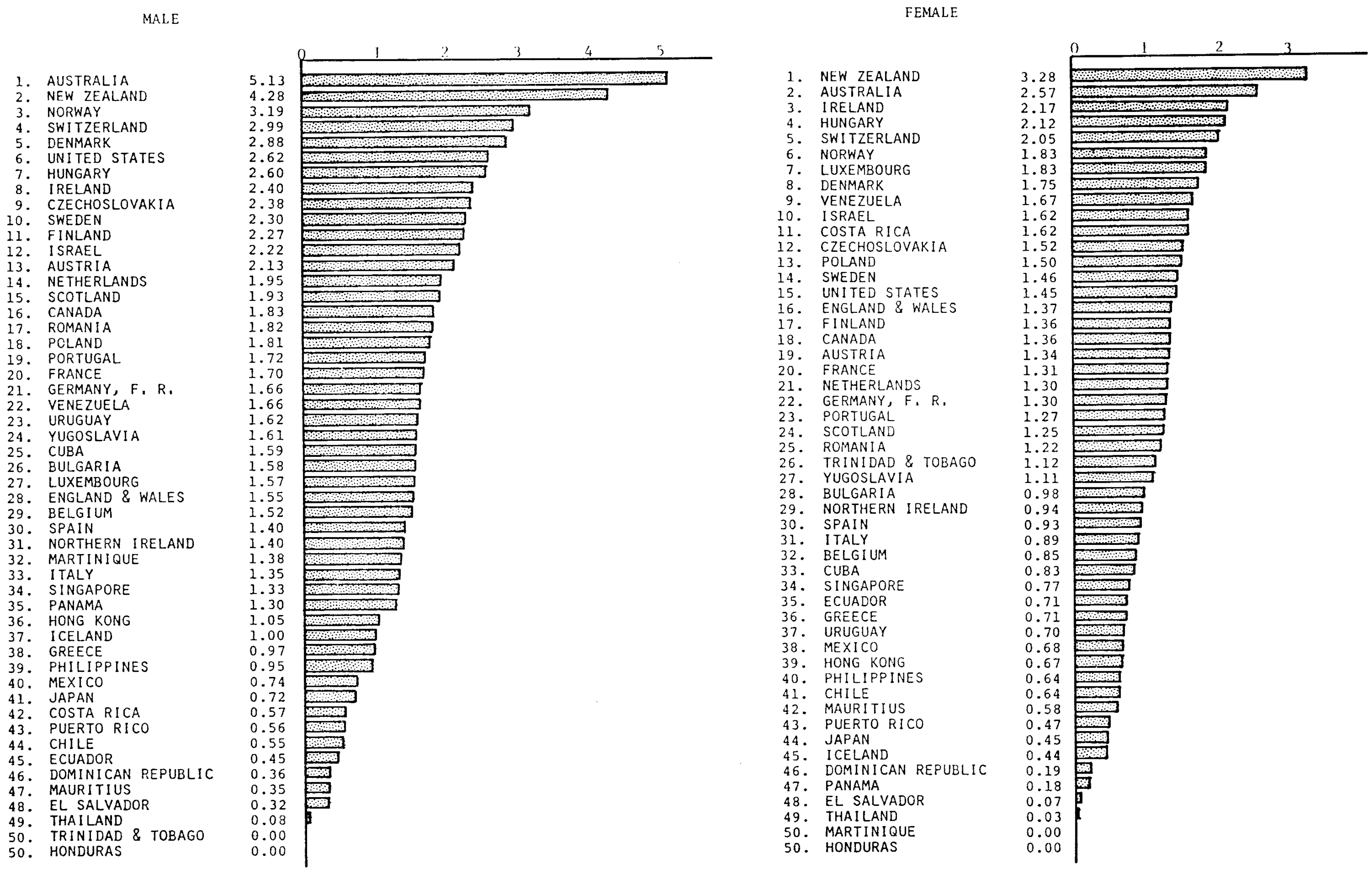

Fig. 1. *Rank of age-adjusted mortality rates of skin cancer of male and female in 1974 for 50 countries (based on the data by* S*EGI*, *1979).*

