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Cancer incidence in French Polynesia 1985–95

Béatrice Le Vu[1,2], Florent de Vathaire[1], Cécile Challeton de Vathaire[3], John Paofaite[4], Laurent Roda[5], Gilles Soubiran[5], François Lhoumeau[6] and François Laudon[6]

1 *Institut National de la Santé et de la Recherche Médicale, Institut Gustave Roussy, Villejuif, France*
2 *Institut Curie, Paris, France*
3 *Office de Protection contre les Rayonnements Ionisants, Le Vésinet, France*
4 *Institut de Recherche pour le Développement, Arue, Tahiti, French Polynesia*
5 *Centre Hospitalier Territorial Mamao, Papeete, Tahiti, French Polynesia*
6 *Direction de la Santé, Papeete, Tahiti, French Polynesia*

Summary

OBJECTIVE To describe the variations in cancer incidence in the population born in French Polynesia (FP) according to the archipelago of birth and to compare this incidence with that of Hawaiians and Maoris.
METHODS Study of data from the Cancer Registry of FP, evacuation files, insurance records, hospital and pathology laboratory files.
RESULTS The overall world standardized cancer incidence in FP during the 1985–95 period in the populations born and living in FP was 246 per 105 person-years (PY) among women and 244 per 105 PY among men. The overall cancer incidence was similar to that in Hawaiians, but 25% lower than in Maoris. Digestive tract cancer incidence was a third that of these two reference populations, whereas that of pharynx, larynx and thyroid cancers was approximately twice as high. The overall cancer incidence rate increased between the period 1985–89 and the period 1990–95 in women, but was stable in men. Colorectal cancer incidence was highest in inhabitants born on the Windward Islands. Women born on the Austral Islands had a higher thyroid and liver cancer incidence and a lower breast cancer incidence.
CONCLUSIONS Further studies are needed to elucidate the variations observed between FP archipelagos, Maoris and Hawaiians.

keywords cancer incidence, French Polynesia, epidemiology, thyroid cancer, colorectal cancer, geographical study

correspondence Florent de Vathaire, Institut National de la Santé et de la Recherche Médicale (INSERM) Unit 521, Institut Gustave Roussy, 39 rue Camille Desmoulins, 94805 Villejuif Cedex, France. Fax: 33 1 4211 5427.

Introduction

French Polynesia (FP) is a French overseas territory located in the middle of the Pacific Ocean (4500 km from Hawaii, 4400 km from New Zealand, 5700 km from Australia). It is composed of five archipelagos: the Windward and the Leeward Islands (which constitute the Society Islands), the Marquesas and Austral Islands and the Tuamotu-Gambier archipelago, including about 121 atolls or islands spread over 4 million km^2 of the Pacific Ocean. Only 4000 km^2 of this area is solid dry land. According to the 1996 census, approximately 220 000 inhabitants were living in FP, of whom 192 000 were born there. Currently, 85% of native French Polynesians live in the Society Islands, whose capital is Papeete on the island of Tahiti. The territory is divided into 58 administrative areas called communes (municipalities). Each commune comprises one or several atolls, except for the islands of Tahiti and Moorea, both situated in the Society Islands.

The way of life in FP has been modified considerably by a flow of capital generated by the French nuclear test site. In most areas, imported food has replaced traditional Polynesian food, and tobacco consumption doubled between 1961 and 1967, but has decreased since (de Solminihac 1987). The pattern of the cancer incidence will probably reflect these changes in the future. A cancer registry was created in FP in 1983 (Laudon *et al*. 1992; Gleize *et al*. 1996, 1998; Laudon 1998). The South Pacific Commission, which is responsible for centralizing data from cancer registries in this area, has only published proportional incidence ratios for various sites rather than standardized incidence ratios (Henderson *et al.* 1985). From 1966 to 1974, France performed 41 atmospheric nuclear weapon tests in the Mururoa and Fangataufa Atolls in FP.

We conducted a study of cancer incidence in FP during the 1985–95 period, based on data from the Cancer Registry of FP and on an intensive investigation of evacuation files, insurance records, hospital and pathology laboratory files. This study was undertaken in order to investigate a possible relationship between geographical variations in cancer incidence and atmospheric nuclear tests performed by France on Mururoa and Fangataufa between 1966 and 1974. Separate analyses were conducted for patients who were children during the atmospheric tests (born between 1950 and 1975) and for those born earlier. Only a study of variations in the incidence of thyroid cancer could be of interest, due to several factors:

- the size of the population living less than 1000 km from Mururoa,
- published data on caesium 137 concentration in coconuts in the Tuamotu-Gambier archipelago since 1967 (Kabis de Saint-Chamas *et al.* 1991),
- the delay of 10 years between the end of the atmospheric tests and the beginning of our study period, and
- the fact that an international panel of the International Atomic Energy Agency (IAEA) considered the residual radiation still present to be devoid of consequences on human health (Anonymous 1998).

