CANCER IN SINGAPORE — ETHNIC AND DIALECT GROUP VARIATIONS IN CANCER INCIDENCE

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SYNOPSIS

The results of cancer registration in Singapore, which began in 1968, are presented with particular reference to differences in cancer incidence among the major ethnic (racial) groups and Chinese dialect groups resident in Singapore.

A total of 7,000 new cases of cancer (4,103 in males and 2,897 in females) were diagnosed in the Singapore population during a three-year period (1. 1. 1968 to 31. 12. 1970); the age-standardised incidence of cancer (ICD 140-205) was 217·5 per 100,000 persons per year for males and 143·6 for females. The five most common cancers in males were lung (795 cases; 44·3 per 100,000 per year), stomach (674; 38·1), liver (526; 27·1), nasopharynx (326; 13·9) and oesophagus (273; 16·3). The five most frequent cancers among females were breast (378; 18·3), cervix (331; 16·2), stomach (313; 16·4), lung (277; 14·9) and colon (142; 7·4). Cancer is a major health problem and is the second ranking cause of death after cardiovascular diseases.

The age-standardised incidence of lung cancer in Singapore males is higher than in other Asian countries and is roughly of the same level as in Europe and N. America. The incidence in Singapore females, standardised for age, is among the highest in the world. In comparison with Western countries, Singapore has higher incidence rates for cancers of the nasopharynx, oesophagus, stomach and liver, and lower rates for cancers of the colon, rectum, breast, prostate and skin.

Comprehensive registration of cancer cases began in Singapore in 1968. This paper presents the results of cancer registration during a 3-year period (1968-1970) with particular reference to differences in cancer incidence among the major ethnic (racial) groups and Chinese dialect groups resident in Singapore. Some ethnic differences have been suspected previously on the basis of "relative frequency" studies; these will be put on a quantitative basis. Comprehensive registration has revealed hitherto unsuspected differences in cancer incidence among specific communities or dialect groups of Chinese in Singapore.

PATTERNS OF CANCER FROM PREVIOUS STUDIES

Prior to the organisation of the Cancer Registry, information on cancer patterns has been derived from: 1. Relative frequencies or ratios of various cancers among hospital admissions, biopsies or necropsies; 2. Minimum incidence rates based on histologically confirmed cancers, and 3. Cause of death returns from the Registrar General.

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1. Relative frequencies or ratios of cancer: among hospital admissions, biopsies and necropsiess These have provided useful information on local cancer patterns but they are not reliable bases for the estimation of cancer risks as they are influenced by various forms of bias in the selection of cases and do not take into account the age/sex composition of the population at risk.

Hospital records would be a good source of information if all cancer cases are admitted to hospital. However, variations in record systems and patterns of hospital admissions have reduced their reliability. Cancer patients who are diagnosed and treated as out-patients have been omitted from these data. On the other hand some of the figures have been spuriously inflated by counting re-admissions as separate cases.

Biopsies are an inherently reliable source of information on account of their diagnostic accuracy but are biased in favour of sites more accessible to biopsy; they are therefore likely to exhibit a preponderance of neoplasms of sites such as the skin, nasopharynx and cervix. The records in Singapore are reasonably accurate. Since 1950, the Institute of Pathology has maintained a card index of all histologically diagnosed cancers (biopsies and necropsies) which are checked to ensure that each cancer patient is counted only once.

Necropsy records have the highest degree of diagnostic accuracy, and no case comes up twice,

but the material is heavily biased in favour of cancers that pose diagnostic problems *viz.* those of internal organs.

The cancer patterns derived from each of the above sources of information have been widely divergent on account of their inherent deficiencies and sources of bias. Published data on relative frequencies of various cancers in hospital admissions, biopsies and necropsies in Singapore differ so widely that anyone not aware of their sources of bias may well wonder if they are derived from the same population. Relative frequencies studies however are not without value. The data are easily obtained from existing hospital and Pathology records and may reveal interesting variations in site distribution and thereby stimulate research on local cancer patterns.

It is important to remember that any ethnic (racial) variations outlined in these studies are influenced by differences in utilization of hospital facilities by the major groups in Singapore. The hospital admission and outpatient attendance rates for Malays are significantly lower than those for Indians and Chinese. The admission rates per thousand per annum for Chinese, Malays, Indians and Others for the years 1954-58 were 52, 20, 87 and 96 respectively (Shanmugaratnam and Muir, 1967). The biopsy rates for Malays are also significantly lower than those for Indians and Chinese (Muir *et al*, 1971) and necropsies are hardly ever done on Malays except on Coroners' cases. In 1970, the proportions of deaths certified by Inspecting Officers (i.e. not qualified medical practitioners) were 15·7% for Chinese, 39·0% for Malays, 16·1% for Indians and 6·1% for Others. The hospital admission, biopsy and necropsy rates for Indians have generally been higher than those for Chinese (Shanmugaratnam and Muir, 1967; Muir *et al*, 1971).

2. **Minimum incidence rates based on histologically diagnosed cases:** The Institute of Pathology has maintained, since 1950, a card index of all cancers diagnosed histologically (biopsies and necropsies) in the Singapore population. These cards are checked to eliminate multiple examinations on the same patient; patients who are not permanent residents of Singapore are also excluded. Minimum age-specific and age-adjusted incidence rates for various cancers were calculated by referring these histologically diagnosed cases to an extrapolated population based on the 1947 and 1957 Censuses (Shanmugaratnam and Muir, 1967; Muir *et al*, 1971). As many cases of cancer are not verified histologically, these incidence rates are of value only in-so-far as they indicate *minimum* rates. Comparisons between these *minimum* rates and incidence data from Western countries have shown higher risks for cancers of the nasopharynx, oesophagus, liver and choriocarcinoma among the Chinese, cancers of the nasopharynx and choriocarcinoma among the Malays and cancers of the oral cavity in Indians. There were elevated rates for oesophageal cancer and choriocarcinoma among Indians but the numbers were too small to establish significance. The rates were lower for all the racial groups for cancers of the breast, prostate, colon and rectum (Muir and Shanmugaratnam, 1966; Shanmugaratnam and Muir, 1967; Shanmugaratnam, 1971; Muir *et al*, 1971).

3. **Cause of death returns of the Registrar General:** Certification of death is virtually complete in Singapore but not all deaths are certified by qualified medical practitioners. Of the 140,059 deaths in Singapore during the period 1950 to 1963 only 56·7% were certified by medical practitioners and a further 12·2% were certified by the Coroner, generally after post-mortem examination. The remaining 31·1% were certified by lay inspecting officers, most of whom are hospital assistants with nursing experience. A substantial proportion (26·1% in 1950, 16·9% in 1960 and 12·1% in 1970) of all deaths have been coded under the rubric "ill-defined and unknown causes." There were 10,793 deaths in Singapore in 1970 comprising 8,786 (81·4%) certified by qualified medical practitioners and the Coroner and 2,007 (18·6%) by Inspecting Officers (Report on the Registration of Births, Deaths and Marriages, 1970). There were 184 deaths from cancer certified by Inspecting Officers but the diagnosis in almost all of these cases had been previously made at various hospitals and by medical practitioners.

