health events. *Morbidity and Mortality Weekly Rep*, Atlanta, 1990, **39** (RR-11).
5. Neutra RR. Counterpoint from a cluster buster. *Am J Epidemiol* 1990, **132**, 1–8.
6. Whittemore AS, Friend N, Brown BW, Holly EA. A test to detect clusters of disease. *Biometrika* 1987, **74**, 631–635.
7. Ohno Y, Aoki K, Aoki N. A test of significance for geographic clusters of disease. *Int J Epidemiol* 1979, **8**, 273–281.
8. Geary R. The contiguity ratio and statistical mapping. *Incorporated Statist* 1954, **5**, 115–145.
9. Weinstock MA.A generalised scan statistic test for the detection of clusters. *Int J Epidemiol* 1981, **10**, 289–293.
10. Wallenstein S. A test for the detection of clustering over time. *Am J Epidemiol* 1980, **111**, 367–372.
11. Ederer F, Myers MH, Mantel N. A statistical problem in space and time: do leukemia cases come in clusters? *Biometrics* 1966, **20**, 626–638.
12. Knox G. The detection of space–time interactions. *Appl Statist* 1964, **13**, 25–29.
13. Barton DE, David FN. The random intersection of two graphs. In David FN, ed. *Research Papers in Statistics*. New York, John Wiley & Sons Inc, 1966, 455–559.
14. Selvin S, Shaw G, Schulman J, Merrill DW. Spatial distribution of disease: three case studies. *JNCI* 1987, **79**, 417–423.
15. Selvin S, Merrill D, Schulman J, *et al.* Transformations of maps to investigate clusters of disease. *Soc Sci Med* 1988, **26**, 215–221.
16. Openshaw S, Craft AW, Charlton M, Birch JM. Investigation of leukaemia clusters by use of a geographical analysis machine. *Lancet* 1988, **i**, 272–273.
17. Samet JM. Radon and lung cancer. *JNCI* 1989, **81**, 745–757.
18. Harley NH, Harley JH. Potential lung cancer risk from indoor radon exposure. *A Cancer J for Clinicians* 1990, **40**, 265–275.
19. Bowie C, Bowie SHU. Radon and Health. *Lancet* 1991, **337**, 409–413.
20. Canada Census 1986: *Census Divisions and Subdivisions; Ontario: Part 1—Profiles*. Cat. No. 94-111, Ottawa, Statistics Canada, 1987.
21. Canada Census 1986. *Census Divisions and Subdivisions; Ontario: Part 2—Profiles*. Cat. No. 94-112. Ottawa, Statistics Canada, 1987.
22. Radiation Protection Bureau. Department of National Health and Welfare (personal communication, Feb 1991).
23. Alphanuclear Company, Missisauga Ontario (personal communication, Feb 1991).
24. Clarke EA, Marrett LD, Kreiger N. *Twenty Years of Cancer Incidence, 1964–1983: The Ontario Cancer Registry*. Toronto, The Ontario Cancer Treatment and Research Foundation, 1987.
25. Rothman KJ. A sobering start for the cluster busters' conference. *Am J Epidemiol* 1990, **132** (Suppl. 1), S6–S13.

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Cancer Risks Among European Migrants in Sáo Paulo, Brazil

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Using both mortality and incidence data, cancer risk in Italian, Spanish and Portuguese migrants to Sáo Paulo were compared with those in the Brazil-born population, and with those in their countries of origin. Italian and Spanish migrants show changes in cancer risks which are rather similar to those observed in migrants of the same origin in other parts of South America: they increase their rates of oropharyngeal, oesophageal, cervical and breast cancers and they decrease their rates of lung cancers. However, for cancer of the oesophagus, the changes are greater in Sáo Paulo, where migrants acquire rates similar to those of the natives. For colon cancer, rates in Italian migrants decrease in the low risk area of Sáo Paulo and increase in the high risk area of Argentina. Changes in Portuguese migrants are less evident: their rates of colorectal cancer remain high, and, as found for Japanese migrants in Sáo Paulo, they also retain their higher risks of stomach cancer.
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INTRODUCTION

STUDIES OF cancer risk in European populations migrating to South America are scarce. Death rates from cancer among migrants in Uruguay and Argentina have recently been published, and show interesting patterns, especially for digestive cancers [1, 2]. The only published studies of migrants to Brazil concern Japanese in Sáo Paulo [3–5], although the cancer pattern in migrants to Brazil is of particular interest, as there are unusually high local rates of oral cavity, oesophageal, stomach and cervix uteri cancers.

