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THE GEOGRAPHICAL DISTRIBUTION OF CANCER

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STUDY of the geographical distribution of cancer has long been recognized to be one way of obtaining clues to its causation, and a great deal of work has been carried out to determine the incidence of different types of cancer in different parts of the world. Detailed incidence rates have been obtained for more than fifty populations, either by national or regional cancer registries or by special investigations in selected areas. Many of the results have been published in book form or government reports which are not readily accessible, and others have been published only in summary or in such a way that comparison with other sets of data is difficult or impossible. To help overcome this, incidence data for thirty-four populations in twenty-three countries have recently been brought together in comparable form in a single volume by the International Union against Cancer (1966).

Incidence data, however, constitute only part of the available evidence. Mortality statistics have been published for the principal types of cancer in forty-eight countries and in the urban areas of the fifteen Soviet republics (World Health Organization, 1966; Segi and Kurihara, 1964; Merkova, Tserkovnogo, and Kaufman, 1963) and, in some circumstances, these can provide useful indicators of incidence. Indeed, in some areas in which cancer registration is incomplete, mortality can provide a better indication of incidence than the official " incidence statistics ", particularly for cancers whose fatality is high or for which it is possible to obtain a reasonably accurate indication of the proportion that are not directly responsible for causing death.

Finally, there is an immense number of clinical and pathological records. Few can be used to provide reliable estimates of incidence, but, in exceptional circumstances, they provide a clear indication of a situation that is qualitatively different in different parts of the world (as with Burkitt's lymphoma and Kaposi's sarcoma).

The extent of the variation in cancer incidence has been reviewed and the geographical distribution of six types of cancer has been published in map form elsewhere (Doll, 1967 and 1968). Corresponding numerical data and incidence rates for ten other types of cancer are given here.

TABLE I.—*Multiplying Factors Used to Estimate Incidence of Different Types of Cancer in Persons Aged* 35 *to* 64 *Years From Mortality Rates* (*Male Rates Except for Breast-Cancer*)

Site of primary cancer (international list number)	Oesophagus (150)	Stomach (151)	Colon (153)	Rectum (154)	Pancreas (157)	Lung (162–3)	Breast ♀ (170)	Prostate (177)	Bladder (181)	Thyroid (194)	Leukaemia (204)
Factor to convert mortality at ages 35–64 years to incidence at ages 35–64 years	1·19	1·12	1·67	2·08	1·13	1·20	2·26	2·18	2·41	2·43	1·29
Factor to convert mortality at ages 30–54 years to mortality at ages 35–64 years	1·91	1·77	1·74	1·87	—	1·70	1·39	2·99	—	—	1·37

To allow for differences in the age distribution of different populations the tabulated rates have been standardized for age, using a rounded off variant of Segi's "world population" (Segi, 1960; International Union against Cancer, 1966). Standardization does not, however, overcome the difficulty that cancer incidence varies with age in different ways in different countries nor, in particular, for the fact that in some populations the incidence of many cancers levels off or even falls in old age, whereas in other countries it continues to rise. This difference can be due to cohort effects produced by changes in the prevalence of carcinogenic factors with time or to other factors, such as the failure of old persons to make use of the medical services. Comparisons have, therefore, been limited to the age range 35 to 64 years, in which most cancers are relatively frequent, but which excludes data for the oldest ages that are least likely to reflect current conditions and are least likely to be accurate (Doll and Cook, 1967).

To enable mortality rates to be used, conversion factors have been calculated from the data for eight countries that have published incidence and mortality rates over approximately the same periods (Chile, Denmark, Finland, Israel, New Zealand, Norway, Puerto Rico, and Sweden). These factors have been obtained by dividing the relevant truncated incidence rates* (standardized for age) by the corresponding mortality rates and averaging the result over the eight populations. Estimates of cancer incidence in other countries have then been obtained by multiplying the site-specific mortality rates by the corresponding factors. Judged by the variability of the factors in the eight countries the error in the derived incidence rates is, for the most part, likely to be less than 20 per cent (47 out of 70 observations) but it could rise to 30 per cent (8 out of 70 observations), and the most extreme variations would be from -40 per cent to $+68$ per cent. For some countries mortality rates have been published only for ten-year age groups from 30 to 39 years of age rather than from 35 to 44 years of age. Other factors have, therefore, been derived from British experience, using the pooled mortality data for England and Wales over the ten years 1950 to 1959, to convert standardized mortality rates at ages 30 to 59 years into the corresponding rates at ages 35 to 64 years. Both sets of factors are shown in Table I.