The number of cancer deaths in Singapore has risen from 362 in 1940 to 1688 in 1971 (Reports on the Registration of Births, Deaths and Marriages, Singapore). This increase is not entirely due to the increase in population as the proportion of cancer deaths has also shown a steady rise. Cancer deaths comprised 2·3% of total deaths in 1940, 2·8% in 1950, 10·0% in 1960 and 14·9% in 1970.

The question of what disease or group of diseases is the top ranking cause of death is complicated by variations in classification in the cause of death returns. In Singapore cancer has been the top ranking cause of death, outstripping pneumonia, tuberculosis and heart disease since 1959. Since 1965 the combined rubric "diseases of the circulatory system" (i.e. total of heart disease, hypertension and other diseases of the circulatory system) has been the top ranking cause of death.

The crude cancer mortality rate per 100,000 persons per annum was estimated to be 12·6% for the years 1906 to 1910 (Hoffmann, 1915), 40·6 for the years 1926 to 1931, and 51·6 for the years 1954

to 1958 (Muir, 1963). The crude cancer mortality rate was 74·6 for males and 48·9 for females in 1960, and 91·4 for males and 61·7 for females in 1970. The relatively low crude death rate is due to the high proportion of young persons in our population; the age-standardised mortality rates for cancer were 159·7 for males and 94·1 for females in 1970.

THE SINGAPORE CANCER REGISTRY

A scheme for comprehensive cancer registration was developed in order to obtain accurate information on cancer incidence, i.e. numbers of new cases of cancers of various sites appearing in populations of known size and age/sex composition in specified periods of time. This was done not only because such information was essential for the investigation and control of this disease but also because comprehensive registration was an eminently practicable proposition in Singapore.

Singapore, an island of conveniently small size, has a well counted non-migratory, multiracial population. Singapore has a fairly good standard of medical service with centralised services for pathology, radiotherapy and death registration. In 1970 there were 1,363 registered medical practitioners of whom 867 were in private practice and 496 in the full-time service of the Ministry of Health and the University of Singapore. A total of 7,837 hospital beds were available for the population—6,954 in Government and Institutional hospitals and 883 in private hospitals (Ministry of Health 1972). The Government also provides 51 Maternal and Child Health Clinics and 27 outpatient clinics which offer an essentially general practitioner type of service. A nominal fee of $1 is charged in Government hospitals and clinics and even this fee is waived for those unable to pay; paying beds are available for those who wish more privacy. The island has excellent roads and transportation. There is thus no financial or physical reason why cancer patients should not attend hospital.

Sources of Information on Cancer Cases

Notifications of cancer cases (cases with histological confirmation as well as cases diagnosed on clinical, radiological and other grounds) are received from all sections of the medical profession. Doctors are provided with forms and pre-paid envelopes for notification; cancer is not a notifiable disease in Singapore and there is no notification fee. The Registry ensures that notifications are as complete as possible by examining all pathology records, hospital discharge certificates and death certificates issued in Singapore. Cases of cancer that are picked up from these sources are checked against registered cases, and reminders are sent to the doctors in charge of cases that have not been notified to the Registry. The Registry ensures that no case is registered twice by cross-checking the names and National Registration Identity Card numbers of cancer cases.

The Singapore Population

A total of 2,074,507 persons were enumerated at the 1970 Census of Population comprising Chinese 76%, Malays 15%, Indians 7% and Others 2% (Fig. 1). A remarkable feature of the Singapore population is its extreme youth; only 33% of the Singapore population belongs to the age group of 30 years and above (Fig. 2).

The Chinese in Singapore are for the most part derived from the South Eastern provinces of Fukien and Kwangtung and comprise several specific communities or dialect groups. The major dialect groups in Singapore (Fig. 3) are Hokkien (42·2% of the Chinese population) derived from Fukien province, Teochew (22·4%) from the Teochew district of Kwangtung province and the Cantonese (17·0%) who are derived from the other parts of Kwangtung. Other Chinese dialect groups (18·5%) in Singapore are Hainanese, Hakka, Foochow, Hockchiu, Hokchia and Others (Department of Statistics, 1972). The dialect group status of a person is easily ascertained either directly from the person concerned or by reference to the National Registration Identity Card that is possessed by all persons aged 12 years and over. In both the National Census and the Singapore Cancer Registry the ethnic/dialect group of persons with mixed parentage is that of the father. The overwhelming majority of adult Chinese in Singapore (96% of 2,028 hospital patients aged 20 years and above interviewed between 1966 and 1968) are children of within-dialect marriages. More recently however the proportion of inter-dialect marriages has increased and Yeh (1964) reported that only 61% of a sample of couples married in 1962 were within-dialect marriages.

The Malays, derived from Malaysia and Indonesia, comprise several sub-communities. Most of the Indians in Singapore are Tamils (approximately $\frac{2}{3}$s) and Malayalees (approximately $\frac{1}{6}$) derived respectively from the South Indian states of Madras and Kerala.

The Singapore population has a sex ratio of 1·05 (1,062,127 males and 1,012,380 females). The sex ratios for the major ethnic groups are 1·02 for the Chinese, 1·04 for Malays and 1·52 for Indians. The overall preponderance of males (Fig. 4) among Indians reflects their migrant origin.

Immigration into the combined territories of Malaya and Singapore was partially controlled after

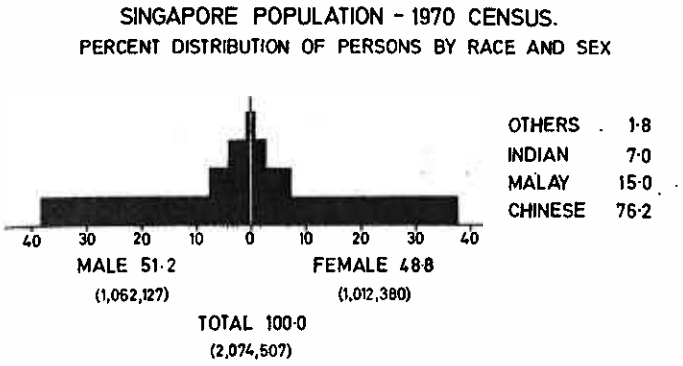
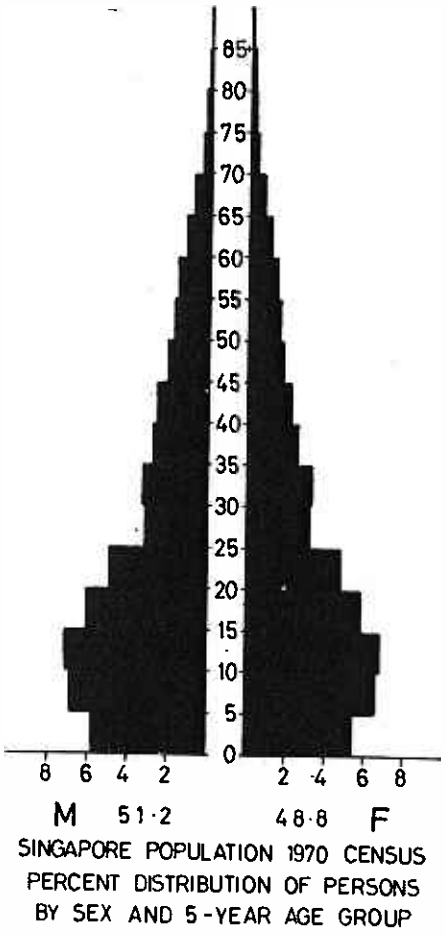