The analysis of thyroid cancer has been published separately (de Vathaire *et al.* 2000). Some other results, concerning leukaemia incidence during the 1990–95 period, have already been published (Roda *et al.* 1999). This report describes the variations in cancer incidence in the population born in French Polynesia according to the archipelago of birth and compares this incidence with that of the nearest ethnic populations: Hawaiians of Hawaii and Maoris of New Zealand.

Materials and methods

Cases of cancer

The Cancer Registry of FP is a member of the Cancer Database of the South Pacific Commission. Each cancer case must be declared to the Territorial Health Office in Papeete, which is responsible for the registry. Between 1985 and 1995, it had recorded 3037 cancer cases, excluding tumours of uncertain malignancy, *in situ* carcinoma, thyroid cancer < 5 millimetres in diameter (microcancer) and skin epithelioma. We included each primary cancer case diagnosed between January 1st 1985 and December 31st 1995 in a subject born and living in FP at the time of the diagnosis of cancer. Cases were included even when the diagnosis was made elsewhere; conversely foreign patients or Polynesians living elsewhere in the Pacific area whose tumours were diagnosed in FP were excluded. Double entries were defined as subjects with the same first name, last name, birthday, birthplace, and the same site of cancer diagnosed during the same year; and subjects with the same first name, last name, birthday, birthplace, and a subsequent cancer at any site, without histological confirmation. We excluded 233 double entries and 480 subjects born outside FP.

Data from the registry were verified and completed using evacuation files, insurance records and hospital and pathology laboratory files. The medical evacuation files at the Department of Health include all FP patients referred usually to France, New Zealand or Hawaii for radiotherapy or intensive chemotherapy. The database of the national medical insurance system in FP, the 'Caisse de Prévoyance Sociale', covers most of the populations, and specifies the diagnoses. Medical records at the only public hospital in FP providing treatment for cancer (Mamao Territorial Hospital Center), and at the two private hospitals, cover patients who are admitted or treated as outpatients and register the diagnoses. Histological and biological reports from the pathology and biology laboratories in Mamao Hospital, from the only private pathology laboratory, and from the two private biology laboratories in FP were reviewed. The medical records at the only private endocrinology centre in FP were also examined. Finally, we wrote to the hospitals in France, New Zealand and Hawaii to which patients had been evacuated from FP, requesting their list of patients from FP, and a confirmation of the cancer diagnoses. We examined 30 000 records and 539 cancer cases diagnosed between 1985 and 1995 among patients born and living in FP that had not been included in the cancer registry of FP. We verified the place of birth for most cancer patients using the database containing the birth certificates of the FP population.

A total of 2863 incident cases of cancer were thus recorded among inhabitants born in FP or an unknown location ($n = 273$). We decided to keep patients with an unknown place of birth in the study because it was highly likely that they were born in FP. Tumours were classified according to the International Classification of Diseases 9th revision (ICD9) (WHO 1975) and the International Classification of Disease-Oncology (ICD-O) (Anonymous 1980).

Populations

From the Institut Territorial de la Statistique (ITSTAT) in Tahiti we obtained the gender, date of birth, place of birth and place of residence of each person residing in FP at the

Table 1 Number of person years during the 1985–95 period according to the archipelago of birth

Place of birth	Person-years between 1985 and 1995	
	Females	Males
Windward Islands	597 526	619,868
Leeward Islands	149 469	151,918
Marquesas Islands	48 557	52,049
Austral Islands	44 452	45,462
Tuamotu-Gambier	71 784	72,942

time of the censuses of October 1983, September 1988 and September 1996. Similar individual data were also obtained for each death occurring between 1985 and 1995. These data were used to estimate the populations at risk by sex, year of birth, and calendar year, according to the place of residence and to the place of birth. The populations at risk correspond to the population in which cases were identified. We first estimated the population size, by sex and age, on January 1st 1983, January 1st 1988 and January 1st 1996, by adding deaths that occurred between these dates and the corresponding census. From 1983 to 1988, migration was estimated as the difference between the populations observed on January 1st 1988 and that predicted from the population on January 1st 1983 and the number of deaths per year, age and sex from 1983 to 1987. Migration was estimated in a similar manner for the 1988–96 period. Migration was uniformly distributed for each year of age during the 1983–87 period and the 1988–95 period. Table 1 shows the estimated person-years at risk, during the 1985–95 period by sex and archipelago of birth.