The European migration to Brazil dates back to the beginning of the nineteenth century, due in part to the development of extensive agriculture, mainly coffee and cotton, and to the existence of large unpopulated areas in the southern part of the country. This movement was slowed down by the Brazilian government at the time of the coffee crisis in 1930, and the only county which had enough financial resources to maintain the immigration level was that of Sáo Paulo. In Sáo Paulo, the main

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European migrant groups at the present time are from Portugal, Italy and Spain.

The purpose of this study is to examine the death rates from cancer among European migrants in Sáo Paulo, and compare these rates to those of the Brazil-born, and of the countries of origin of the migrants. Poisson regression was used to estimate age-adjusted risks for country of origin and for migrants, relative to local-born in Brazil. In order to confirm the mortality results, a second analysis was performed using incidence data from the Sáo Paulo cancer registry. A case–control approach was applied, considering as controls all cases from other cancers; risks were estimated using logistic regression taking into account potential confounders such as ethnicity.

MATERIALS AND METHODS

Data

The population data consisted of cross-tabulations from the 1980 census [6], by age, sex and country of birth for the resident population of Sáo Paulo county.

The mortality data consisted of 311 698 records of deaths in the resident population of the county of Sáo Paulo for the period 1978–1982, provided by the Sáo Paulo Bureau of Statistics (FSEADE). Deaths were classified according to age, sex and country of birth. Cause of death was coded according to the 9th revision of the International Classification of Diseases (ICD-9), except for the first year 1978, for which deaths have been coded following the 8th revision, and converted to the 9th revision for analysis.

The data of the countries of origin (Italy, Spain and Portugal) were obtained from the WHO database and consisted of the numbers of deaths by cause, age and sex, and the populations at risk during the 1978–1982 period. Cause of death in those national datasets was coded according to ICD-9 except for the first 2 year period for Portugal and Spain and for 1978 for Italy, and converted to the 9th revision for analysis.

The incidence data consisted of 79 229 invasive incident cancers recorded in the Sáo Paulo cancer registry during the period 1969–1974. This registry has been in operation since 1969, and covers the area of Sáo Paulo county, which includes Sáo Paulo city and surroundings, comprising about 40% of the population of the state of Sáo Paulo. 5700 (7.2%) were excluded due to either an unknown age at diagnosis (2726), an unknown or invalid year of diagnosis (1739), an unknown sex (53), a sex/site incompatibility (61), other invalid values (74), or a place of residence other than Sáo Paulo county (1047). For each incident case, data are recorded on age, sex, site of tumour, histology, date of diagnosis, source of information, civil status, occupation, ethnicity and country of birth. Tumour site, coded according to the 8th revision of the International Classification of Diseases (ICD-8), was recoded to the 9th revision [7]. Occupation, coded according to the International Standard Classification of Occupation, was recoded as a social class indicator of five levels. Ethnicity was recorded from clinical records as white, black, mulatto and yellow. The 1980 census figures indicated that blacks and mulattos represented, respectively, 4.7 and 19.9% of the resident population.

Quality of data

For mortality data, three indicators of data quality were calculated: percentage of deaths attributable to senility or ill-defined conditions (ICD-9 codes 780–799/all deaths), percentage of deaths classified as due to cancer of ill-defined sites (ICD-9 codes 159, 165, 195–9/140–208) and percentage of deaths classified as uterus otherwise specified (ICD-9 179/179+180+182). The percentages were age-standardised by the direct method, taking as the standard proportions those observed in the Brazil-born mortality data in Sáo Paulo for the same period [8]. For incidence data, quality is reflected by both the percentage of cases identified based on death certificate only (9%) and the level of histological confirmation (70%). As differences were observed between one site and another and across birthplaces, all the risk estimates in incidence data were adjusted for these quality indicators. Occupation was poorly recorded: more than 35% of cases in males are in the 'unknown' category, and about 70% of cases in females are in the 'other' category, which includes mainly housewives. The 'unknown' category for country of birth represented less than 1% of the death records, and about 10% of the records of incident cases.

Statistical methods

For mortality data, Poisson regression was applied, assuming that the number of deaths per cell has a Poisson distribution, and that the logarithm of the rate is a linear function of the classification variables ([9], pp. 131–135). The age was bracketted into six age groups. The variable birthplace was coded as Brazil-born, Italy-born, Spain-born, Portugal-born, Italy national, Spain national or Portugal national.