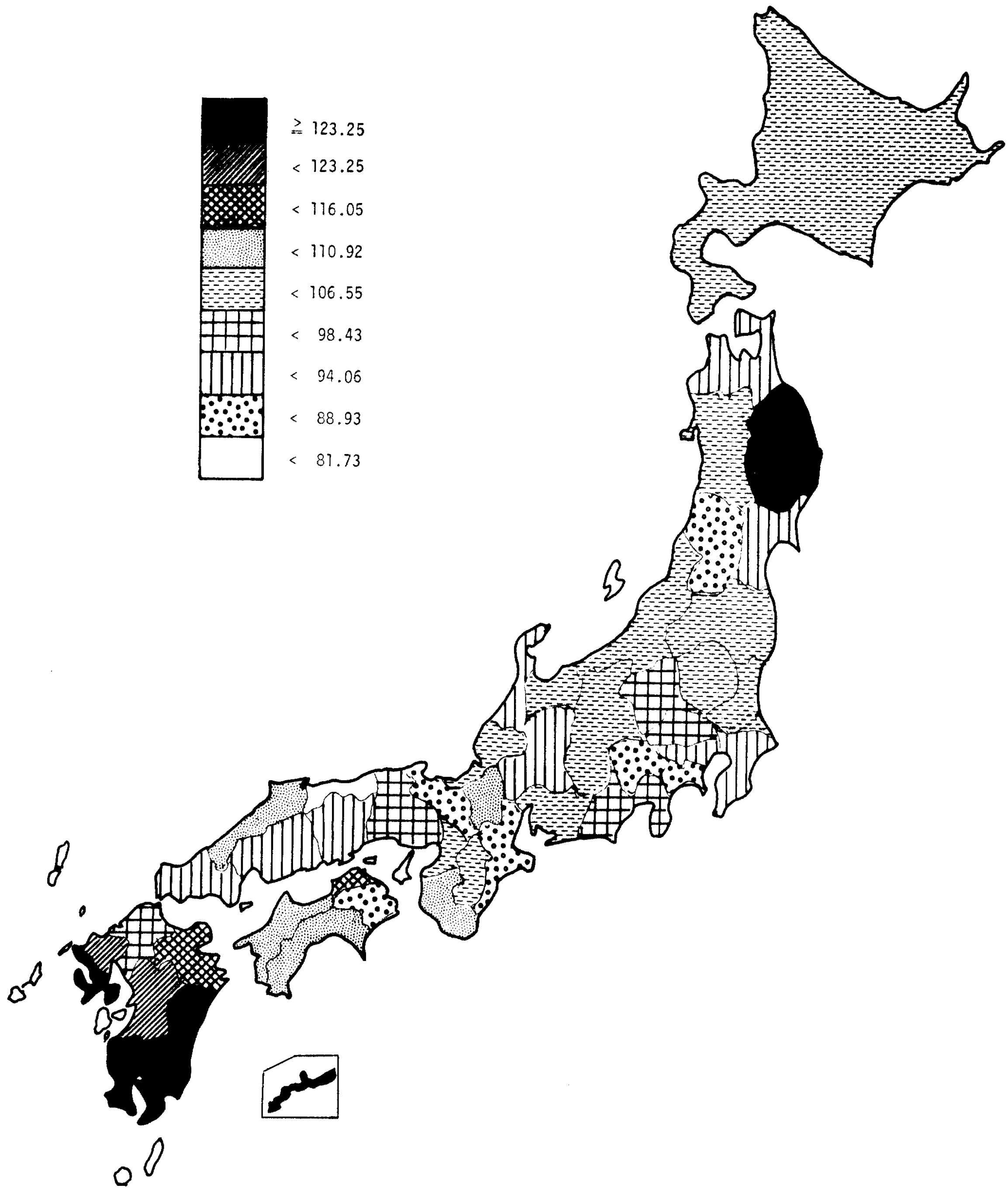

Fig. 2. Japanese geographical map of averaged annual standardized mortality ratios of skin cancer from 1971 to 1977 for each prefecture (Japan 1975 standard).

duration of sunshine available and the altitude. In this paper each figure of climatological indexes is the average compiled from 1941 to 1970.