As registration according to ethnic origin is precluded in France, it was not possible to compare cancer incidence rates between ethnic groups. In 1988, the distribution of ethnic groups among the inhabitants born in FP was estimated as follows: Polynesians 93%, Europeans 2% and Chinese 5%. The proportion of Polynesians varied according to archipelago from 99.6% in the Austral Islands to 91.8% in the Windward Islands.

Analysis

Incidence rates were computed by dividing the number of cases by the number of person-years (PY) at risk of developing a cancer, as estimated below. The 95% confidence interval (95% CI) of these rates was estimated assuming that the number of cases followed Poisson distribution. Our estimation of the cancer incidence was compared with that documented in Hawaiians in Hawaii and Maoris in New Zealand during the 1988–92 period and published by the International Agency on Research against Cancer (IARC) (Parkin *et al*. 1997).

As reference rates were based on a small number of cases in most of the comparisons we performed, we decided to take into account the variability due to both the numerator (dependent on the number of cases in FP) and the denominator (dependent on number of cases on which the rates in the reference rate were based). The distribution of a ratio of two numbers which follow a Poisson's law cannot be directly estimated by analytical methods. The 95% confidence interval (95% CI) and *P*-values were therefore obtained by simulations. For each 5 year age class, a couple of independent pseudo-random numbers was simulated following a Poisson's law of parameter equal to the observed number of cases in the 5 year age class in FP and in the same 5 year age class in the reference population. The SIR was obtained as

$$SIR = \sum_{i=1}^{17} \frac{N_{1i}}{N_{2i}} \cdot \frac{PY_{2i}}{PY_{1i}}$$

Where i is one of the 17 5 year age classes, N_{1i} is the number of cases in the 5 year age class in FP; N_{2i} is the number of cases in the 5 year age class in the reference population; PY_{1i} is the number of PYR in the 5 year age class in French Polynesia; and PY_{2i} is the number of PYR in the 5 year age class in the reference population. We simulated 10 000 SIRs. The 250th and the 750th of these values marked the extremes of the 95% confidence intervals.

Results

The mean annual population between 1985 and 1995 was estimated to be 168 560 inhabitants (85 663 men and 82 897 women), born and residing in FP, of whom 85% lived on the Society Islands, 4% on the Marquesas Islands, 4% on the Austral Islands and 7% on the Tuamotu-Gambier archipelago. Table 1 details the number of persons-years according to the archipelago of birth. 59% of the native population were < 25 years old. Compared to the other Pacific populations, the age distribution was similar to that of Hawaii and New Zealand during the 80s.

Of the 2863 incident cases of cancer diagnosed during the 1985–95 period among inhabitants born in FP or in an unknown place of birth, 22 were second primary malignancies. 76% of all cancer cases were histologically proven, i.e. histological examination of the primary or secondary tumour, a cytological or haematological examination, or a biochemical test.

Among the 677 cases for which histopathological proof was not available, 338 were in the initial Cancer Registry of FP (of which 165 were based on the death certificate) and 339 were added during our investigations. Of these 677 cases, 165 were classified as cancer of the digestive system, 124 as lung

Table 2 World-standardized cancer incidence rate per 10^5 person-years (number of cases) among native men and women from French Polynesia during the 1985–95

Localization	ICD9	Women		Men	
Oral cavity	140–145	4.1	(24)	6.9	(40)
Hypopharynx	148	0.2	(1)	2.8	(18)
Pharynx	146–149	3.8	(23)	12.3	(75)
Oral cavity and pharynx	140–149	7.9	(47)	19.1	(115)
Oesophagus	150	1.3	(7)	5.9	(31)
Stomach	151	6.6	(37)	9.6	(51)
Small intestine	152	1.0	(6)	0.8	(5)
Colon, rectum, anal canal	153–154	9.9	(57)	12.9	(69)
Liver	155	4.8	(29)	13.4	(79)
Gallbladder	156	1.8	(11)	2.6	(13)
Pancreas	157	3.9	(22)	5.4	(28)
Digestive system	150–159	31.9	(183)	54.2	(295)
Larynx	161	1.6	(10)	5.2	(31)
Trachea, bronchus, lung	162	27.2	(146)	68.1	(348)
Pleura, thymus, heart, mediastine	163–164	1.6	(9)	2.6	(16)
Other respiratory organs†	160 and 165	1.1	(7)	1.2	(7)
Bone	170	2.3	(19)	3.2	(23)
Connective and soft tissues	171	1.9	(13)	3.1	(20)
Malignant melanoma of the skin	172	0.1	(1)	0.9	(4)
Breast	174 or 175	62.8	(382)	1.9	(12)
Cervix uteri	180	29.8	(192)		
Corpus uteri	182	9.2	(54)		
Ovary, other uterine annexes	181 and 183	10.1	(62)		
Prostate gland	185			28.9	(126)
Testis	186			1.2	(12)
Other genital organs†	184	3.0	(18)	0.6	(3)
Bladder	188	2.1	(12)	6.0	(28)
Kidney and other urinary organs	189	2.1	(14)	4.3	(24)
Eye and annexes	190	0.6	(5)	1.0	(7)
Brain and central nervous system	191 and 192	5.3	(40)	2.9	(21)
Thyroid gland	193	16.8	(119)	5.7	(35)
Other endocrine glands	194	0.6	(6)	1.6	(12)
Hodgkin's disease	201	0.9	(7)	0.9	(9)
Other lymphoid neoplasm	200 and 202	4.0	(28)	5.6	(39)
Multiple myeloma	203	3.3	(18)	4.4	(25)
Leukaemia	204–208	6.6	(48)	10.9	(76)
Secondary sites or ill-defined	195–199	7.8	(46)	10.7	(55)
All cancer but skin	140–208 (but 173)	246.2	(1520)	244.1	(1343)