Fig. 1.



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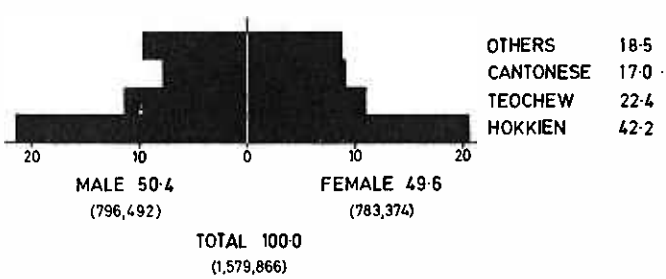

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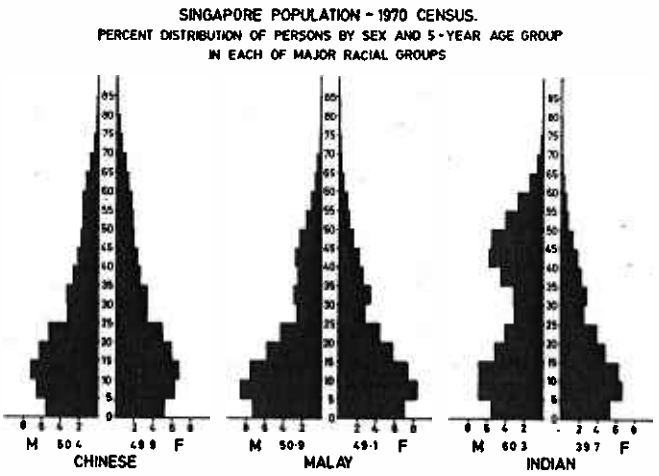

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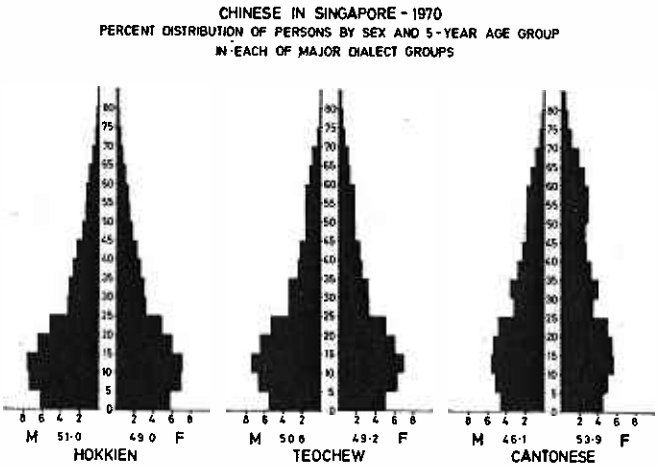

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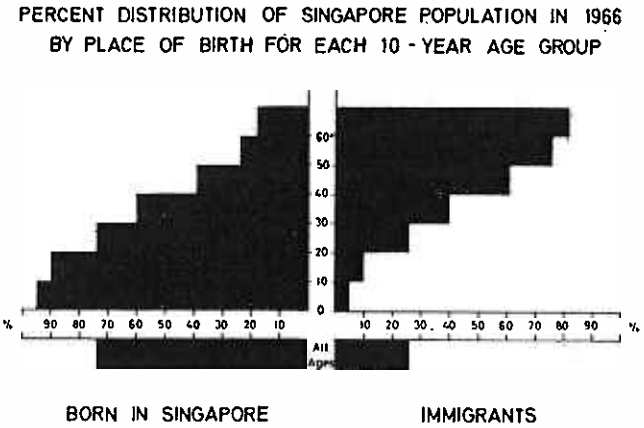

Fig. 6.

TABLE I

CANCER INCIDENCE IN SINGAPORE, COMPARED WITH SELECTED COUNTRIES/POPULATIONS* IN ASIA, EUROPE AND AMERICA. RATES PER 100,000 PERSONS PER YEAR, AGE-STANDARDISED TO WORLD POPULATION

Country		Singapore (All Races) 1968-70	Japan (Miyaji) 1962-64	India (Bombay) 1964-66	England (Birmingham) 1963-66	Norway 1964-66	U.S.A. (Connecticut) 1963-65	U.S.A.-Hawaii (Chinese) 1960-64
Mouth	M	3·3	1·1	6·5	1·4	0·9	4·0	0·6
(143 - 145)	F	0·6	0·6	5·9	0·6	0·5	1·4	0·0
Nasopharynx	M	13·9	0·1	0·6	0·5	0·4	0·5	10·4
(147)	F	5·7	0·1	0·5	0·2	0·1	0·1	4·6
Oesophagus	M	16·3	14·5	13·0	4·7	2·8	4·1	7·6
(150)	F	6·8	4·9	11·3	2·6	0·9	1·4	0·0
Stomach	M	38·1	95·3	10·0	25·2	28·8	15·3	9·5
(151)	F	16·4	44·7	6·5	13·2	15·4	6·8	14·2
Colon	M	9·6	4·1	4·1	15·3	12·0	24·0	35·9
(153)	F	7·4	4·0	3·4	14·9	11·6	26·7	23·5
Rectum	M	8·4	4·8	4·3	15·8	6·8	15·5	15·8
(154)	F	6·6	5·0	3·2	9·3	4·7	10·7	9·4
Liver	M	27·1	1·3	0·5	0·8	1·0	?	7·3
(155·0)	F	6·9	0·8	0·1	0·3	0·4	?	0·0
Nasal Cavity	M	1·2	3·4	1·4	0·7	0·8	2·1	2·4
(160)	F	0·2	1·9	1·0	0·6	0·3	1·3	2·4
Larynx	M	6·6	2·4	13·8	3·8	2·0	7·5	0·6
(161)	F	0·7	0·3	2·8	0·5	0·2	0·8	0·0
Lung	M	44·3	15·6	13·3	73·3	16·5	44·0	27·2
(162)	F	14·9	6·0	3·7	8·4	3·1	7·8	16·7
Melanoma-	M	0·6	0·3	0·2	1·1	3·6	3·5	3·0
Skin (172)	F	0·2	0·2	0·5	1·8	4·0	3·2	0·0
Skin-Other	M	5·0	1·5	1·3	27·9	?	?	0·6
(173)	F	4·6	1·4	1·6	17·6	?	?	0·0
Breast (174)	F	18·3	11·0	20·4	51·1	41·0	62·3	44·3
Cervix uteri (180)	F	16·2	?	24·7	13·6	16·2	10·3	13·4
Corpus uteri (182)	F	4·8	1·3	1·5	9·0	8·2	15·3	19·5
Prostate (185)	M	3·6	3·2	6·5	18·4	29·8	33·0	9·8
All Sites	M	217·5	196·0	139·5	254·5	174·8	257·8	207·0
(140 - 205)	F	143·6	142·8	131·1	196·3	164·9	220·0	228·3