Generally, environmental temperature increases as the latitude decreases. This decrease should be associated with changes in the kind and amount of clothing worn. Skin exposed to the sun depends largely on habits of dress and outdoor activities. For example, an increase of mortality due to skin cancer in Finland (TEPPO *et al.*,

Table 2. Relationship between standardized mortality ratios of skin cancer and climatological, socioeconomic, and body constitutional variables.

Variables	Correlation coefficient	Level of significance
Climatological:		
Latitude	−0.471	**
Annual temperature		
Normal	0.390	**
Maximum	0.378	**
Ratio of forest area	0.432	**
Socioeconomic:		
Difference of income	−0.564	**
Minryoku (Regional strength)	−0.470	**
Money of tobacco	−0.489	**
Ratio of high school advanced couse	−0.317	*
Body constitutional:		
Average height (14 yeas old)	−0.562	**
Average weight (14 years old)	−0.451	**
Life expectancy	−0.323	**
Infant death rate	0.337	*
Neonatal death rate	0.292	*
Death ratio of infectious diseases	0.315	*

*: $p<0.05$, **: $p<0.01$
14 variables of 33 variables were decidely significance.

Table 3. Calculation of the cumulative mortality rates and age-adjusted mortality rates for skin cancer for sex and country from 1950 to 1960 and from 1960 to 1970 (after SEGI, 1979).

	Cumulative death rates				Age-adjusted death rates			
	Male		Female		Male		Female	
	60/50	70/60	60/50	70/60	60/50	70/60	60/50	70/60
Canada	1.1	1.0	0.9	1.0	1.1	0.9	1.1	0.9
Chile					1.1	1.1	1.0	0.9
Israel	1.1	1.6	1.6	0.8	1.4	1.3	1.5	0.8
Japan	0.8	1.0	0.9	0.8	0.9	1.0	1.0	0.8
Germany, F. R.	1.1	1.1	1.2	1.0	1.2	1.0	1.0	0.9
Austria		1.3		1.3	1.0	1.2	1.1	1.1
Belgium		1.1		0.8		1.1		0.8
Denmark	1.2	1.6	2.0	1.2	1.2	1.4	1.9	1.2
Finland	1.5	1.3	0.8	1.2	1.6	1.3	0.8	1.2
France	0.8	0.9	0.9	0.8	0.8	0.8	1.0	0.7
Ireland	0.8	0.8	1.2	1.4	1.0	0.7	1.1	1.1
Italy	0.7	1.2	0.8	1.1	0.7	1.1	0.8	1.0
Norway		2.2		1.4	1.2	2.2	1.1	1.4
Netherlands	1.1	1.3	1.1	1.0	1.0	1.2	1.1	1.1
Portugal		0.7		0.9				
England & Wales	0.8	1.1	1.0	1.1	0.8	1.0	0.9	1.1
Scotland	1.2	0.9	1.0	1.1	1.3	0.9	1.1	0.9
Northern Ireland	1.7	1.3	2.0	1.3	1.0	1.5	1.2	1.2
Sweden	3.0	1.2	4.0	1.2	2.9	1.1	2.4	1.3
Switzerland	1.2	1.2	1.6	1.0	1.2	1.2	1.3	0.9
Australia	1.4	1.1	1.2	1.3	1.2	1.1	1.1	1.3
New Zealand	0.8	1.4	1.5	1.2	0.9	1.2	1.7	1.1