† or ill-defined sites within the system.

cancer, and 74 as breast cancer, and there were no second primary malignancies. A total of 46 (3%) and 55 (4%) secondary sites or ill-defined neoplasms were identified among women and men, respectively.

The crude annual incidence of cancer was higher among women (167 per 10^5) than men (143 per 10^5 PY) at risk, whereas world-standardized rates were similar: 246 per 10^5 PY for women and 244 per 10^5 PY for men (Table 2). The total number of cancer cases between 1985 and 1995 was 1530 for women and 1350 for men. The mean annual number of cancer cases between 1985 and 1995 was 139 for women and 123 for men. The mean age at the diagnosis of cancer was 51 among women and 55 in men. The cumulative incidence rates before the age of 64 were 16.7% and 14.5%, respectively. The most frequent cancer sites were the breast, cervix uteri, digestive system, lung and thyroid among women and the lung, digestive tract, prostate gland and oral cavity among men.

We were unable to identify the birth place in 283 cases (10%). Table 3 indicates world-standardized incidence rates for each cancer site among women and men, according to the archipelago of birth. In women, overall cancer incidence was

Table 3 World-standardized cancer incidence rate per 10^5 person-years (number of cases) among native women and men from French Polynesia during the 1985–95 period according to archipelago of birth

	WOMEN					MEN				
Localization	Windward I.	Leeward I.	Marquesas	Austral I.	Tuamotu-Gambier	Windward I.	Leeward I.	Marquesas	Austral I.	Tuamotu-Gambier
Oral cavity and pharynx	8.2 (25)	5.6 (8)	14.5 (4)	6.2 (3)	3.8 (3)	20.1 (58)	15.6 (24)	18.2 (7)	13.1 (6)	14.4 (11)
Oesophagus	2.1 (5)	0.0 (0)	0.0 (0)	1.9 (1)	0.0 (0)	6.3 (15)	4.6 (6)	2.4 (1)	6.6 (3)	7.0 (5)
Stomach	3.8 (10)	4.5 (6)	21.4 (7)	6.4 (3)*	6.8 (5)	7.8 (21)	6.1 (8)	12.1 (4)	14.4 (6)	9.1 (7)
Small intestine	1.3 (4)	0.0 (0)	0.0 (0)	2.3 (1)	1.2 (1)	0.8 (3)	0.0 (0)	0.0 (0)	0.0 (0)	1.1 (1)
Colon, rectum, anal canal	12.1 (34)	1.5 (2)*	9.8 (4)*	1.6 (1)	4.2 (3)*	14.2 (34)	11.8 (16)	8.2 (3)*	2.4 (1)	6.0 (4)*
Liver	3.9 (12)	3.0 (4)	0.0 (0)	12.6 (6)	5.5 (4)	11.9 (33)	8.3 (12)	12.5 (4)	40.3 (20)**	6.4 (5)
Gallbladder	0.5 (2)	1.6 (2)	4.0 (1)	0.0 (0)	3.7 (3)	1.3 (3)	5.9 (8)	0.0 (0)	0.0 (0)	3.6 (2)
Pancreas	4.3 (12)	4.2 (6)	0.0 (0)	0.0 (0)	1.6 (1)	6.0 (15)	7.2 (8)	0.0 (0)	0.0 (0)	3.1 (2)
Digestive system	30.3 (86)	18.2 (24)	35.2 (12)	24.9 (12)	27.6 (20)	50.6 (132)	46.4 (61)	39.2 (14)	71.3 (33)	40.6 (29)
Larynx	0.9 (3)	0.8 (1)	7.6 (3)	2.1 (1)	2.9 (2)	4.3 (12)	4.4 (7)	0.0 (0)	6.1 (3)	7.1 (6)
