Cancer in Bermuda

Incidence Rates and Comparison with the United States

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November 2004

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PLAIN LANGUAGE SUMMARY

In this study, the rate of cancer in Bermuda was calculated using the Bermuda cancer registry and population counts from the Bermuda Statistics Department. All incidence rates were adjusted according to the age of the Bermudian population so that they can be compared to those in the United States. Overall, for the years 2000-2003, it was found that the rate of cancer was similar in both countries, except for a higher rate in white females from Bermuda.

Differences between the two countries were found when the rates of specific cancer types in Bermuda were compared to those in the United States. It was found that the rates in Bermuda were higher for cancer of the mouth, ovarian cancer (only in black women), melanoma (only in Whites), colon and rectum cancer (only in white women), and breast cancer (only in white women). On the other hand, lung, colon and rectum cancers were less frequent in Blacks from Bermuda compared to Unites States. Preventive measures for cancers with a higher rate in Bermuda include; the promotion of a healthy diet, of physical exercise, effective screening programs, and abstinence from cigarettes and alcohol.

Cancer mortality was generally found to be higher in Bermuda compared with United States. However, mortality results according to race were not available and the differences between the two countries must be viewed with caution (a bias is introduced when both races are combined). Nevertheless, it seemed likely that mortality rate for prostate cancer, pancreas cancer, ovarian cancer, and breast cancer were higher in Bermuda.

Between 1991 and 2003, the cancer rate in Bermuda increased by an average of 5-10 cases per year. This is in contrast with figures in the Unites States where cancer rates dropped for men and remained stable for women during the same years.

KEY FINDINGS

- Except for white females, cancer rates in Bermuda and the United States were similar in 2000-2003.
- Cancer rates in White women were found be higher in Bermuda
- In Whites, the specific cancer types that had a higher rate in Bermuda when compared to the United States included; oral cavity cancer, melanoma, colorectal cancer (in females), and breast cancer.
- In Blacks, the specific cancer types that had a higher rate in Bermuda when compared to the United States included; oral cavity cancer (in males), and ovarian cancer.
- Lung and colorectal cancers had lower rates in Blacks from Bermuda when compared to Black from the Unite States.

1. INTRODUCTION

The Public Research Unit of Laval University Medical Center recently conducted a study on environmental contaminants in Bermuda using its mobile laboratory *Atlantis*. During the conception of the study protocol, a question was raised concerning the evaluation of potential environmental carcinogens. People in Bermuda strongly feel that the rate of cancer on the Island is high, but few reports of standardized cancer rates in Bermuda exist. A preliminary report from the University of Texas Southwestern Medical Center at Dallas concluded that the incidence rate of breast cancer and colon cancer in white females was higher in Bermuda compared to the United States. In the same report, no statistically significant differences in rates were found between Bermuda and the U.S. for prostate, colon in males, and ovarian cancers, although some differences were observed (1).

To address the necessity of evaluating environmental carcinogens, as well as to have a better picture of the incidence rates of cancer in Bermuda, it was decided to use the Bermuda tumor registry to evaluate the crude and age-adjusted incidence of cancer in Bermuda, and to compare these rates to the United States population. It was beyond the scope of the work to formerly identify risk factors associated with specific cancers in the Bermuda context. However, known risk factors that could provide an explanation for the differences observed are discussed.

2. METHODOLOGY

Cancer cases and mortality

Data on new cancer cases for 1991-2003 were extracted from the Bermuda Tumor Registry. Cases were categorized by their primary site (using ICD-O codes). Subcategories were also created for leukemia, lymphomas, and skin cancer using the histology type (ICD-O code). Unless specified otherwise, *in-situ* carcinomas and basal and squamous skin cancers were excluded from the analyses. Mortality data were obtained through the Bermuda Department of Health. At the time these analyses were done, mortality data were available up to the year 2000.

Population data

Population data were obtained directly through the Bermuda Statistics Department. Population data for 1991 were the actual data from the 1991 census, while population data for 1992-2003 were projections computed from the 1991 census data (these calculations were done by the Statistics Department). Even though the data for the 2000 census were available, we used the data from the 1991 census because the population projections computed from the 2000 data were not available at the time these analyses were done.