*UICC "Cancer Incidence in Five Continents" (1970).

1930 but migration between Singapore and Malaya was relatively free until Singapore's independence in 1965. Throughout the 19th century immigration has been principally of males in the working age groups. Following the depression of the early 1930s strict controls were imposed on the immigration of Chinese men. However, as Chinese women were exempted from such controls there was a net immigration of some 200,000 Chinese women between 1934-1938, virtually all Cantonese, into the combined territories of Malaya and Singapore (Ginsberg and Roberts, 1958). In the Censuses of Population held subsequently the Cantonese were the only dialect group in which women outnumbered men (Fig. 5). The sex ratios for the Hokkiens, Teochews and Cantonese in 1970 were 1·04, 1·03 and 0·86 respectively (Department of Statistics, 1972).

Although the majority of the Singapore population are Singapore-born, the proportion of immigrants is higher among those aged 30 years and above. In 1957 only $\frac{1}{3}$ of persons aged 30 years and above were born in Singapore and Malaysia, most of the remainder being immigrants from South China or South India. In 1966, 74% of the population were Singapore-born and 26% were immigrants (Singapore Sample Household survey, 1966). The proportion of immigrants rises with age (Fig. 6); 60% of those aged 30 years and above and 82% of those aged 60 years and above were immigrants. It follows therefore that the cancer data reported in this paper may reflect the influence of the environments of China, India and elsewhere as well as that of Singapore.

Analysis of Data

The data presented in this paper are based on all new cases of cancer in the Singapore population registered during a three-year period—1.1.1968 to 31.12.1970. Included in this analysis are cases diagnosed on radiological and clinical grounds as well as those confirmed histologically. Excluded from this analysis are cases diagnosed before 1.1.1968, cancers occurring in persons who are not permanently resident in Singapore and cases of carcinoma-in-situ.

Age specific incidence rates were calculated on the basis of the 1970 census population. Age-standardised incidence rates for males and females, adjusted to the world population, were calculated for the Singapore population (all races) and for each of the major ethnic groups and Chinese dialect groups by the method outlined in UICC (1970). Relative incidence rates, comparing the rates for Chinese, Malays and Indians with each other, and the rates for Cantonese with the pooled rates for Hokkiens and Teochews were calculated by the method described by Mantel and Haenszel (1969). These relative risks are presented mainly for those sites in which there were at least 100 cases for each sex; rates based on lesser numbers are more likely to be unstable. The Hokkiens and Teochews were grouped together for this purpose as their cancer patterns were found to be closely similar.

RESULTS

A total of 7,000 cases of cancer (4,103 in males and 2,897 in females) were registered in the Singapore population during a three-year period (1968-1970). The age-standardised incidence of various cancers among males and females in Singapore is compared with those of selected Asian, European and American populations (UICC, 1970) in Table I.

The five most common sites of cancer in Chinese, Malays and Indians are shown in Table II.

TABLE II

FIVE MOST COMMON CANCERS IN SINGAPORE (ALL RACES). NUMBERS OF CASES FOR 1968-1970 BY RANK ORDER, RACE AND SEX

Rank	Chinese			
	Males		Females	
1	Lung	752	Breast	314
2	Stomach	607	Cervix	284
3	Liver	462	Stomach	276
4	Nasopharynx	312	Lung	259
5	Oesophagus	255	Colon	130
	All Cancers	3603	All Cancers	2524

Rank	Malays			
	Males		Females	
1	Liver	33	Breast	39
2	Lung	27	Cervix	29
3	Stomach	20	Stomach	25
4	Nasopharynx	10	Ovary	15
5	Colon	9	Lung	13
	All Cancers	210	All Cancers	231

Rank	Ind. & Pak.			
	Males		Females	
1	Stomach	43	Breast	15
2	Liver	28	Cervix	13
3	Rectum, lung	14	Stomach	10
4	Oesophagus, Colon	13	Colon	6
5	Tongue Mouth Larynx	10	Oesophagus	4
			Rectum, Uterus, Ovary, Thyroid, Myeloid Leuk.	
	All Cancers	253	All Cancers	94

Rank	All Races			
	Males		Females	
1	Lung	795	Breast	378
2	Stomach	674	Cervix	331
3	Liver	526	Stomach	313
4	Nasopharynx	326	Lung	277
5	Oesophagus	273	Colon	142
	All Cancers	4103	All Cancers	2897

TABLE III

INCIDENCE OF CANCERS OF SELECTED SITES IN SINGAPORE (ALL RACES) FOR THE PERIOD 1968-70, BY RACE AND SEX: RATES PER 100,000 PERSONS PER ANNUM, AGE-STANDARDISED TO THE WORLD POPULATION