Trachea, bronchus, lung	27.7 (72)	15.0 (19)*	26.9 (7)	16.7 (8)	32.7 (24)	63.1 (147)	64.3 (80)	28.1 (9)*	66.9 (31)	73.5 (55)
Pleura, thymus, heart, mediastine	0.5 (2)	1.5 (2)	6.8 (2)	4.5 (2)	0.0 (0)	2.2 (8)	1.5 (2)	2.2 (1)	2.4 (1)	4.3 (3)
Other respiratory organs†	1.0 (4)	0.0 (0)	0.0 (0)	1.8 (1)	1.3 (1)	1.0 (3)	0.6 (1)	2.6 (1)	0.0 (0)	1.1 (1)
Bone	2.3 (12)	2.6 (4)	4.4 (1)	0.0 (0)	4.0 (2)	3.7 (16)	2.7 (4)	0.0 (0)	4.9 (2)	1.9 (1)
Connective and soft tissues	2.2 (9)	0.6 (1)	0.0 (0)	0.0 (0)	2.4 (2)	2.4 (8)	1.8 (3)	2.6 (1)	2.5 (1)	2.1 (2)
Malignant melanoma of the skin	0.0 (0)	0.7 (1)	0.0 (0)	0.0 (0)	0.0 (0)	0.1 (0)	0.0 (0)	0.0 (0)	1.8 (1)	0.0 (0)
Breast	59.8 (184)	47.5 (72)	48.7 (16)	43.0 (21)	67.3 (50)	1.1 (3)	3.4 (5)	2.4 (1)	0.0 (0)	2.2 (2)
Cervix uteri	26.2 (87)	28.6 (44)	28.2 (10)	12.0 (6)	25.4 (21)					
Corpus uteri	8.4 (24)	6.2 (9)	2.7 (1)	6.3 (3)	7.7 (6)					
Ovary, other uterine annexes	8.0 (26)	7.7 (11)	7.0 (2)	8.5 (4)	12.7 (9)					
Prostate gland						35.2 (68)	11.5 (13)**	7.5 (2)*	21.3 (9)*	30.1 (19)
Testis						1.2 (8)	0.6 (1)	0.0 (0)	0.0 (0)	2.2 (2)
Other genital organs†	2.2 (6)	1.2 (2)	2.6 (1)	2.1 (1)	6.0 (5)	0.9 (2)	0.9 (1)	0.0 (0)	0.0 (0)	0.0 (0)
Bladder	2.6 (7)	1.4 (2)	0.0 (0)	0.0 (0)	0.0 (0)	6.3 (14)	2.9 (3)	4.1 (1)	5.2 (2)	7.5 (5)
Kidney and other urinary organs	1.2 (6)	2.2 (3)	0.0 (0)	0.0 (0)	3.0 (2)	3.7 (12)	3.5 (4)	6.3 (2)	1.9 (1)	4.9 (3)
Eye and annexes	0.6 (3)	0.0 (0)	0.0 (0)	0.0 (0)	2.6 (1)	0.4 (3)	0.0 (0)	5.7 (2)	0.0 (0)	1.8 (1)
Brain and central nervous system	5.4 (25)	2.9 (5)	4.2 (1)	5.7 (3)	4.9 (3)	3.1 (13)	0.0 (0)	1.7 (1)	4.1 (2)	5.0 (4)
Thyroid gland	13.8 (53)	17.7 (29)	18.2 (7)*	29.1 (14)*	13.7 (13)	6.2 (18)	6.1 (9)	1.7 (1)	0.0 (0)	7.9 (6)
Other endocrine glands	0.8 (5)	0.0 (0)	0.0 (0)	0.0 (0)	1.1 (1)	1.5 (7)	1.1 (2)	1.6 (1)	0.0 (0)	0.0 (0)
Hodgkin's disease	0.7 (3)	1.3 (2)	0.0 (0)	0.0 (0)	1.3 (1)	0.7 (5)	0.0 (0)	2.5 (1)	0.0 (0)	4.7 (3)
Other lymphoid neoplasm	3.7 (16)	2.9 (4)	4.0 (2)	2.5 (1)	4.2 (3)	5.6 (22)	4.2 (6)	9.9 (5)	0.0 (0)	6.7 (5)
Multiple myeloma	2.8 (7)	3.7 (5)	2.2 (1)	4.4 (2)	1.6 (1)	4.7 (12)	4.0 (6)	0.0 (0)	6.4 (3)	1.1 (1)
Leukaemia	6.3 (30)	6.2 (9)	5.4 (2)	2.3 (1)	4.5 (4)	10.6 (44)	9.9 (14)	8.7 (4)	8.9 (4)	12.0 (8)
Secondary sites or ill-defined	6.4 (20)	8.6 (12)	2.6 (1)	6.5 (3)	7.6 (5)	10.6 (25)	8.1 (10)	4.3 (2)	7.1 (3)	6.1 (4)
All cancer but skin	227.2 (730)	190.0 (278)	225.9 (75)	185.5 (89)	242.0 (182)	239.1 (640)	193.5 (256)	149.1 (56)	223.8 (102)	237.3 (171)

* P-value < 0.05.
** P-value < 0.01.
† or ill-defined sites within the system.