Calculation of crude and age-adjusted rates

Crude incidence rate were calculated by dividing the number of cases diagnosed in a given year by the corresponding population of that year. It is noteworthy that information on the race of each cancer patient is determined by hospital staff during patient' registration. It is not self-reported, such as in the census data. Because race is determined differently for cases and for the general population, a bias can be present in race-specific rates. It is however expected to be small.

Age-adjusted rate were weighted on the 2000 United States standard population by 5-year age groups using the formula:

$$I_S = \sum_{k=1}^{18} I_k w_k$$

where is the age-adjusted incidence rate, k indexes 5-year age categories, I_k is the incidence rate in the age group k, and w_k is the proportion of the reference population count in age group k. Data on 2000 standard population was gather from the United States National Cancer Institute (2). The 2000 U.S. standard population is a *million population*, that is, the sum of the people in all age groups is 1 000 000. In this analysis, the set of weight used was divided by 1 000 000 so that the sum of the weight was equal to 1.0. Table 1 shows the weights used by 5-year age-group.

Table 1 : Weight based onthe 2000 U.S. standard population by 5-year age groups

Age group	2000 U.S. standard million population	Weights used for standardization
0 - 4	69135	0.069135
5 - 9	72533	0.072533
10 - 14	73032	0.073032
15 - 19	72169	0.072169
20 - 24	66478	0.066478
25 - 29	64529	0.064529
30 - 34	71044	0.071044
35 - 39	80762	0.080762
40 - 44	81851	0.081851
45 - 49	72118	0.072118
50 - 54	62716	0.062716
55 - 59	48454	0.048454
60 - 64	38793	0.038793
65 - 69	34264	0.034264
70 - 74	31773	0.031773
75 - 79	26999	0.026999
80 - 85	17842	0.017842
85+	15508	0.015508
Total	1000000	1.0000

Age-adjustment on combined rates

When combined rates are presented (such as males and females combined), the adjustment on age was performed on the combined rates (total cases / total population) and not on sex-specific rates (such as taking the mean of adjusted sex-specific rates). In some situations, for example when the male cases are younger that the female cases, the age-adjusted combined rates can be higher than all the sex-specific rates. The same is true for race.

Comparison with United Sates rates

At the time these analyses were performed, United Sates cancer and mortality rates were available for 1997-2001. To allow a better comparison with the U.S data, the Bermuda cancer rates were computed for the same years. Data on cancer incidence in the United States were from the National Cancer institute (3).

An adaptation of the method described by Bouyer *et al.* (4) was used to compute *p*-value for rate ratios. The *p*-value was obtained from the *Z* statistic using the equation:

$$Z = \frac{\ln SR_{Bermuda} - \ln SR_{US}}{\sqrt{Variance(\ln SRR_{Bermuda})}}$$

where $SR_{Bermuda}$ is the age-adjusted rate in Bermuda, SR_{US} is the age-adjusted rate in the United States, and $SSR_{Bermuda}$ is the standardized rate ratio in Bermuda compared to Unites States. The variance of $\ln SRR_{Bermuda}$ was obtained using the equations:

$$Variance(\ln SRR_{Bermuda}) = \frac{Variance(SR_{Bermuda})}{SR^2_{Bermuda}} + \frac{1}{d_{US}}$$

$$Variance(SR_{Bermuda}) = \sum_{k=1}^{18} w_k^2 \frac{d_{kBermuda}}{n^2_{kBermuda}}$$

where d_{US} is the number of cases in the Unites States for the period studied, k indexes 5-year age groups, w_k is the 2000 U.S. population weight in the age group k, $d_{kBermuda}$ is the number of cases in the age group k in Bermuda, and $n_{kBermuda}$ is the population in the age group k in Bermuda. Because several rate ratio were computed, a p-value < 0.01 was considered statistically significant.

Time trend analyses

To assess the presence of a temporal variation between 1991 and 2003, Poisson regression was performed on age-adjusted rates using the year of diagnosis as the main independent variable. The annual percent change (APC) was computed from the coefficient estimate β of the regression using the equation:

$$APC = (1 - e^{\beta}) \times 100$$

3. RESULTS

Number of cases

The database analyzed included new cancer cases from 1991 to 2003. There was a total of 3502 cases registered in the database. Table 2 shows the number of cases by year of diagnosis, sex, and race.