For incidence data, logistic regression was applied, considering as cases incident cancers at one specific site, and as controls all other incident cancers ([9], pp. 115–118). The variable birthplace was coded as: Brazil-born white, Brazil-born other colour, Italy-born, Spain-born, Portugal-born, and other. In addition to age, four additional control variables were available in the incidence data: civil status (single, other), social class (high, medium, low, other, unknown), death certificate only case (yes, no) and histological confirmation (yes, no). As cancer occurrence is dependent on ethnicity [10], Brazilian-born whites were chosen as the reference category to estimate risks for the European migrants.

All the models were fitted using maximum likelihood estimation in the GLIM package [11], and the analyses were done for each sex separately. The results were expressed as estimates of risks relative to the reference group (Brazil-born for mortality data, and Brazil-born white for incidence data).

RESULTS

The distribution of the population by age and country of birth is shown in Table 1. Migrants constitute 3% of the population, the largest groups being those born in Portugal (55% of the foreign-born), Italy (19%) and Spain (15%). The population of Sáo Paulo is young with more than 70% aged under 35, and the European migrants are much older than the natives.

In the period 1978–1982 there were a total of 19 579 cancer deaths, of which 916 were among migrants from Italy, 756 from Spain and 1841 from Portugal. During the period 1969–1974, 73 529 incident cases were recorded in the Sáo Paulo cancer registry, of which 2230 occurred among Italy-born, 1584 among Spain-born and 16 671 among Portugal-born.

Tables 2 and 3 show for males and females, respectively, the estimates of risk of different cancers in European migrants and their countries of origin, relative to the Brazil-born. As can be seen from the column labelled 'country of origin', the death rates from cancer of the mouth and pharynx, oesophagus, cervix and corpus uteri are much lower in the European countries than in the Brazil-born residents of Sáo Paulo. On the contrary, colon and rectum cancers are more common in Italy and in Portugal

Table 1. Population figures by country of birth, and percentage distribution by age; both sexes

Country of birth	Population 1980	Age groups 0–34	35–44	45–54	55–64	65–74	75+	Unknown	Total
Brazil	7997994	72.2	11.6	8.2	4.8	2.2	0.8	0.1	100
Italy	43463	11.7	13.9	21.2	20.5	16.9	15.7	0.1	100
Spain	33996	12.6	13.6	18.4	17.1	20.9	16.3	0.2	100
Portugal	125183	20.4	18.8	23.0	16.4	13.1	8.1	0.1	100
All countries	8225031	70.6	11.7	8.6	5.1	2.6	2.6	0.1	100

than in Brazil-born. Furthermore, lung, liver, bladder and nervous system cancers have higher rates in Italy and in Spain than in Brazil-born, with also a higher rate for kidney and pancreas cancers, Hodgkin's disease and leukaemia in Italy. Rates for stomach cancer are higher in Portugal than in Brazil-born, but they are lower in Spain (in males only), and about the same in Italy. Among females, rates of larynx cancer are lower in European countries than in natives. In both sexes, rates for melanoma and gall-bladder cancer are lower in Spain than in the Brazilian natives.

In comparison with the locally born, a low relative risk is observed in males for stomach cancer among Italian migrants, and for pancreas cancer among Spain-born, and in females for oesophagus cancer among Italy and Portugal-born, for pancreas cancer among Italian-born, and for cervix cancer among all European migrants groups. A high relative risk is observed in males for gall bladder and bladder cancers among Italian-born, for larynx cancer and melanoma among Spain-born, for stomach, colon, rectum and prostate cancers among Portugal-born. In females, higher risks are observed for stomach cancer among Portugal-born, and lower risks are observed for rectum cancer among Italy-born and for kidney cancer among Spain-born.

The odds ratios estimated from incidence data generally agree with the risk estimates based on the mortality data, except for some cancer sites for which the rate is known to be dependent on ethnicity, such as pancreas and gallbladder cancers, melanoma and diseases of the lympho-haematopoietic system [10], and for some sites known to be frequently misclassified in death records, such as large bowel cancers and female gynaecological cancers [12].