Table 4 World-standardized incidence rates per 10^5 person-years for 1985–89 and 1990–95 periods, among native French Polynesians

	World-standardized incidence rate per 10^5 py			
	Women		Men	
Localization	1985–89	1990–95	1985–89	1990–95
Oral cavity	2.9	4.9	9.0	5.4
Hypopharynx	0.0	0.3	2.7	2.9
Pharynx	3.7	3.8	13.1	11.6
Oral cavity and pharynx	6.5	8.7	22.1	17.0
Oesophagus	1.7	1.1	5.1	6.3
Stomach	4.7	7.8	9.7	9.5
Small intestine	0.4	1.4	0.6	1.0
Colon, rectum, anal canal	10.2	9.7	14.3	11.9
Liver	4.2	5.2	11.9	14.4
Gallbladder	1.6	2.0	0.7	3.9
Pancreas	3.4	4.2	4.7	6.1
Digestive system	29.4	33.5	50.6	56.6
Larynx	2.5	1.1	7.8	3.4*
Trachea, bronchus, lung	22.9	30.0	75.5	62.8
Pleura, thymus, heart, mediastine	1.2	1.8	3.8	1.7
Other respiratory organs†	1.6	0.6	2.0	0.6
Bone	2.7	2.1	4.3	2.4
Connective and soft tissues	2.8	1.3	1.6	4.0
Malignant melanoma of the skin	0.0	0.2	0.0	1.5
Breast	55.7	67.5**	3.1	1.1
Cervix uteri	30.6	29.0		
Corpus uteri	7.6	10.5		
Ovary, other uterine annex	8.0	11.5		
Other genital organs†	3.3	2.8	0.4	0.8
Prostate gland			18.4	35.9***
Testis			1.0	1.4
Bladder	1.0	2.7	7.2	5.1
Kidney and other urinary organs	1.1	2.7	3.8	4.6
Eye and annexes	0.4	0.6	1.3	0.8
Brain and central nervous system	4.5	5.9	3.0	2.8
Thyroid gland	11.3	20.6***	6.4	5.2
Other endocrine glands	0.7	0.5	1.0	2.0
Hodgkin's disease	2.3	0.0	1.5	0.5
Other lymphoid neoplasm	4.1	4.1	4.1	6.6
Multiple myeloma	2.0	4.1	6.9	2.7*
Leukaemia	7.4	6.0	13.5	9.0
Secondary sites or ill-defined	9.3	6.9	8.8	12.0
All cancer but skin	226.0	259.5***	248.0	240.5

† or ill-defined sites within the system.
* *P*-value for a comparison between the 1985–89 and the 1990–95 period < 0.05.
** *P*-value < 0.01.
*** *P*-value < 0.001.

higher among individuals born in the Windward Islands, the Marquesas Islands and the Tuamotu-Gambier archipelago than in those born in the Leeward and Austral Islands. Most of the variability in rates by birth place was due to digestive tract, lung, cervix uteri and thyroid cancers. Compared with women born in the Windward Islands, women born in the Leeward Islands were at lower risk of colorectal cancer and lung cancer; those born in the Marquesas Islands were at lower risk of colorectal but at higher risk of thyroid cancer; women born in the Austral Islands were at higher risk of stomach and thyroid cancer and those born in the Tuamotu-Gambier archipelago were at lower risk of colorectal cancer.

Table 5 Standardized incidence ratios (SIR). Reference populations: Hawaiians & Maoris (1988–92)