Table 2 : Number of cases in database by year of diagnosis, sex, and race

Year of diagnosis	Total cases	Sex		Race		
		Female	Male	Black	White	Other
1991	206	91	115	120	86	0
1992	203	97	106	107	95	1
1993	202	107	95	110	92	0
1994	229	111	118	120	109	0
1995	234	122	112	125	108	1
1996	238	128	110	134	104	0
1997	314	149	165	175	138	1
1998	344	157	187	166	177	0
1999	317	151	166	161	156	0
2000	316	140	176	156	157	3
2001	297	145	152	168	127	2
2002	312	146	166	169	143	0
2003	297	143	154	171	124	2

Age structure

Figure 1 shows the distribution of the population in 5-year age groups for the years 1991 and 2003, according to race. The curve of the distribution of the U.S. 2000 standard population is also shown for comparison. In 1991, compared to the U.S. 2000 standard population, the Bermuda population had a lower proportion of persons aged 5-19, but a higher proportion of persons aged 20 to 39. The population projection of 2003 had the 20-39 years peak shifted to the right (by about 5 to 10 years). When race-specific data are considered, one can observe that this shift is mostly due to Blacks, while the proportions of Whites did not change significantly. However, the differences between Bermuda and the United States in the distribution of the population before 45 years old was mostly due to Whites.