Sites (ICD 8th Revision)		Chinese		Malays		Ind. & Pak.		Others		All Races	
		M	F	M	F	M	F	M	F	M	F
141	Tongue	1·8	0·6	2·0	0·0	5·7	4·6	0·0	0·0	2·1	0·6
143-5	Mouth	2·7	0·3	3·4	1·4	8·0	7·2	—	—	3·3	0·6
146	Oropharynx	1·2	0·3	0·4	0·0	1·6	0·0	0·0	0·0	1·1	0·2
147	Nasopharynx	18·5	6·8	3·1	0·6	0·9	0·0	1·3	0·0	13·9	5·7
148	Hypopharynx	0·6	0·0	0·0	0·0	3·8	0·0	0·0	0·0	0·8	0·0
150	Oesophagus	19·4	7·0	2·7	4·3	6·6	4·1	0·0	3·3	16·3	6·8
151	Stomach	43·9	16·8	10·0	12·6	33·1	20·8	19·6	6·8	38·1	16·4
153	Colon	10·6	7·9	4·6	3·7	5·7	12·9	9·5	0·0	9·6	7·4
154	Rectum	9·3	7·0	3·0	2·4	8·2	4·8	4·8	5·8	8·4	6·6
155	Liver	31·5	6·9	13·5	7·2	10·9	2·5	6·0	10·2	27·1	6·9
160	Nasal cavity	1·4	0·3	0·2	0·0	1·3	0·0	0·0	0·0	1·2	0·2
161	Larynx	7·5	0·7	0·9	0·4	7·3	0·6	0·0	0·0	6·6	0·7
162	Lung	53·5	15·9	14·6	7·6	4·8	9·7	2·8	7·0	44·3	14·9
172	Skin, melanoma	0·6	0·2	0·3	0·0	0·6	0·0	0·0	0·0	0·6	0·2
173	Other Skin	4·7	4·5	4·5	4·3	4·2	7·7	19·4	12·1	5·0	4·6
174	Breast	0·3	18·2	0·0	16·5	0·9	30·4	0·0	26·3	0·3	18·3
180	Cervix	—	16·6	—	12·9	—	19·4	—	12·4	—	16·2
181	Choriocarcinoma	—	1·0	—	1·3	—	0·7	—	0·0	—	1·0
182	Other Uterus	—	4·8	—	3·2	—	6·6	—	12·3	—	4·8
185	Prostate	3·5	—	3·0	—	2·0	—	14·5	—	3·6	—
188	Bladder	5·0	1·8	5·8	—	4·6	4·0	0·0	0·0	4·9	1·7
193	Thyroid	1·1	4·0	0·8	4·7	0·8	5·5	0·0	7·0	1·1	4·1
200	Lymphosarcoma Reticulum cell sarcoma	3·3	1·5	3·2	2·9	2·3	4·4	5·6	0·0	3·2	1·7
201	Hodgkin's Disease	0·8	0·2	0·8	0·0	0·8	0·0	0·0	0·0	0·8	0·1
140-209	All SITES	247·6	147·7	93·9	103·3	137·5	162·1	107·5	138·1	217·5	143·6

The incidence of various cancers in these ethnic groups, age-standardised to the world population, is shown in Table III and in Figures 7, 8 and 9. Relative incidence rates, comparing the incidence of selected cancers among Chinese, Malays and Indians are given in Table IV.

The five most common sites of cancer among Hokkiens, Teochews and Cantonese are shown in Table V. The incidence of various cancers among these Chinese dialect groups, age-standardised to the world population, is shown in Table VI and in Figs. 10 and 11. Relative incidence rates, comparing the incidence of selected cancers in Cantonese with the pooled Hokkien and Teochew groups are given in Table VII.

DISCUSSION

Cancer Incidence in Singapore as a Whole

Differences in methods of obtaining data and variations in levels of under-reporting or over-reporting of cancers may make it difficult to make valid comparisons between incidence rates reported from various countries. Despite these difficulties we believe the data presented in Table I, all of which are age-standardised to the world population, are reasonably comparable.

The age-standardised incidence of cancer (ICD 140-209) in Singapore males is a little lower than in most countries in Europe and America (UICC, 1970) but appreciably higher than in Japan, Bombay and Israel, which are the only other centres in Asia with population-based Cancer Registries. The cancer incidence level in Singapore females is approximately similar to those in Japan, Bombay and Israel, and lower than in most Western countries (UICC, 1970). The age-standardised incidence of lung cancer in Singapore males (44·3 per 100,000 persons per year) is higher than in other centres in Asia and roughly of the same level as in the West.

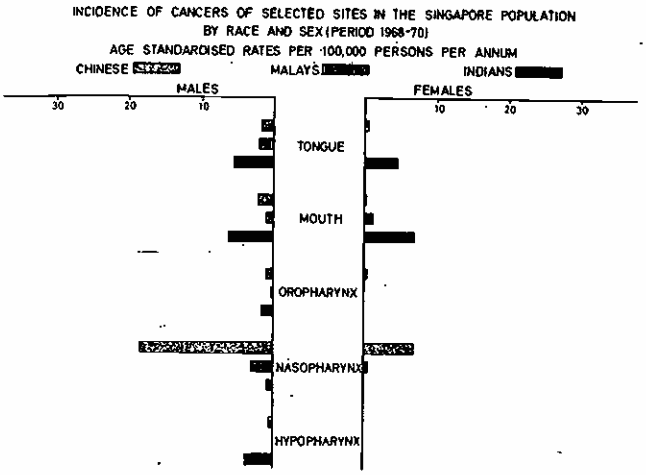

Fig. 7.

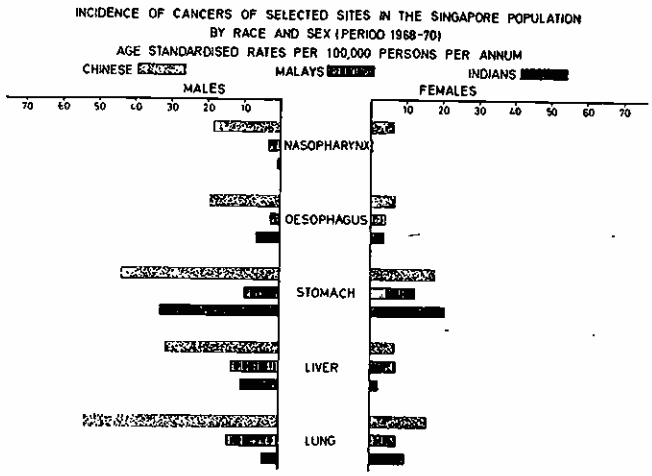

Fig. 8.

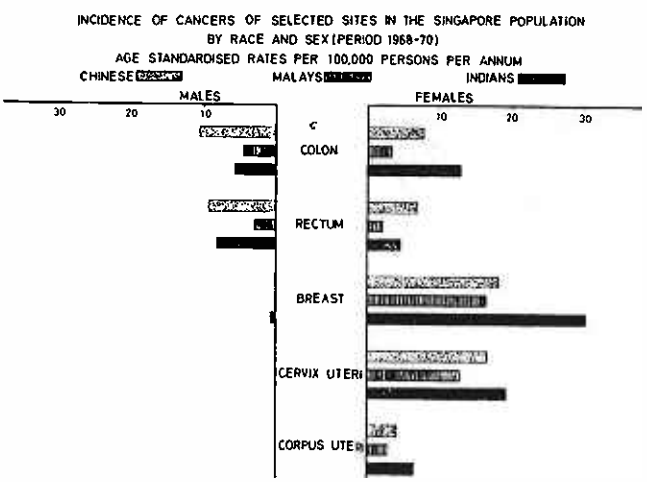

Fig. 9.