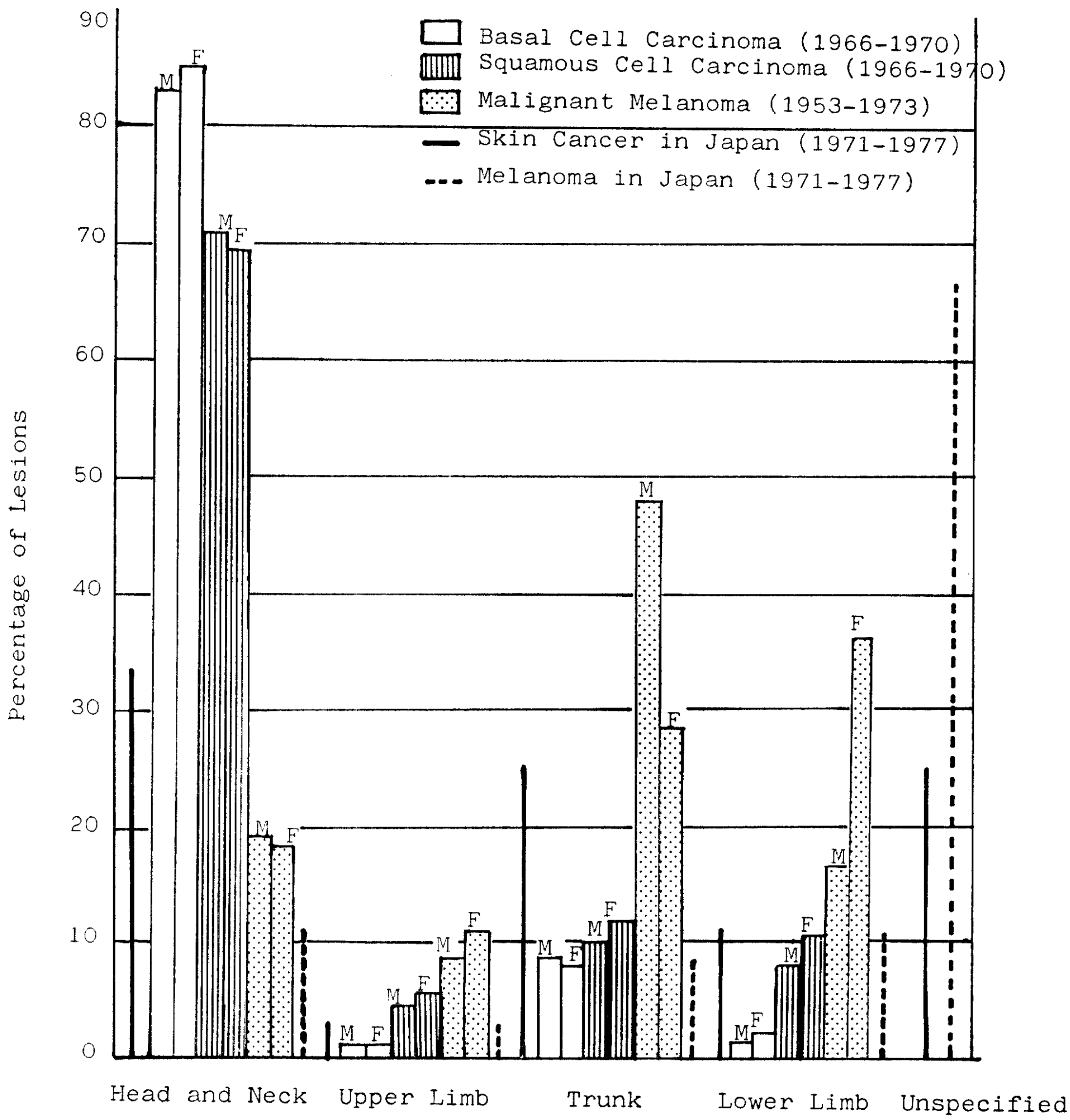

Fig. 3. Distribution of basal cell cancer, squamous cell cancer and malignant melanoma in Finland compared with that in Japan (based on the data by TEPPO *et al., 1978).*

1978) and Japan has been found mainly on women's lower parts of the legs and men's backs as shown in Fig. 3. Throughout Japan, about 35% of the skin cancer begins on the head and neck, 25% on the back and from 2 to 10% on the arms and legs.

The SMR is also remarkable among the highest socioeconomic income class, as shown in Table 3. There was a statistically significant correlation ($p<0.01$) between the SMRs, the annual average income ($r=-0.56$), and the "Minryoku" index (regional strength concerned in production, consumption and civilization, $r=-0.47$). This fact suggests that sunlight is the risk factor of skin cancer. Less income and "Minryoku" index brings about a significant reduction in leisure activities.

The CMRs and AMRs for skin cancer by sex and country from 1950 to 1960 and from 1960 to 1970 are shown in Table 3. For this trend analysis, the 1950–1960 rates were compared with the 1960–1970. The trends of the AMRs in Japan have remained

Table 4. Both observed and anticipated numbers of patients from skin cancer in Japan for each sex and prefecture from 1975 to 1980.