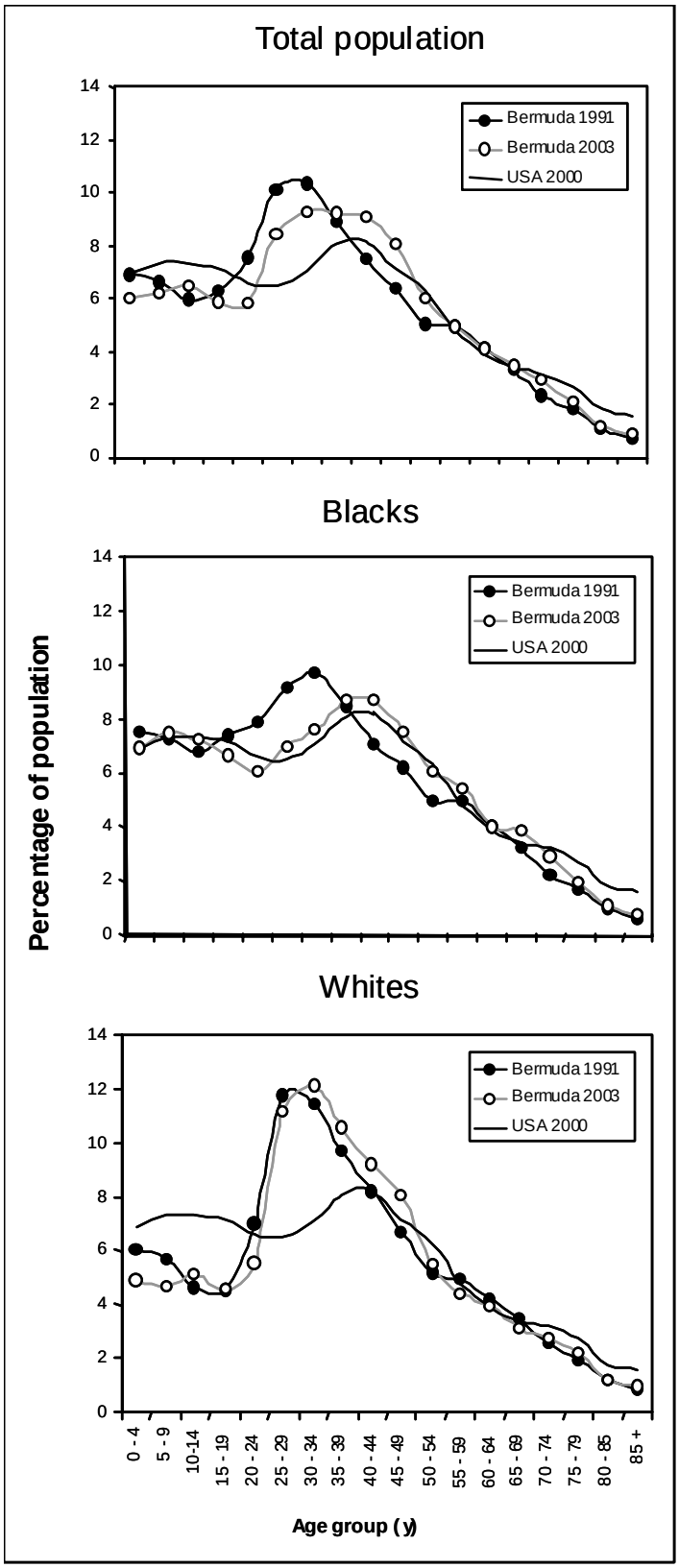

Figure 1 : Proportion of population in 5-year age groups

Because the proportion of the population aged 25-40 years is higher in the Bermudian population compared to that of the U.S. 2000 standard population, the age adjustment will decrease the incidence rate for cancers affecting mostly people aged 25-40 years (such as Hodgkin's lymphoma), and will increase the incidence for cancers affecting people younger than 25 or older than 40 years. For the same reasons, this effect of age adjustment will be stronger in Whites, and for cases diagnosed in the beginning of the 1990's.

Crude and age-adjusted incidence rate

Table 3 shows the crude and age-adjusted incidence rates of cancer in 2000-2003 by primary site and sex, for all race combined. Not all primary sites are reported, only those with more than 5 cases per 100 000 persons-years, or with clinical significance are shown. Similar to other industrial countries, the most frequent cancer site was prostate in men and breast in women. In Bermuda, colorectal cancer came second, followed by lung and bronchus. After age adjustment, colorectal and lung cancer had similar incidence (49.5 vs. 50.4). In the United States, lung cancers are more frequent than colorectal cancer (61.7 vs. 53.7) (3).

Tables 4 and 5 show the crude and age-adjusted incidence rates for cancer in 2000-2003 by primary site and sex for Blacks and Whites, respectively. For all sites, age-adjusted rates showed that black females had a lower rate compared to white females (394 vs. 508 cases per 100000 person-years), but that black male had a higher incidence than white males (645 vs. 568 cases per 100000 person-years). This was also observed in the U.S. population (3). The prostate cancer rate in black males was almost twice that of white male (325 vs. 168 cases per 100000 person-years). Digestive cancers and non-Hodgkin lymphoma were also more frequent in black males, compared to white males. Most other cancer sites were more frequent in whites. This was in contrast of U.S. data where lung, colorectal, digestive and oral cancers were more frequent in blacks, compared to Whites (3).

Table 3 : Crude and age-adjusted incidence rates of cancer in Bermuda (2000-2003) by primary site and sex (all races)

Cancer site or type	Crude incidence rate (per 100 000 persons-years)			Age-adjusted incidence rate [a] (per 100 000 persons-years)		
	Total	Female	Male	Total	Female	Male
All sites [b]	452.7	419.4	488.8	515.6	440.6	625.5
Oral cavity	16.1	7.0	26.0	17.6	6.7	32.6
Digestive system	89.2	90.2	88.2	107.9	101.2	113.3
Stomach	10.5	8.6	12.6	13.3	9.7	18.5
Colon and rectum	52.9	56.0	49.5	63.4	62.8	61.7
Pancreas	12.5	17.1	7.6	16.1	20.0	8.9
Respiratory system and intra-thoracic organs	46.8	34.2	60.5	54.8	36.6	80.6
Lung and bronchus	41.2	32.6	50.4	48.5	34.9	68.3
Skin (including basal and squamous)	59.3	42.7	77.3	69.7	46.6	102.8
Basal and squamous	40.4	26.4	55.5	50.2	30.4	78.4
Melanoma	18.5	16.3	21.0	19.0	16.1	23.1
Breast	79.1	151.4	0.8	85.7	153.9	0.8
Female genital system	-	50.5	-	-	52.9	-
Endometrium and corpus uteri	-	16.3	-	-	17.1	-
Ovary	-	20.2	-	-	22.1	-
Male genital system	-	-	208.4	-	-	269.5
Prostate	-	-	203.4	-	-	265.2
Urinary system [c]	22.6	16.3	29.4	26.5	17.4	39.7
Urinary bladder [c]	13.7	9.3	18.5	16.7	10.5	25.2
Brain and other nervous system	5.6	6.2	5.0	5.8	5.9	6.2
Endocrine system	1.6	1.6	1.7	1.7	1.4	2.0
Lymphomas	20.6	21.0	20.1	21.6	21.2	21.2
Hodgkin disease	5.7	7.0	4.2	5.0	5.9	4.0
Non-hodgkin lymphomas	14.1	13.2	15.1	15.2	14.1	15.6
Multiple myeloma	6.9	7.0	6.7	7.7	7.5	7.2
Leukemia	8.5	7.8	9.2	9.9	8.0	13.3
Lymphocytic	2.4	1.6	3.4	2.8	1.4	5.1
Myeloid	5.7	5.5	5.9	6.7	5.9	8.2
Other and unspecified primary sites	8.5	10.1	6.7	11.2	11.9	10.2

[a] Age-adjusted to the 2000 United States standard population by 5-year age groups.
[b] Excluding basal and squamous skin cancers and in-situ carcinomas.
[c] Including reports of transformed cells in urine without evidence of a urinary tumor (C67.9 – urinary bladder, NOS).