Table II gives incidence rates for fifteen types of primary cancer (13 in men and 2 in women) for thirty-four populations and for some of these cancers for a further forty-three populations. For thirty-three populations the standardized incidence rates have been derived from the age-specific rates given in the review volume published by the International Union against Cancer (1966) and relate to periods around 1960–62. Exceptionally the data for Denmark relate to 1953–57, for Johannesburg to 1953–55, for Kyadondo County, Uganda, to 1954–60, and for Singapore Chinese to 1950–61. Other sets of rates have been added for Bombay (Bombay Cancer Registry, 1966) and for Indian and African populations in Durban (Schonland and Bradshaw, 1968). For forty-one populations the rates have been derived from the age-specific mortality statistics brought together by the World Health Organization (1966), Segi and Kurihara (1964) and Merkova, Tserkovnogo, and Kaufman (1963). These have been made comparable with the incidence rates by multiplying by conversion factors (Table I) and, in sixteen instances, by further conversion factors (Table I) to allow for the fact that the published rates related to ages 30 to 59 years. These also have been chosen to relate to periods close to or around 1961.

* That is, the rates for a selected age range, in this case usually 35 to 64 years.

TABLE II.—*Incidence of Different Types of Cancer in Different Populations: Annual Rates Per 100,000 Persons Aged 35–64 Years, Standardized for Age (Male Rates Except for Breast and Cervix Uteri)*

Population	Mouth (141, 143–4)	Naso-pharynx (146)	Oesoph-agus (150)	Stomach (151)	Colon (153)	Rectum (154)	Pancreas (157)	Larynx (161)	Lung (162–3)	Breast ♀ (170)	Cervix uteri ♀ (171)	Prostate (177)	Bladder (181)	Thyroid (194)	Leukaemia (204)
	Incidence of cancer of:														
AFRICA															
Mozambique,															
Lourenço Marques	8·5	4·6	11·8	4·7	5·3	0·0	0·4	3·4	7·8	10·2	62·6	17·3	34·6	3·3	4·2
Nigeria, Ibadan	2·3	0·7	2·6	21·9	2·8	3·1	3·8	4·4	3·1	41·4	52·6	13·7	9·4	2·0	9·1
S. Africa															
*(coloured)	—	—	28·0	79·0	13·7	5·6	—	—	56·3	65·1	—	25·5	—	—	3·0
*(white)	—	—	6·1	36·2	17·9	10·8	12·8	—	63·4	100·6	—	17·0	—	—	8·0
Durban															
(African)	10·9	0·0	98·9	19·6	6·6	4·5	4·7	9·5	84·4	24·3	115·5	19·7	4·5	0·8	4·8
(Indian)	3·3	0·0	14·7	28·8	2·5	5·1	6·1	5·0	27·3	40·8	80·8	2·5	11·8	0·0	7·5