What is more intriguing is the fact that the age-standardised incidence of lung cancer in Singapore females (14·9) is among the highest recorded for females in any country; the mortality rate for lung cancer in Singapore females (11·0) is also among the highest in the world. In comparison with Western countries, Singapore has higher incidence rates for cancers of the nasopharynx, oesophagus, stomach and liver and lower rates for cancers of the colon, rectum, breast, prostate and skin. It is beyond the scope of this paper to discuss the aetiological factors that may be involved with these differences. The factors that may have a bearing on the high incidence of nasopharyngeal carcinoma in Singapore have been reviewed (Shanmugaratnam, 1971). The relatively low incidence of skin cancer may be related to the more pigmented skin of Asians that would protect them from the actinic cancers that are common in Caucasean populations. There is yet little information on the factors that may contribute to the relatively high incidence of cancers of the oesophagus, stomach, liver and lung and the relatively low incidence of prostate, breast, colon and rectum cancers.

Cancer registration in Singapore has not continued long enough to evaluate time trends in incidence. However, it appears reasonable to conclude, from a comparison of the present data with records of histologically diagnosed cancers since 1950, that most cancers have shown a steady increase, and that the upward trend has been more marked in the case cancers of lung, stomach, large intestine and liver. While much of the increase may be due to greater use of the medical services and the expansion of the surgical and pathological services, we believe there has also been a true increase in cancer incidence in recent years.

Ethnic (racial) Differences in Cancer Incidence

The incidence rates for cancer of most sites is lower for the Malays than for the Chinese and Indians and this difference is at least partly due to their lower utilization of hospital facilities. Consequently, incidence rates for any cancers that are higher for Malays than for Chinese or Indians are, by the same token, more likely to be significant. Malay women have a significantly higher risk for mouth cancer than Chinese women—a finding that is probably related to their habit of betel nut chewing. The Malays have higher incidence rates for cancers of the nasopharynx, liver and lung than the Indians and, although these differences are not statistically significant, they probably represent a significantly higher risk for the reason given above.

Comparisons between the Chinese and Indian populations are less influenced by differential utilization of hospital facilities. Chinese have higher

TABLE IV

RELATIVE INCIDENCE RATES OF SELECTED CANCERS AMONG MAJOR RACIAL GROUPS IN SINGAPORE

ICD	Site	Relative Risks Chinese/Malay Male	Female	Relative Risks Chinese/Indian Male	Female	Relative Risks Malay/Indian Male	Female
141	Tongue	1·23	—	0·33**	0·18	0·25	—
145	Mouth	1·12	0·07**	0·25**	0·03**	0·26*	0·45
146	Oropharynx	2·51	—	0·62	—	0·28	—
147	Nasopharynx	5·72**	9·23**	18·25**	—	3·23	—
148	Hypopharynx	—	—	0·19**	—	—	—
150	Oesophagus	6·78**	1·34	2·37**	0·78	0·36	0·66
151	Stomach	4·36**	1·17	1·91**	0·90	0·43**	0·80
153	Colon	2·36**	2·25	1·48	0·69	0·64	0·32
154	Rectum	2·64**	2·52*	1·22	0·99	0·46	0·40
155	Liver	2·12**	0·96	2·48**	1·76	1·18	1·95
161	Larynx	7·28**	—	1·29	—	0·17*	—
162	Lung	3·77**	1·96**	6·95**	2·45	1·84	1·28
174	Breast	—	1·04	—	0·92	—	0·90
180	Cervix	—	1·27	—	0·94	—	0·75
183	Ovary	—	1·04	—	1·39	—	1·35
140 - 209	All Sites	2·58**	1·32*	1·92**	1·05	0·72**	0·83

*P<·05 **P<·01

rates for most cancers than Indians despite the fact that their rates of hospital admission, outpatient attendance, biopsies and necropsies are lower than those for Indians. The incidence rates for cancers of the oesophagus, stomach, liver, lung and nasopharynx are significantly higher among the Chinese than in the Indians. On the other hand, the rates for cancers of the tongue, mouth and hypopharynx are significantly higher in Indians than in Chinese.

Of the major ethnic groups in Singapore, the Chinese have the highest cancer incidence; the generally high incidence of cancer in Singapore is largely due to the predominantly Chinese composition of the population. In comparison with immigrant Chinese in Hawaii (Batten and Rogers, 1970) Chinese in Singapore have a lower incidence of cancers of the colon, rectum and breast and a higher incidence of cancers of the liver and stomach. In Singapore, China-born immigrants were found to have a significantly higher risk for liver cancer than local-born Chinese (Shanmugaratnam and Tye, 1970b); no such difference was found for nasopharynx cancer (Shanmugaratnam and Tye, 1970*a*). Epidemiological and laboratory studies have indicated the probability that the high risk

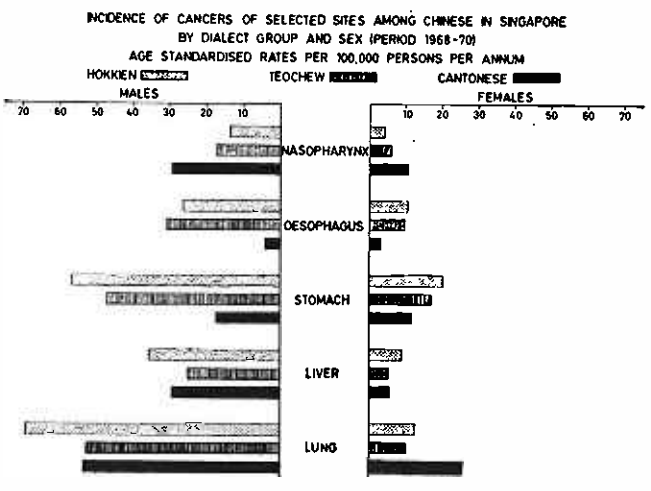

Fig. 10.

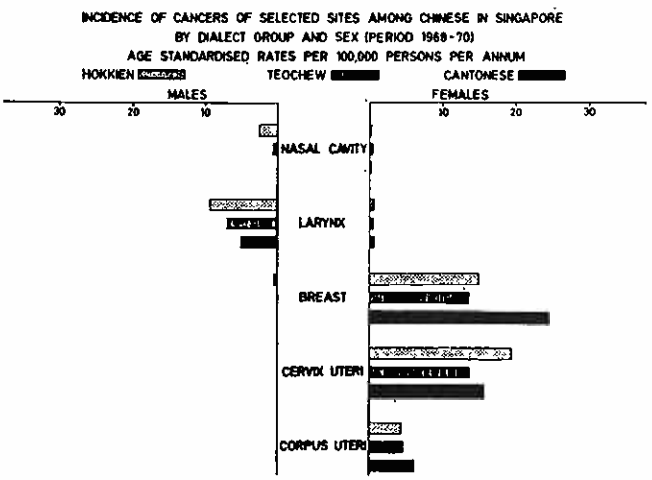

Fig. 11.