DISCUSSION

The information on cause of death is relatively accurate in Sáo Paulo, and variations of quality of death certification by

Table 2. Relative risks for countries of origin and migrant populations using mortality data (Poisson regression) and odds ratio for migrant populations using incidence data (logistic regression); males

ICD-9	Site	Italy Mortality C.O. RR*	Italy Mortality Migrant RR*	Italy Incidence Migrant OR†	Spain Mortality C.O. RR*	Spain Mortality Migrant RR*	Spain Incidence Migrant OR†	Portugal Mortality C.O. RR*	Portugal Mortality Migrant RR*	Portugal Incidence Migrant OR†
140–9	Mouth and pharynx	0.7‡‡	0.6	0.9	0.5‡‡	0.7	0.7	0.6‡‡	0.8	1.0
180	Oesophagus	0.5‡‡	0.9	0.8	0.6‡‡	0.7	0.8	0.6‡‡	0.9	0.9
151	Stomach	0.9	0.7¶	0.9	0.8‡‡	1.0	1.2	1.2‡‡	1.2¶	1.4¶
152,3	Colon§	1.6‡‡	1.2	1.2	1.1	1.3	1.5¶	1.2‡‡	1.2¶	1.3
154	Rectum	1.7‡‡	1.5	1.0	1.3	0.7	1.1	1.8‡‡	1.6¶	1.1
155	Liver	2.0‡‡	1.1	*n*	2.2‡‡	1.3	2.3	n.a.‡	0.9	1.2
156	Gall bladder	0.9	2.2‡‡	1.3	0.6‡‡	1.3	1.1	n.a.	1.1	1.6¶
157	Pancreas	1.4‡‡	1.2	0.9	1.0	0.4††	1.0	n.a.	1.2	1.3
161	Larynx	0.9	0.9	1.0	1.1	1.6¶	1.3	0.8‡‡	1.0	1.1
162	Lung	2.3‡‡	1.2	1.2	1.5‡‡	1.3	1.3††	0.9	1.0	1.0
172	Melanoma	1.1	1.5	1.0	0.4‡‡	2.4¶	*n*	n.a.	1.3	0.9
185	Prostate	0.9‡‡	0.9	0.9	1.0	1.1	0.8	1.1††	1.2¶	0.9
188	Bladder	1.8‡‡	1.7††	1.8‡‡	1.6‡‡	1.0	1.0	n.a.	0.9	1.0
189	Kidney	1.9‡‡	1.8	1.4	1.1	1.4	0.9	n.a.	1.1	0.9
191,2	Nervous system	1.3††	1.0	1.2	1.6‡‡	1.1	0.7	n.a.	1.3	1.1
193	Thyroid	1.1	*n*‖	1.3	0.5††	*n*	0.3	n.a.	*n*	0.3
201	Hodgkin's disease	1.9‡‡	1.0	1.1	1.2	*n*	1.3	n.a.	*n*	1.0
200,2	Other lymphoma	0.9¶	1.3	1.1	0.7‡‡	*n*	1.3	n.a.	0.8	1.0
204–8	Leukaemia	1.3‡‡	0.9	1.1	1.0	*n*	1.1	1.2	0.9	0.6‖

C.O. = country of origin.

*RR are obtained from Poisson regression and are adjusted for age; the reference category is Brazil-born; †OR are obtained from logistic regression and are adjusted for age, period, social class, civil status, histological verification and death certificate only cases; the reference category is Brazil-born white; ‡not available; §includes small bowel in mortality data; ‖number of cases or deaths < 5; ¶$P < 0.05$; ††$P < 0.01$; ‡‡$P < 0.001$.

Table 3. Relative risks for countries of origin and migrant populations using mortality data (Poisson regression) and odds ratio for migrant populations using incidence data (logistic regression); females