Johannesburg															
(African)	7·9	1·7	21·8	19·4	4·0	2·4	5·3	3·6	17·9	25·1	117·4	9·7	7·3	0·3	2·6
Uganda, Kyadondo	1·9	0·0	5·5	6·6	0·0	3·5	3·8	1·7	1·9	21·8	56·5	9·1	14·2	0·0	3·7
AMERICA															
Canada															
Alberta	4·5	1·0	2·2	24·5	20·3	12·4	6·9	2·7	38·5	119·1	51·2	11·9	11·1	1·3	6·7
Manitoba	2·9	1·1	2·1	29·8	29·8	15·2	13·6	5·8	59·3	130·7	81·9	15·7	17·6	1·7	12·3
New Brunswick	5·4	0·9	3·9	33·4	24·1	16·8	10·2	6·9	37·1	112·2	79·8	15·4	19·4	1·4	4·7
Newfoundland	3·8	2·4	5·3	53·8	24·9	5·5	6·5	4·8	47·8	91·1	46·1	7·0	16·9	1·1	4·2
Saskatchewan	3·2	1·4	4·2	25·6	18·0	18·8	10·6	0·7	39·4	128·9	40·3	20·1	16·5	2·1	11·0
Chile	2·3	0·2	18·9	85·2	5·8	6·0	5·7	4·7	25·9	46·2	108·8	8·8	1·9	1·7	4·4
Colombia, Cali	9·0	0·0	8·2	81·6	5·7	3·9	2·0	14·6	25·3	72·9	247·3	19·8	15·4	11·6	4·5
Jamaica, Kingston	7·9	2·2	26·6	40·2	8·7	7·0	5·5	4·9	27·9	62·9	112·9	12·7	8·2	2·5	5·7
Puerto Rico	26·6	0·7	35·2	42·8	6·2	6·9	5·9	10·6	20·8	33·1	111·8	11·5	10·4	1·8	5·9
U.S.A.															
*(non-white)	—	—	20·5	35·6	25·6	16·0	18·3	—	80·9	99·9	—	40·8	—	—	8·3
*(white)	—	—	5·8	14·8	26·6	15·6	12·8	—	70·1	99·7	—	12·6	—	—	10·6
Connecticut	11·5	0·9	9·1	18·9	31·2	20·6	11·7	13·8	75·1	126·0	31·3	21·8	21·2	1·9	11·6
New York State	7·7	1·0	5·8	16·9	27·0	18·5	11·2	8·2	65·0	103·2	32·9	13·8	16·1	1·8	8·9
*Uruguay	—	—	23·6	55·0	26·9	18·7	—	—	74·1	99·4	—	21·4	—	—	9·4
*Venezuela	—	—	4·8	53·5	7·3	4·4	—	—	18·1	34·6	—	14·8	—	—	4·1
ASIA															
*Hong Kong	—	—	23·0	36·8	14·5	9·2	—	—	50·8	41·4	—	—	—	—	3·1
India, Bombay	61·3	—	21·3	17·3	6·6	8·0	—	—	25·6	45·7	62·3	3·8	—	—	3·7
Israel	3·0	2·8	4·2	35·4	15·0	10·0	12·7	13·3	39·9	119·8	14·8	8·5	17·4	2·8	10·6
Japan, Miyagi	1·9	1·5	20·7	158·3	5·0	8·1	9·2	3·7	22·6	33·4	53·9	4·1	4·6	1·6	3·2
Singapore, (Chinese)	4·6	35·9	24·6	29·5	4·6	8·5	1·6	7·5	24·6	18·9	52·2	1·1	3·2	0·9	1·3
*Taiwan	—	—	12·1	42·8	9·2	5·6	—	—	18·8	19·4	—	0·7	—	—	—
U.S.S.R., towns															
*†Armenia	—	—	9·1	60·8	—	—	—	—	46·9	24·8	—	—	—	—	—
*†Azerbaidjan	—	—	28·6	85·9	—	—	—	—	84·3	32·3	—	—	—	—	—
*†Georgia	—	—	7·9	48·7	—	—	—	—	65·1	60·9	—	—	—	—	—
*†Kazakhstan	—	—	64·9	149·5	—	—	—	—	90·0	22·3	—	—	—	—	—
*†Kirghizia	—	—	23·6	160·4	—	—	—	63·9	—	25·7	—	—	—	—	—
*†Tadjikstan	—	—	32·5	126·3	—	—	—	—	43·0	16·3	—	—	—	—	—
*†Turkmenistan	—	—	110·5	150·5	—	—	—	—	83·6	20·7	—	—	—	—	—
*†Uzbekistan	—	—	48·6	110·5	—	—	—	—	59·6	23·2	—	—	—	—	—