TABLE V

FIVE MOST COMMON CANCERS AMONG CHINESE IN SINGAPORE. NUMBERS OF CASES (1968-1970) BY RANK ORDER, DIALECT GROUP AND SEX

Rank	Hokkien			
	Males		Females	
1	Lung	322	Cervix	119
2	Stomach	277	Stomach	114
3	Liver	185	Breast	94
4	Oesophagus	117	Lung	68
5	Nasopharynx	89	Oesophagus	54
	All Cancers	1450	All Cancers	896

Rank	Teochew			
	Males		Females	
1	Lung	173	Stomach	60
2	Stomach	147	Breast	51
3	Oesophagus	90	Cervix	49
4	Liver	77	Oesophagus	35
5	Nasopharynx	62	Lung	35
	All Cancers	782	All Cancers	456

Rank	Cantonese			
	Males		Females	
1	Lung	139	Lung	124
2	Nasopharynx	91	Breast	110
3	Liver	83	Cervix	71
4	Stomach	48	Stomach	57
5	Colon	28	Nasopharynx	49
	All Cancers	548	All Cancers	730

Rank	All Chinese			
	Males		Females	
1	Lung	752	Breast	314
2	Stomach	607	Cervix	284
3	Liver	462	Stomach	276
4	Nasopharynx	312	Lung	259
5	Oesophagus	255	Colon	130
	All Cancers	3603	All Cancers	2524

for nasopharynx cancer among Chinese may be due to a genetic predisposition to some environmental factor.

Dialect Group Differences in Cancer Incidence among Chinese

Epidemiological studies in China have shown that nasopharynx cancer occurs with highest frequencies in the Southern provinces, especially in Kwangtung and Kwangsi (Hu and Yang, 1959; Liang, 1964) and that carcinoma of the oesophagus is more prevalent in the north, particularly in the Lin County in Honan province (Hu and Yang, 1959; Li *et al*, 1962). Differences in cancer incidence among specific Chinese communities or dialect groups has hitherto been reported only with respect to nasopharynx cancer. Studies in China (Jung and Yu, 1963; Liang, 1964) Hong Kong (Ho, 1967) and Singapore (Shanmugaratnam and Tye, 1970*a*) have shown that this neoplasm has a significantly higher frequency among Cantonese than other dialect groups.

Comprehensive registration of cancer cases in Singapore has confirmed the significantly higher incidence of nasopharynx cancer among Cantonese than among other Chinese dialect groups; it has also revealed other dialect group differences in cancer incidence that have not hitherto been suspected. The overall incidence of cancer (ICD 140-209) among Cantonese males is significantly lower than that in Hokkien and Teochew males but Cantonese females have a significantly higher incidence of cancer than Hokkien and Teochew females. The Hokkiens and Teochews resemble each other closely in their cancer patterns; this finding is of interest in view of the general impression that these groups resemble each other more closely than the Cantonese in their ancestry, speech and various modes of life. The incidence of cancers of the oesophagus and stomach among Hokkiens and Teochews is significantly higher than among Cantonese. The incidence of cancers of the lung and breast in Cantonese women is significantly higher than those in Hokkien and Teochew women; the incidence of lung cancer among Cantonese females in Singapore (25·6 per 100,000 per year) is indeed among the highest reported for females from any country.

As these dialect group differences have not been recorded previously, the first question to be answered is whether they may be explained by any source of bias in collection of data, or differential use of medical facilities. Rates of hospital admission, biopsy and necropsy are not available by Chinese dialect groups but it is our impression that these groups do not differ significantly in their use of hospital and diagnostic facilities. The close similarity between these groups in the modes of diagnosis of the cancers in question (Table VIII) supports our impression. Furthermore, such bias is most unlikely because these dialect group differences have not occurred "across the board" but have varied in extent and direction for different cancer sites—the Cantonese have a significantly higher incidence of cancers of the nasopharynx (both sexes), breast and lung (females) and a significantly lower incidence of cancers of the oesophagus and stomach (both sexes). We are therefore fairly confident that the dialect-group differences outlined in this paper represent real differences in risk.

It is of course obvious that the occurrence of cancer does not depend on whether persons belong

TABLE VI

INCIDENCE OF CANCERS OF SELECTED SITES AMONG CHINESE IN SINGAPORE FOR THE PERIOD 1968-70, BY DIALECT GROUPS AND SEX: RATES PER 100,000 PERSONS PER ANNUM, AGE-STANDARDISED TO THE WORLD POPULATION

Sites (ICD 8th Rev.)		Hokkien		Teochew		Cantonese		Others		Total Chinese	
		M	F	M	F	M	F	M	F	M	F
143-5	Mouth	2·9	0·0	3·4	0·5	2·4	0·6	1·4	0·3	2·7	0·3
147	Nasopharynx	13·7	4·4	17·4	5·9	29·4	10·8	19·0	6·6	18·5	6·8
150	Oesophagus	26·3	10·6	30·7	9·9	4·1	3·3	10·7	3·3	19·4	7·0
151	Stomach	56·9	20·2	47·1	17·2	17·4	11·9	40·4	17·0	43·9	16·8
153	Colon	10·7	8·6	7·4	4·8	11·0	9·1	12·3	9·6	10·6	7·9
154	Rectum	8·5	8·7	8·2	7·1	8·4	4·4	13·1	7·6	9·3	7·0
155	Liver	35·4	8·9	25·0	5·5	29·3	5·7	31·7	7·3	31·5	6·9
160	Nasal Cavity	2·5	0·3	0·6	0·5	0·0	0·3	1·9	0·0	1·4	0·3
161	Larynx	9·3	0·6	6·9	0·6	5·0	0·7	8·2	0·8	7·5	0·7
162	Lung	69·2	12·8	52·9	10·2	53·6	25·6	34·5	12·9	53·5	15·9
172	Skin Melanoma	0·6	0·0	0·6	0·6	0·4	0·0	0·9	0·0	0·6	0·2
173	Other Skin	3·7	2·7	4·1	1·3	3·3	5·2	9·0	11·9	4·7	4·5
174	Breast	0·5	15·0	0·0	13·6	0·0	24·4	0·6	21·1	0·3	18·2
180	Cervix	—	19·5	—	13·7	—	15·5	—	16·2	—	16·6
181	Choriocarcinoma	—	1·2	—	1·0	—	0·7	—	0·7	—	1·0
182	Other Uterus	—	4·4	—	4·7	—	6·1	—	4·6	—	4·8
185	Prostate	3·4	—	1·6	—	5·3	—	4·2	—	3·5	—
188	Bladder	4·4	1·7	7·6	0·8	3·2	1·8	4·8	3·7	5·0	1·8
193	Thyroid	0·9	4·0	0·6	3·2	0·0	3·8	2·7	5·4	1·1	4·0
200	Lymphosarcoma Reticulum cell sarcoma	2·4	1·3	3·8	0·9	3·8	1·7	4·2	2·1	3·3	1·5
201	Hodgkins Disease	0·8	0·2	0·4	0·6	0·4	0·0	1·4	0·0	0·8	0·2
140-209	ALL SITES	285·4	152·3	243·9	122·1	199·4	157·8	235·4	159·0	247·6	147·7

to this or that ethnic or linguistic group but on exposure to carcinogens that may be associated with various modes of life. The proposition that genetic factors are more important than environmental factors in the etiology of nasopharynx cancer is probably valid, but the high risks and increasing incidence of other cancers such as those of the lung, stomach and liver are undoubtedly attributable to environmental, and hence preventable, causes. The ethnic groups and Chinese dialect groups in Singapore, especially those in the immigrant generation, have differred significantly in their food habits, occupation, areas of residence and other modes of life.