		Italy			Spain			Portugal		
		Mortality		Incidence	Mortality		Incidence	Mortality		Incidence
ICD-9	Site	C.O. RR*	Migrant RR*	Migrant OR†	C.O. RR*	Migrant RR*	Migrant OR†	C.O. RR*	Migrant RR*	Migrant OR†
140–9	Mouth and pharynx	0.8	n‖	1.0	0.5‡‡	n	0.7	0.7	0.5	0.8
150	Oesophagus	0.5‡‡	n	0.6	0.5‡‡	1.0	1.3	0.9	0.5†	0.9
151	Stomach	1.0	0.9	0.9	0.9	1.0	1.1	1.4‡‡	1.3††	1.6‡‡
152,3	Colon§	1.2‡‡	0.9	1.3	0.9	0.9	1.5¶	1.3‡‡	1.2	1.4¶
154	Rectum	1.4‡‡	1.8††	1.0	1.1	0.7	1.1	1.2††	1.3	1.7‡‡
155	Liver	1.7‡‡	0.7	n	2.2‡‡	n	n	n.a.‡	n	n
156	Gall bladder	0.8‡‡	0.8	0.7	0.6‡‡	1.1	1.1	n.a.	1.2	0.7
157	Pancreas	1.0	0.7¶	1.5	0.7‡‡	1.0	1.2	n.a.	1.0	1.1
161	Larynx	0.6‡‡	n	n	0.5‡‡	n	n	0.9	n	n
162	Lung	1.1	1.1	1.2	0.7‡‡	0.8	0.8	0.7‡‡	0.9	1.4
172	Melanoma	1.1	2.1¶	n	0.4‡‡	n	n	n.a.	1.2	0.7
174	Breast	1.2‡‡	1.1	1.3††	0.8¶	0.9	1.1	0.9	1.0	1.0
180	Cervix	0.2‡‡	0.6¶	0.6‡‡	0.2‡‡	0.3††	0.7¶	0.6‡‡	0.6‡‡	0.6‡‡
182	Corpus	0.5‡‡	0.8	1.1	0.4‡‡	1.3	1.1	n.a.	1.0	0.8
179	Uterus NOS	1.6‡‡	1.1	1.3	1.2‡‡	1.1	1.0	n.a.	1.1	1.4
183	Ovary	1.0	0.9	1.2	0.6‡‡	0.7	2.2‡‡	n.a.	1.2	1.0
188	Bladder	1.2	1.1	1.4	1.0	n	0.8	n.a.	1.1	0.9
189	Kidney	1.9‡‡	n	1.3	1.3¶	2.4¶	1.3	n.a.	n	0.9
191,2	Nervous system	1.2	0.9	1.2	1.5††	0.8	0.9	n.a.	1.1	1.1
193	Thyroid	1.0	n	n	0.5‡‡	1.6	0.8	n.a.	0.9	1.1
201	Hodgkin's disease	2.3‡‡	n	1.2	1.3	n	n	n.a.	n	n
200,2	Other lymphoma	0.8‡‡	1.1	1.7¶	0.6‡‡	0.8	0.6	n.a.	0.8	1.2
204–8	Leukaemia	1.2‡‡	1.0	1.0	1.0	0.7	1.4	1.2¶	1.3	0.8

C.O. = country of origin.

*RR are obtained from Poisson regression and are adjusted for age; the reference category is Brazil-born; †OR are obtained from logistic regression and are adjusted for age, period, social class, civil status, histological verification and death certificate only cases; the reference category is Brazil-born white; ‡not available; §includes small bowel in mortality data; ‖number of cases or deaths <5; ¶$P < 0.05$; ††$P < 0.01$; ‡‡$P < 0.001$.

birthplace are not large enough to generate significant differences in specific cancer risks between migrants and natives, except possibly for cancer of the uterus, as the differences in the proportions of "uterus, unspecified" are more substantial (Table 4). Comparisons between different countries are more problematical, given the well-known international variation in quality of death certification [13]. There are differences in the quality of death certification between Sáo Paulo and the three countries of birth studied, in particular regarding Portugal (Table 4). This implies that the comparisons between countries should be treated with caution. In addition, migrant populations originate from specific areas of their country—Italians from southern Italy, Spanish from Andalusia and Galicia, and Portuguese from the rural areas of Tras os Montes, alto Douro, Funchal and Acores, and the national rates for country of origin may therefore differ from the local rates in the migrants' birthplaces.

Table 4. Age-standardised percentages of quality indicators of information on cause of death in 1978–1982; both sexes*

Country	% of all deaths certified as senility or ill-defined conditions†	% of cancer deaths with ill-defined primary sites‡	% of uterus cancer deaths certified as not specified §
Brazil, Sáo Paulo			
Born in Brazil	1.4	9.0	36.0
Born in Italy	0.7	9.3	42.5
Born in Spain	0.9	10.2	29.9
Born in Portugal	0.8	8.9	47.7
Italy	1.7	6.4	79.6
Spain	2.6	8.9	73.1
Portugal	8.9	15.4	59.9

*Percentages are age-standardised by the direct method, taking as the standard those observed in Brazil-born mortality data in Sáo Paulo; †ICD-9 codes 780–799/all deaths; ‡ICD-9 codes 159, 165, 195–9/140–208; §ICD-9 codes 179/179+180+182.