EUROPE														
*Austria	—	—	4·9	59·0	18·0	17·5	11·6	—	96·4	71·0	—	12·9	—	—	9·4
*Belgium	—	—	6·2	42·1	20·9	19·6	8·0	—	89·3	91·5	—	12·6	—	—	9·8
*†Bulgaria	—	—	2·5	56·4	7·8	13·2	—	—	60·6	44·6	—	12·4	—	—	8·7
*Czechoslovakia . . .	—	—	3·3	67·3	12·9	23·3	—	—	103·3	61·9	—	10·7	—	—	8·8
Denmark	2·2	—	3·9	37·4	17·1	20·8	8·6	3·0	50·6	91·5	68·4	10·5	18·5	0·9	9·0
England and Wales															
Birmingham region .	4·4	1·0	4·8	45·5	17·4	20·7	9·0	5·8	138·3	102·1	29·7	10·0	13·6	0·9	6·2
Liverpool region . .	3·7	0·6	4·6	47·8	24·1	15·4	10·4	6·4	140·4	88·2	35·4	7·4	14·0	0·7	6·6
S. Metropolitan region .	3·1	0·9	5·1	30·7	15·8	16·2	9·2	6·4	128·4	103·4	26·6	7·4	16·9	0·8	6·8
S. Western region . .	2·5	0·9	4·8	30·1	17·2	16·6	8·3	5·9	100·0	101·0	32·0	8·9	17·0	0·7	6·4
Finland	2·4	0·5	8·6	72·0	8·3	7·5	12·8	15·6	119·7	58·7	39·6	10·3	7·8	1·4	8·1
*France	—	—	25·5	33·0	20·2	16·8	—	—	50·5	67·6	—	13·7	—	—	9·4
‡*Germany F.R. . . .	—	—	4·8	51·3	14·2	16·6	8·7	(8·3)	76·9	72·5	(93·2)	11·1	—	(1·6)	9·2
*Greece	—	—	2·5	25·1	10·0	2·1	—	—	54·1	33·2	—	5·0	—	—	9·0
*Hungary	—	—	4·3	68·2	14·2	15·2	—	—	61·6	59·7	—	12·9	—	—	11·2
Iceland	1·3	1·8	8·0	102·3	9·3	7·5	6·1	2·7	28·2	84·1	39·2	8·8	8·5	2·3	10·7
*Ireland	—	—	8·0	38·8	25·2	13·9	9·2	—	66·1	94·9	—	10·7	—	—	9·7
*Italy	—	—	6·5	52·9	16·0	11·6	6·1	—	57·4	68·7	—	10·5	—	—	9·0
Netherlands (3 provinces) .	3·1	0·6	2·5	26·4	12·8	9·5	6·0	7·0	81·3	95·6	51·0	7·5	10·2	1·1	5·4
*N. Ireland	—	—	4·0	43·9	21·9	18·7	10·3	—	87·7	86·6	—	10·9	—	—	7·9
Norway	3·1	0·7	3·9	38·6	12·7	7·5	8·1	3·1	27·4	86·3	38·1	12·5	7·0	1·5	7·5
*Poland	—	—	8·2	74·8	8·2	7·5	—	—	45·4	37·3	—	4·8	—	—	11·4
*Portugal	—	—	11·5	56·9	15·0	9·6	—	—	18·5	53·1	—	12·2	—	—	6·7
*Roumania	—	—	5·2	64·2	8·9	7·9	—	—	53·8	39·8	—	9·6	—	—	6·5
*Scotland	—	—	6·2	43·0	28·2	23·3	10·7	—	154·3	111·0	—	11·1	—	—	7·2
Sweden	2·6	1·3	3·4	32·5	16·0	12·8	9·4	3·4	29·4	96·4	43·7	15·9	12·1	2·1	11·3
*Switzerland	—	—	15·1	34·4	20·9	16·4	8·7	—	69·2	92·2	—	12·4	—	—	8·8
*Yugoslavia	—	—	4·0	38·6	6·2	13·9	—	—	40·3	38·2	—	5·9	—	—	6·6
Yugoslavia, Slovenia . .	5·0	0·6	8·6	74·6	7·0	9·1	6·6	7·6	61·8	48·3	65·3	7·8	5·4	3·2	6·5
U.S.S.R., towns															
*†Belorussia	—	—	9·3	132·3	—	—	—	—	49·4	24·2	—	—	—	—	—
*†Estonia	—	—	15·0	99·4	—	—	—	—	71·4	44·9	—	—	—	—	—
*†Latvia	—	—	11·6	76·2	—	—	—	—	98·9	49·9	—	—	—	—	—
*†Lithuania	—	—	5·2	88·5	—	—	—	—	75·3	28·6	—	—	—	—	—
*†Moldavia	—	—	9·1	91·3	—	—	—	—	56·1	55·3	—	—	—	—	—
*†R.S.F.S.R.	—	—	24·1	172·3	—	—	—	—	102·1	33·6	—	—	—	—	—
*†Ukraine	—	—	10·7	104·3	—	—	—	—	80·0	38·9	—	—	—	—	—
OCEANIA															
*Australia	—	—	5·0	22·7	23·5	13·7	10·3	—	57·4	81·8	—	13·7	—	—	8·3
New Zealand	3·9	0·6	6·8	29·5	30·6	20·8	13·3	5·6	64·5	103·3	35·8	19·0	12·7	1·4	7·8
U.S.A., Hawaii															
(Caucasian	16·8	1·6	10·2	18·6	27·6	12·4	14·3	14·6	67·5	133·1	84·8	33·0	26·6	1·4	5·9
(Hawaiian)	5·9	10·2	10·4	91·2	27·1	10·1	14·2	11·9	99·0	109·2	116·2	14·5	18·6	13·	15·6
(Japanese). . . .	1·9	0·0	5·8	58·8	28·0	19·1	5·7	1·0	21·0	50·9	58·4	11·	9·		6·7