Prefecture	Observed (O)	Expected (E)	Ratio	*P*
Hokkaido	15	12.32	122.2	0.077
Aomori	4	3.23	123.8	0.1776
Iwate	10	3.98	251.3	*0.0051
Miyagi	5	4.57	109.4	0.17
Akita	2	2.74	73.3	0.24
Yamagata	5	2.07	241.5	0.04
Fukushima	8	3.98	201.0	0.029
Ibaraki	—	5.59	—	**0.0037(—)
Tochigi	2	4.16	48.1	0.13
Gunma	11	4.02	273.6	**0.0019
Saitama	11	10.73	12.5	0.119
Chiba	14	9.48	147.7	0.039
Tokyo	27	26.18	103.1	0.075
Kanagawa	10	14.48	69.1	0.05
Niigata	5	4.54	110.1	0.17
Toyama	3	2.70	111.1	0.22
Ishikawa	2	2.35	85.1	0.26
Fukui	—	1.56	—	0.20
Yamanashi	—	1.54	—	0.21
Nagano	2	5.44	36.8	0.06
Gifu	2	3.05	65.6	0.22
Sizuoka	5	8.35	59.9	0.07
Aichi	8	11.62	68.8	0.04
Mie	4	3.89	102.8	0.19
Shiga	—	1.94	—	0.14
Kyoto	8	6.14	129.9	0.10
Osaka	16	16.90	100.6	0.09
Hyogo	4	9.96	40.2	*0.019(—)
Nara	3	2.13	140.8	0.18
Wakayama	6	3.00	200	0.05
Tottori	4	1.40	285.7	0.03
Shimane	2	1.74	114.9	0.26
Okayama	2	4.04	49.5	0.14
Hiroshima	6	6.70	89.6	0.15
Yamaguchi	2	3.16	63.3	0.21
Tokushima	2	1.52	131.6	0.26
Kagawa	1	2.44	41.0	0.21
Ehime	3	2.82	106.4	0.22
Kochi	4	1.40	285.7	0.04
Fukuoka	9	10.18	88.4	0.12
Saga	—	2.49	—	0.08
Nagasaki	2	3.44	58.1	0.19
Kumamoto	1	3.27	32.1	0.12
Oita	8	3.12	256.4	*0.009
Miyazaki	2	2.38	84.0	0.26
Kagoshima	6	3.98	150.8	0.10
Okinawa	4	2.17	185.2	0.10
Total	250	250	100	—

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

almost unchanged during the period from 1950 to 1970. In short, the incidences of skin cancer in Japan have not increased over a long period of time.

It is important to determine whether mortality patterns relating to climatological indexes are similar to morbidity patterns. The numbers of patients by prefecture with skin cancer for the combined sexes are summarized in Table 4. The observed patients did not differ significantly in 42 of the 47 prefectures, compared with the corrected number of expected patients. The O/E ratios were 273.6 in Gunma prefecture, central Japan and 256.4 in Oita prefecture, southern Japan, for both sexes. However, a conclusion cannot be drawn due to the insufficient number of observed patients. Furthermore, the association between the number of the observed patients and the latitude and temperature was not significant.

It seems certain that much of the skin cancer other than melanoma is associated with solar UV-B in Europe and America. When comparing the incidence of the skin cancer of the Japanese with that of northern Europeans, it seems evident that genetic susceptibility linked to skin colour may be a determinant factor.

The most important point, however, is that a depletion of stratospheric ozone has been observed over the Antarctic continent in September and October. Updated data of NRC (1982, 1984) predicted that a 1% reduction in the amount of stratospheric ozone gives an approximate 2% increase in UV-B, and then a 2–5% increase in basal skin cancers. For squamous cell skin cancers, the increase would be about twice that of the basal skin cancer. Furthermore, the data associating sunlight with melanoma is not sufficient to make a prediction of incidence due to increased exposure to solar UV.

During the last few years, the theoretical study on the depletion of the atmospheric ozone layer has been thoroughly improved. Further research is needed to clarify the role of exposure dosages to UV-B.

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