Data from the cancer registry showed that two of the migrant groups (Italian and Portuguese) were of higher social class than the local-born. For this reason, all the relative risk estimates were adjusted for this variable; however, because for a significant proportion of cancer registrations occupation was not recorded (particularly for females) the possibility of residual confounding is present. The quality indicator variables (HV%, DCO%) were also included, to allow for differences in the accuracy of registry information in the groups being compared.

For Italian and Spanish migrants, results on cancer mortality are available from recent studies in Uruguay and Argentina [1, 2], but there were too few Portuguese migrants in these countries to justify a separate analysis.

Oropharyngeal and oesophageal cancers

The incidence of these cancers is high in the southern states of Brazil and in Uruguay, where drinking cachaça (a local spirit)

and maté, two important aetiological factors, is common [14–16]. European migrant males in Sáo Paulo appear to acquire rates which are similar to those of the local-born, while female migrants retain a lower risk. The fact that males are more likely to acquire the local habit of drinking maté and/or chachaça may explain this discrepancy between the sexes. Such an increase after migration has been observed among European migrants in Uruguay and in Argentina. In those countries, however, the rates of oesophageal cancer remain considerably lower in migrants than in natives [1, 2].

Stomach cancer

The rate of stomach cancer is high in South America. Spanish and Portuguese migrants in Sáo Paulo acquire rates which are similar to those in the natives, as did European migrants to Uruguay and Argentina [1, 2]. Portugal is a particularly high risk area for stomach cancer, with rates even higher than those in Brazil-born. Portuguese of both sexes appear to retain the high rates of their country of origin after migration, as did Japanese migrants in Sáo Paulo and Argentina [2, 4, 5]. Other studies on European populations who have migrated to the lower-risk countries of Australia [17] and Israel [18] also suggest that the risk of stomach cancer changes rather slowly after migration.

Colon and rectum cancers

Compared to Europe, Brazil is a low risk country for cancers of the colon and rectum. With the mortality data, only Portuguese maintain their higher rates for both colon and rectum cancers, as they did for stomach cancer. It is well known that in mortality data, a certain amount of misclassification occurs between colon and rectum cancers [19]. Incidence data are, therefore, more appropriate for the study of these cancers: the risk estimates for colon cancer are rather greater than those based on the mortality data, with odds ratio values higher than unity in migrants of both sexes from Spain, and in males from Portugal.

The only other data on migrants from high- to low-risk countries concern Scots in Australia for colon cancer, and English in Australia for rectal cancer [17]. These migrants have been found to have lower rates than those of their countries of origin, but the change in relative terms is less than that observed in migrants moving to a country at higher risk (e.g. European migrants to Uruguay [1], Argentina [2] and the U.S.A. [20, 21]). Other studies of changes in risks for colorectal cancers following migration from high to low risk areas are needed to investigate the hypothesis that an increase in risk following migration to a higher risk environment is more likely than a decrease in risk following migration to a lower risk environment.

Liver cancer

This site is notoriously prone to misclassification, with inclusion of metastatic cancer as "liver cancer" on the death certificate [12]. Comparisons between countries of origin and Brazil are, therefore, hazardous. The incidence of liver cancer in southern Europe is rather higher than in Sáo Paulo [22], but because of the small number of cases, no clear pattern is observed among Europeans using the incidence data.

Gall-bladder cancer

Death rates from gall-bladder cancer are quite high in north-east Europe and in some parts of South America; Spanish and Italian male migrants undergo a substantial increase in risk in Sáo Paulo, and their rates apparently overshoot the host country level. This was not found in Argentina, where the risk in Italian migrants was intermediate between country of origin and host country [2], and in Israel, where the risk declines with increased duration of residence for European migrants [18].

Pancreas cancer

For pancreas cancer no clear pattern is observed; for example, in females, although death rates in Italy are similar to those of the Brazil-born, the migrants have lower risks. Studies on mortality in European migrants to Australia [17] and to the U.S.A. [21] suggested a rather generalised increase in rates, often in excess of those in the new host country. This has not been found for European migrants to Uruguay and Argentina who have risks intermediate between the locally born and their country of origin [1, 2]. These apparent contradictions may be explained by the well-known differences between countries in the quality of death certification for this cancer.

Lung cancer

European migrants have a risk of lung cancer which is intermediate between that of their country of origin and that of the Brazilian-born, as found in Uruguay and Argentina [1, 2].