* Estimated from mortality data.
† Estimated from data for ages 30–59 years.
‡ Figures in parentheses refer to Hamburg only.

TABLE III.—*Incidence of Cancer of the Oesophagus and of the Cervix Uteri in Selected Populations: Annual Rates per* 100,000 *Persons Aged* 35–64 *Years, Standardized for Age.*

	Incidence of cancer of	
Populations	Oesophagus (150)	Cervix uteri (171)
AFRICA		
S. Africa Transkei (African)	357·2	—
S. Rhodesia Bulawayo (African)	157·5	—
AMERICA		
New York City (Jewish)	—	8·8
,, ,, ,, (Negro)	—	100·6
,, ,, ,, (Puerto Rican)	—	271·9
,, ,, ,, (White non-Jewish)	—	38·5
ASIA		
*Kazakhstan Ghurjev district	547·2	—

* Estimated from data for ages 30–59 years

Table III gives further data of particular interest for cancer of the oesophagus in three populations (Kmet, personal communication; Rose, 1967; and Skinner, 1967) and for cancer of the cervix uteri in four populations (Haenszel and Hillhouse, 1959).

Table IV gives incidence rates for primary cancer of the liver in forty-seven populations over the age range 15 to 44 years. For this type of cancer, comparisons are made at younger ages, partly because liver cancer appears early in adult life in areas where it is common and partly because there is less possibility of confusion between primary and secondary cancers than at older ages when gastric, colonic, bronchial, and gall bladder cancers are relatively frequent. Most of the rates (33) have been reported specifically for primary cancer of the liver, but 14 have been estimated from the recorded mortality for cancer of the liver and biliary passages or from incidence data that may include some other liver cancers. These last have been included because examination of the rates in six populations (Canada, Finland, Israel, New Zealand, Norway and Sweden) for which both the mortality from cancer of the liver and biliary passages and the incidence of primary liver cancer have been published, shows that, at ages 15 to 44 years, both sets of rates are practically identical. It will be noted that all the estimated rates, which may be regarded as maximal, are low.

All rates are shown for one sex only.* For comparison between countries this is usually unimportant, as the sex ratio of most cancers is relatively constant from one population to another. Cancer of the oesophagus—and to a less extent cancer of the lung and cancer of the larynx—provide exceptions. For cancer of the oesophagus the sex ratio at ages 35 to 64 years varies from less than 1·5 to 1 in England and Wales, Bombay, and Kazakhstan to 20 to 1 in France.

Further data that cannot be expressed in comparable arithmetrical form have also been collected in an extensive review of the subject by Dunham and Bailar (1968).

* Tables showing comparable rates for women can be obtained on application to Medical Research Council's Statistical Research Unit.

TABLE IV.—*Incidence of Primary Liver Cancer in Different Populations: Annual Rates Per 100,000 Men Aged 15–44 Years, Standardized for Age*

Population	Incidence
AFRICA	
Mozambique	
Lourenço Marques	164·6
Nigeria	
Ibadan	10·2
S. Africa	
Durban (African)	12·3
Durban (Indian)	0·7
Johannesburg (African)	10·2
*white	0·6
Uganda	
Kyadondo	6·5
AMERICA	
Canada	
Alberta	0·0
Manitoba	0·3
New Brunswick	0·0
Newfoundland	0·0
Saskatchewan	0·0
Chile	1·1
Colombia	
Cali	0·7
Jamaica	
Kingston	2·0
Puerto Rico	0·3
U.S.A.	
*non-white	1·0
*white	0·2
Connecticut	0·4
New York State	0·1
ASIA	
India	
‡Bombay	0·1
Israel	0·5
*Japan	0·4
Singapore (Chinese)	4·1
EUROPE	
*Austria	0·1
*Belgium	0·3
†Denmark	0·2
England and Wales	
Birmingham region	0·1
Liverpool region	0·3
S. Metropolitan region	0·2
S. Western region	0·0
Finland	0·3
*Germany F.R.	0·2
†Iceland	0·3
*Ireland	0·1
*Italy	0·4
Netherlands	
3 provinces	0·2
Norway	0·1
*Scotland	0·4
Sweden	0·1
*Switzerland	0·4
Yugoslavia Slovenia	0·1
OCEANIA	
*Australia	0·2
New Zealand	0·5
U.S.A., Hawaii	
(Caucasian)	0·0
(Hawaiian)	1·5
(Japanese)	1·4

* Estimated from the mortality rates for cancer of the liver and biliary passages (see text).
† Including, for Iceland, cancer of biliary passages and, for Denmark, cancer of the liver, primary site unknown.
‡ Estimated from the rate for ages 10-39 years by multiplying by 1·7.

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