	Women		Men	
Localization	Hawaii	New-Zealand	Hawaii	New-Zealand
Oral cavity	1.93	1.18	1.22	1.08
Hypopharynx	0.64	0.	1.50	4.74***
Pharynx	2.97**	4.85***	2.30**	3.00***
Oral cavity and pharynx	1.22	0.90	0.95	1.02
Oesophagus	1.04	0.62	0.83	0.71
Stomach	0.63*	0.44***	0.72	0.37***
Small intestine	0.70	1.21	0.42*	0.45
Colon, rectum, anal canal	0.42***	0.41***	0.39***	0.42***
Liver	1.81	1.45	2.07***	1.08
Gallbladder	1.36	1.54	1.53	1.29
Pancreas	0.53*	0.61	0.63	0.59*
Digestive system	0.36***	0.32***	0.39***	0.31***
Larynx	3.28	1.64	1.54	1.90*
Trachea, bronchus, lung	0.77**	0.37***	0.94	0.71***
Pleura, thymus, heart, mediastine	2.53	6.79**	5.37**	2.65*
Other respiratory organs†	0.75	0.	1.18	6.35*
Bone	3.75**	2.52*	2.48*	1.34
Connective and soft tissues	0.72	0.66	0.87	1.02
Malignant melanoma of the skin	0.14*	0.05***	0.88	0.15***
Breast	0.77***	0.81**	4.12*	3.69*
Cervix uteri	3.28***	0.92		
Corpus uteri	0.43***	0.60**		
Ovary, other uterine annex	1.22	0.78		
Prostate gland			0.68***	0.69**
Testis			0.34**	0.18***
Other genital organs†	1.65	0.96	2.47	2.12
Bladder	0.71	0.97	1.37	0.59*
Kidney and other urinary organs	0.77	0.61	0.53*	0.55*
Eye and annexes	0.52	1.77	4.73*	5.90*
Brain and central nervous system	1.72	1.29	0.65	0.56*
Thyroid gland	1.82***	2.56***	1.71	3.74***
Other endocrine glands	3.11	0.76	1.08	1.14
Hodgkin's disease	0.37*	1.48	1.38	0.71
Other lymphoid neoplasm	0.99	0.67	0.57**	0.74
Multiple myeloma	0.79	0.56	1.19	0.83
Leukaemia	1.04	0.83	1.17	0.93
Secondary sites or ill-defined	0.98	0.39**	1.37	0.39***
All cancer but skin	0.97	0.75***	0.91*	0.73***

† or ill-defined sites within the system.
* P-value < 0.05.
** P-value < 0.01.
*** P-value < 0.001.

The overall cancer incidence in native men in the Windward and Austral Islands and the Tuamotu-Gambier archipelago was similar to that of native men in the Leeward and Marquesas Islands. It was higher in the Windward Islands than elsewhere in FP. Compared to men born in the Windward Islands, native men in the Leeward Islands were at lower risk of prostate cancer and those born in the Marquesas Islands were at lower risk of colorectal prostate cancer, and lung cancer. Men born in the Austral Islands were at higher risk of liver cancer and at lower risk of prostate cancer and those born in the Tuamotu-Gambier archipelago were at lower risk of colorectal cancer than native men in the Windward Islands.

The standardized incidence of all cancers increased significantly in women from the 1985–89 period to the 1990–95 period, but was stable in men (Table 4). Between these two periods, the incidence of breast and thyroid cancer increased significantly among women and that of prostate cancer increased significantly among men. On the other hand, the incidence of larynx cancer and multiple myeloma declined significantly among men between these two periods.

The overall incidence of cancer in FP during the 1985–95 period was similar to that in Hawaiians during the 1987–92 period, but lower than in Maoris during the same period (Table 5). Cancers of the pharynx, larynx, bone and thyroid were more frequent for both genders in FP than in the reference populations, as were cancers of the 'pleura, thymus, heart, mediastinum' group. Stomach, colorectal, pancreas, lung and kidney cancers as well as malignant melanoma were less frequent for both genders in FP than in the reference populations. Among women, the incidence of breast and corpus uteri cancer was lower in FP than in the reference populations. A lower incidence of prostate and testis cancers was found among men in FP.

Discussion

The major finding of this study is the low incidence for both genders, of stomach, colorectal and all digestive tract cancers in FP, compared to Hawaiians and Maoris: the world standardized incidence is, respectively, 6.6, 9.9 and 19.8 per 10^5 PY in women, and 9.9, 12.9 and 29.2 per 10^5 PY in men. These cancers are known to be strongly related to diet, but a genetic predisposition should not be excluded. Indeed, an Australian group who studied the role of N-acetyltransferase polymorphism showed that individuals with the low rate acetylator phenotype were at a lower risk of colorectal cancer, when controlling for diet (Roberts-Thomson *et al*. 1996). The quality or quantity of food intake may be of particular importance. Obesity is frequent among such individuals and indirect economic measurements showed profound changes in nutritional behaviour. After the 1960s, traditional foods based on local fruits, vegetables and fish were replaced by western foods.