Melanoma

This cancer is strongly correlated with ethnicity; the mixture of ethnic groups which compose the reference category in Sáo Paulo mortality data is therefore not appropriate for estimating the change in risk among migrants. In the incidence data analysis, because of the small number of cases, data are available only for Portuguese migrants of both sexes and for male Italian migrants, both of which have a risk similar to that of the natives. Studies of European migrants to Australia and Israel have shown that fair-skinned people who move to sunny environments acquire an increased risk for melanoma [23, 24].

Breast cancer

In Sáo Paulo, European migrants experience mortality rates which are intermediate between that of their countries of origin and that of Brazil-born. Risks intermediate between those of the host country and that of the country of origin have been observed in Italian and Spanish migrants to Uruguay and among Spanish migrants to Argentina [1, 2]. The same was found in migrants from European countries with a relatively low risk of breast cancer to the U.S.A. [20, 21], England and Wales [25], and Australia [26].

Cervical cancer

Mortality rates for cervical cancer are particularly high in Brazil, and Italian and Spanish migrants have rates which are intermediate between those of their countries of origin and that of Brazil-born. In Portugal, the rate is also high, but the rate in Brazil is even higher and Portuguese retain rates typical of their country of origin. Misclassification of uterus cancer deaths is known to be frequent, and incidence data provide more valid information: in all migrants, the risk is about half of that of the natives.

Similar results have been reported for Italian migrants to Uruguay and Italian and Spanish migrants to Argentina [1, 2]. The main risk factors for cervical cancer in South America, as well as in other countries, are age at first intercourse and number of sexual partners [27], which are both likely to vary according to birthplace.

Corpus cancer

The risk for cancer of the corpus uteri is significantly lower in Italy and in Spain than in Brazil or Uruguay, but no significant differences between migrants and natives are observed in either Brazil or Uruguay [1].

Prostatic cancer

The mortality rate in Italy is lower than in Brazil-born, while for Portugal it is higher; both groups of migrants retain the rates of their country of origin. This was also observed for European migrants in Argentina [2].

Bladder cancer

The risk of bladder cancer is higher in Italy and Portugal than among Brazil-born, and male Italian migrants maintain their higher risks. A similar pattern was observed in Italian migrants in Argentina [2].

Leukaemia

The risk is higher in Italy than in Brazil-born, and Italian migrants acquire similar rates to the natives; the same pattern was found in Italian migrants to Uruguay [1] and Argentina [2].

CONCLUSION

In general Italian and Spanish migrants to Sáo Paulo show rather similar changes in cancer risks to those observed in migrants from the same countries in Argentina or Uruguay. However, for cancer of the oesophagus, the changes are greater in Sáo Paulo, where migrants appear to acquire the rates of the local population, suggesting that they adopt the local habits in Brazil more rapidly than in Argentina or Uruguay. For Portuguese, changes with migration are less evident. Rates of colorectal cancer remains high in Portuguese migrants, and, as found for Japanese migrants to Sáo Paulo, they also retain their higher risks of stomach cancer. Although this may partly reflect quality of Portuguese mortality data, it may also suggest that Portuguese retain the eating habits of their country, or that there is a slower change in gastrointestinal cancer risks when moving from a high- to a low-risk area than when moving from a low- to a high-risk area.