The relatively higher risks for cancers of the breast and lung among Cantonese women are probably related to socio-environmental factors. Many of the older women in this group came to Singapore during the period of selective immigration in the 1930s and there is little doubt that of all the Chinese groups of the immigrant generation in Singapore only Cantonese women have lived and worked in substantial numbers independent of residential family ties (Wee, 1972). There is also an impression that the proportion of smokers among Cantonese women may be higher than among women in other dialect groups, but this has not been confirmed by controlled studies.

The high risks for oesophagus and stomach cancers among Hokkiens and Teochews are highly significant. The composition and temperature of the food, and the use of alcohol are among some of the factors that have been postulated in the etiology of upper gastrointestinal tract cancers but it is necessary to collect more information on ethno-linguistic groups in Singapore before any hypothesis can be developed to explain local differences in cancer incidence. The Government Gazette of Chang Chiew prefecture and the Lung Chih District of Fukien province, and geneological studies of popular surnames in the Chang Chiew area indicate (Tan, 1972) that Hokkiens and Teochews are descendants of groups that had migrated to Fukien between A. D. 713 to 755 from the

TABLE VII

RELATIVE INCIDENCE RATES OF SELECTED CANCERS FOR CANTONESE TO THE POOLED HOKKIEN AND TEOCHEW GROUPS

ICD (8th Rev.)	Site	Males	Females
147	Nasopharynx	2·033**	2·245**
150	Oesophagus	0·171**	0·331**
151	Stomach	0·342**	0·626**
153	Colon	1·164	1·189
154	Rectum	0·997	0·541*
155	Liver	0·962	0·752
161	Larynx	0·593	—
162	Lung	0·838	2·228**
174	Breast	—	1·652**
180	Cervix	—	0·908
183	Ovary	—	1·185
140 - 209	All Sites	0·754**	1·125*

*Significant at ·05 level
**Significant at ·01 level

province of Honan, more specifically from the Kwangchow, Ku Shih district. Surveys on the incidence of oesophagus cancer in North China (Li *et al*, 1962) have shown that the highest incidence of this neoplasm is found in the Lin County of Honan province. It is tempting to speculate that the high incidence of oesophagus cancer among Hokkiens and Teochews in Singapore may somehow be linked to their origin from this part of China.

The collection of cancer incidence data is of course not an end in itself but an essential first step in investigations on the aetiology and control of this disease.

Some epidemiological and laboratory studies related to the aetiology of particular cancers are being conducted in the University of Singapore, the Ministry of Health and the WHO Immunology and Training Centre in Singapore. The results of these studies and those of cancer registration over the next 10 to 20 years, when increasing proportions of persons in the older age groups will be Singapore-born, may assist in assessing to what extent genetic and environmental factors may contribute to local cancer patterns. Life styles in Singapore are changing rapidly with re-allocation of housing, more inter-ethnic and inter-dialect marriages and the merging of cultures, both indigenous and foreign. Studies on the genetic profiles and modes of life of the various ethno-linguistic groups in Singapore should therefore be expanded and undertaken without delay.

Of the three major ethnic groups in Singapore the Chinese have the highest cancer incidence. They have significantly higher incidence rates for cancers of the oesophagus, stomach, liver, nasopharynx and lung than the other ethnic groups. The Indians have significantly higher rates for cancers of the tongue, mouth and hypopharynx. The Malays have the lowest rates for cancer but this is probably due, at least in part, to their lower utilisation of hospital facilities and hence the likelihood of more cancers being unrecognised. The Malays, nonetheless, have higher rates than Indians for cancers of the nasopharynx, liver and lung which, although not statistically significant, probably represent relatively higher risks. Malay women have significantly higher rates for mouth cancer than Chinese women.

Significant differences were observed in the cancer patterns of the major Chinese dialect groups in Singapore. Hokkiens and Teochews, who resemble each other closely in their cancer patterns, have significantly higher rates for cancers of the oesophagus and stomach than other dialect groups. Cantonese have higher rates for nasopharynx cancer; female Cantonese have higher rates for cancers of the lung and breast. These dialect group differences, apart from those in nasopharynx cancer, have not been reported previously.

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TABLE VIII

BASIS OF DIAGNOSIS OF SELECTED CANCERS AMONG CHINESE IN SINGAPORE (1968-1970) BY DIALECT GROUP AND SEX

	Basis of Diagnosis									
	Necropsy		Biopsy		Cytology		Exploration X-ray		Clinical	
	M	F	M	F	M	F	M	F	M	F
Hokkien										
Nasopharynx	—	—	83	24	—	—	—	—	6	4
Oesophagus	2	—	67	32	—	—	27	8	21	14
Stomach	10	1	142	55	2	1	63	19	60	38
Rectum	—	2	35	39	—	—	1	—	5	7
Lung	29	3	131	29	10	4	122	21	30	11
Breast**	—	—	—	80	—	—	—	2	—	12
Other Sites	29	13	356	345	36*	23*	45	30	136	79
Teochew										
Nasopharynx	1	1	56	22	—	—	—	—	5	2
Oesophagus	5	—	50	17	1	—	25	7	9	11
Stomach	3	2	67	28	5	—	31	11	41	19
Rectum	—	—	22	24	—	—	2	—	2	1
Lung	15	2	72	18	3	2	67	11	16	2
Breast	—	—	—	39	—	—	—	1	—	11
Other Sites	16	10	164	161	19*	13*	18	8	67	33
Cantonese										
Nasopharynx	1	—	83	45	—	—	—	—	7	4
Oesophagus	—	—	6	9	—	—	3	3	3	4
Stomach	2	3	26	27	1	—	8	11	11	16
Rectum	—	—	20	16	—	—	1	1	1	3
Lung	12	9	48	53	9	8	65	45	5	9
Breast	—	2	—	100	—	—	—	—	—	8
Other Sites	20	20	131	263	13*	16*	28	18	44	37

*includes haematology **excludes 2 males

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