Colorectal cancer was about 2.5 times less frequent in FP during 1985–95 than in Hawaiians and Maoris during 1988–92. It is noteworthy that the incidence of colorectal cancer in these two reference populations was similar for both genders during the 1988–92 period: 25 per 10^5 PY in women and 34 per 10^5 PY in men (Parkin *et al*. 1997). The incidence of colorectal cancers was stable in FP between the 1985–89 and the 1990–95 periods, but increased between the 1978–82, 1983–87 and 1988–92 periods in the two reference populations, except among Hawaiian men, where it remained stable. The University of Hawaii showed that the incidence of colorectal cancer was negatively linked to fibres of vegetable origin (Le Marchand *et al*. 1997), and positively linked to sedentary activity, obesity, smoking, alcohol use, diabetes (Le Marchand *et al*. 1997) and a family history of colorectal cancer (Le Marchand *et al*. 1996). This last study also confirmed that the risk of colorectal cancer was not linked to total dietary fat intake, i.e. saturated fat and polyunsaturated fat, but negatively linked to the ratio between polyunsaturated and saturated fat (Le Marchand *et al*. 1997). This group also performed an environmental study of diets, which showed that the Tahitian diet is fattier, with a lower retinol β-carotene, α-carotene, and lutein intake than the diet of natives of New Caledonia, Hawaii, the Cook Islands and Fiji. On the other hand, the dietary fibre intake of Tahitians was high (Le Marchand *et al*. 1995). Notwithstanding, the low incidence of colorectal cancer could stem from an earlier introduction of a western-style diet in FP than in Hawaii and New Zealand. This hypothesis is strengthened by the fact that the incidence of colorectal cancer was 12 per 10^5 PY in women and 14 per 10^5 PY in men born in the Leeward Islands, values which are much higher than the 3 per 10^5 PY in women and 7 per 10^5 PY in men observed on other archipelagos where traditional diets based on local fruits, vegetables and fish were eaten until more recently (de Solminihac 1987).

The incidence of stomach cancer increased in women but was stable in men. Oesophagus and stomach cancer incidence was also stable in Maoris in New Zealand, between 1978 and 1992, as opposed to that observed in the United States of America and in European countries (Armstrong & Borman 1996). Liver and intrahepatic cancers were more frequent in French Polynesians than in other Maoris, but this difference was significant only when compared to Hawaiian men. The role of hepatitis B virus in the incidence of liver cancer in FP has already been studied (Boutin *et al*. 1990) and a generalized vaccination campaign of newborns was initiated in the 1990s.

Lung cancer incidence was lower in FP women than in Hawaiians and in Maoris. The incidence among French Polynesian men was lower than that of men in New Zealand but similar to that of men in Hawaii. In 1985, lung cancer incidence was found to be higher in Hawaiians than in other ethnic groups in the Pacific Islands, and was attributed to a higher rate and longer duration of tobacco consumption (Shimizu *et al*. 1985). In fact, dietary factors seem to explain part of the variability in lung cancer incidence in Hawaii (Le Marchand *et al*. 1995). Moreover, native Hawaiians are at higher risk of lung cancer when all characteristics of smoking history and dietary factors are taken into account (Le Marchand *et al*. 1992). According to our data, lung cancer incidence seems to be lower among men in the Marquesas Islands than among men in other archipelagos, and lower in women born in the Leeward and Austral Islands.

We found a very high risk of thyroid cancer in FP, compared to that in the two reference populations, for both genders. Any interpretation of this difference is prohibited in the absence of standardized cancer registration procedures. Our findings could be due to our choice of a 5 millimetre threshold for this cancer, whereas registries in Hawaii and New Zealand use the judgements of clinicians and pathologists. In fact such a comparison could be done by adjusting for diagnostic procedures and the distribution of tumour stages at diagnosis in each country. The potential role of the atmospheric nuclear tests performed by France in Mururoa and Fangataufa has been described in a specific publication (de Vathaire *et al*. 2000). The Pacific is a notorious high-risk area for thyroid cancer (Henderson *et al*. 1985). The highest published rates of thyroid cancer were found in New Caledonia between 1985 and 1992: 34 per 10^5 PY in Melanesian women (Ballivet *et al*. 1995). Other factors such as the number of pregnancies in women, dietary intake of iodine via seafood and obesity (Preston-Martin *et al*. 1993) may account for differences in thyroid cancer incidence. Thyroid cancer incidence seems to be particularly high in women born in the Austral Islands.

Breast cancer incidence was estimated to be lower in FP than in the reference populations. In FP, this cancer was more frequent in the Windward Islands and Tuamotu-Gambier than in other archipelagos. A study conducted in Hawaii provided some evidence for a protective role of adolescent obesity against premenopausal breast cancer, but also for an enhancing influence of a positive energy balance during adult life on postmenopausal breast cancer (Le Marchand *et al*. 1988). Some endocrine-disrupting chemicals, particularly chlordane/heptachlor and 1,2-dibromo-3-chloropropane (DBCP) may also play a role (Allen *et al*. 1997).

In conclusion, we found some specific features in cancer incidence among native French Polynesians. Compared to Maoris in New Zealand and to Hawaiians in Hawaii, the incidence of digestive tract, lung, corpus uterus and prostate cancer was lower in FP. By contrast, thyroid cancer incidence was higher. Further studies are needed to elucidate the variations observed between the archipelagos.

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