1. De Stefani E, Parkin DM, Khlat M, Vasalo A, Abella M. Cancer in migrants to Uruguay. *Int J Cancer* 1990, **46**, 233–237.
2. Matos E, Khlat M, Loria DI, Vilensky M, Parkin DM. Cancer in migrants to Argentina. *Int J Cancer* 1991, **49**, 805–811.
3. Prudente A, Mirra AP. Gastric cancer in Japanese people living in Brazil. *Acta Unio Int Cancer* 1961, **17**, 851–857.
4. Tsugane S, De Souza JMP, Costa ML, *et al.* Cancer incidence rates among Japanese immigrants in the city of Sáo Paulo, Brazil, 1969–78. *Cancer Causes Control* 1990, **1**, 189–193.
5. Tsugane S, Gotlieb SLD, Laurenti R, De Souza JMP, Watanabe S. Cancer mortality among Japanese residents of the city of Sáo Paulo, Brazil. *Int J Cancer* 1990, **45**, 436–439.
6. Fundaçáo IBEG. *1980 Census, Censo Demographico: Resultados Preliminares, Sáo Paulo*. Rio de Janeiro, 9 Resenceamento Geral do Brasil, 1982.
7. Mirra AP, Marigo C, Pastorelo EF, *et al.* Brazil, Sáo Paulo. In Muir CS, Waterhouse J, Mack T, Powell J, Whelan S, eds. *Cancer Incidence in Five Continents*. Lyon, IARC Scientific Publications 88, 1987, vol. V, 186–189.
8. Boyle P, Parkin DM. Statistical methods for registries. In Jensen OM, Parkin DM, MacLennan R, Muir CS, Skeet RG, eds. *Cancer Registration Principles and Methods*. Lyon, IARC Scientific Publications 95, 1991, 153–155.
9. Breslow NE, Day NE. *Statistical Methods in Cancer Research*. Vol. II: *The Design and Analysis of Cohort Studies*. Lyon, IARC Scientific Publications 82, 1987.
10. Bouchardy C, Mirra AP, Khlat M. Ethnicity and cancer risk in Sáo Paulo, Brazil. *Cancer Epidemiol Biomark Prev* 1991, **1**, 21–27.
11. Baker RJ, Nelder JA. *Generalised Linear Interactive Modelling (GLIM) System*. Release 3. Oxford, Numerical Algorithms Group, 1978.
12. Percy C, Dolman A. Comparison of the coding of death certificates related to cancer in seven countries. *Public Health Rep* 1978, **93**, 335–350.
13. Percy C, Muir CS. The international comparability of cancer mortality data: results of an international death certificate study. *Am J Epidemiol* 1989, **129**, 934–946.
14. De Stefani E, Munoz N, Estève J, Vasallo A, Victoria CG, Teuchmann S. Maté drinking, alcohol, tobacco, diet and esophageal cancer in Uruguay. *Cancer Res* 1990, **50**, 426–431.
15. Franco EL, Kowalski LP, Oliviera BV, *et al.* Risk factors for oral cancer in Brazil: a case–control study. *Int J Cancer* 1989, **43**, 992–1000.
16. Victoria CG, Munoz N, Day NE, Barcelos LB, Peccin DA, Braga NM. Hot beverages and oesophageal cancer in southern Brazil: a case–control study. *Int J Cancer* 1987, **39**, 710–716.
17. McMichael AJ, McCall MG, Hartshorne JM, Woodings TL. Patterns of gastro-intestinal cancer in European migrants to Australia: the role of dietary change. *Int J Cancer* 1980, **25**, 431–437.
18. Parkin DM, Steinitz R, Khlat M, Kaldor J, Katz L, Young J. Cancer in Jewish migrants to Israel. *Int J Cancer* 1990, **45**, 614–621.
19. Boyle P, Zaridze DG, Smans M. Descriptive epidemiology of colorectal cancer. *Int J Cancer* 1985, **36**, 9–18.
20. Nasca PC, Greenwald P, Burnett WS. Cancer among the foreign-born in New York state. *Cancer* 1981, **48**, 2323–2328.
21. Lilienfeld A, Levin ML, Kessler II. *Cancer in the United States*. Cambridge, Harvard University Press, 1972.
22. Muir CS, Waterhouse J, Mack T, Powell J, Whelan S, eds. *Cancer Incidence in Five Continents*. Lyon, IARC Scientific Publications, 88, 1982, Vol. V, 856–857.
23. Steinitz R, Parkin DM, Young JL, Bieber CA, Katz L. *Cancer Incidence in Jewish Migrants to Israel*, 1961–1981. Lyon, IARC Scientific Publications 98, 1989.
24. Khlat M, Vail A, Parkin DM, Green A. Mortality from melanoma in migrants to Australia: variation by age at arrival and duration of stay. *Am J Epidemiol* 1992, **135**, 1103–1113.
25. Marmot MG, Adelstein AM, Bulusu L. *Immigrant Mortality in England and Wales 1970–78: Causes of Death by Country of Birth*. London, Studies on Medical and Population Subjects 47, Office of Population Census and Surveys, 1984.
26. Armstrong BK, Woodings TL, Stenhouse NS, McCall MG. *Mortality from Cancer in Migrants to Australia—1962 to 1971*. Nedlands, University of Western Australia, 1983.
27. Herrero R, Brinton LA, Reeves WC. Sexual behavior, venereal diseases, hygiene practices, and invasive cervical cancer in a high-risk population. *Cancer* 1990, **65**, 380–386.

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