Table 4 : Crude and age-adjusted incidence rates of cancer in Bermuda (2000-2003) by primary site and sex (Blacks)

Cancer site or type	Crude incidence rate (per 100 000 persons-years)			Age-adjusted incidence rate [a] (per 100 000 persons-years)		
	Total	Female	Male	Total	Female	Male
All sites [b]	439.9	373.7	514.7	495.3	394.1	645.2
Oral cavity	14.1	5.1	24.2	14.5	4.9	27.5
Digestive system	85.0	78.3	92.7	103.1	89.8	119.9
Stomach	11.4	8.8	14.3	14.5	9.8	21.9
Colon and rectum	46.2	44.2	48.5	55.5	52.1	58.1
Pancreas	14.7	17.7	11.4	18.0	19.9	13.6
Respiratory system and intra-thoracic organs	43.5	30.3	58.4	47.0	31.4	68.3
Lung and bronchus	38.2	29.1	48.5	41.8	30.3	57.6
Skin (including basal and squamous)	5.4	3.8	7.1	5.8	3.6	9.6
Basal and squamous	4.7	2.5	7.1	5.1	2.4	9.6
Melanoma	0.7	1.3	0.0	0.6	1.1	0.0
Breast	76.3	142.6	1.4	83.5	145.0	1.4
Female genital system	-	48.0	-	-	50.7	-
Endometrium and corpus uteri	-	10.1	-	-	10.8	-
Ovary	-	24.0	-	-	26.4	-
Male genital system	-	-	256.6	-	-	326.5
Prostate	-	-	255.2	-	-	325.1
Urinary system [c]	20.8	15.1	27.1	24.1	15.8	38.8
Urinary bladder [c]	10.7	6.3	15.7	13.7	7.4	24.0
Brain and other nervous system	6.7	6.3	7.1	7.2	6.2	9.4
Endocrine system	1.3	1.3	1.4	1.5	1.2	1.8
Lymphomas	16.7	13.9	20.0	17.6	17.7	20.9
Hodgkin disease	4.0	3.8	4.3	3.9	3.6	4.2
Non-hodgkin lymphomas	12.7	10.1	15.7	13.7	11.1	16.7
Multiple myeloma	10.0	8.8	11.4	10.5	8.9	11.5
Leukemia	8.7	10.1	7.1	10.0	10.5	9.3
Lymphocytic	2.7	2.5	2.9	2.6	2.2	3.1
Myeloid	5.4	6.3	4.3	6.8	7.1	6.2
Other and unspecified primary sites	8.0	11.4	4.3	10.6	13.2	7.3

[a] Age-adjusted to the 2000 United States standard population by 5-year age groups.
[b] Excluding basal and squamous skin cancers and in-situ carcinomas.
[c] Including reports of transformed cells in urine without evidence of a urinary tumor (C67.9 – urinary bladder, NOS).

Table 5 : Crude and age-adjusted incidence rates of cancer in Bermuda (2000-2003) by primary site and sex (Whites)

Cancer site or type	Crude incidence rate (per 100 000 persons-years)			Age-adjusted incidence rate [a] (per 100 000 persons-years)		
	Total	Female	Male	Total	Female	Male
All sites [b]	462.9	482.1	443.7	527.4	507.5	568.4
Oral cavity	19.2	10.0	28.3	22.2	10.8	38.2
Digestive system	94.1	109.1	79.0	111.8	118.3	99.1
Stomach	9.1	8.1	10.1	11.3	8.9	13.4
Colon and rectum	61.7	74.7	48.6	74.0	82.0	62.9
Pancreas	9.1	16.2	2.0	12.3	18.5	2.1
Respiratory system and intra-thoracic organs	50.6	40.4	60.8	62.4	44.0	91.1
Lung and bronchus	44.5	38.4	50.6	54.9	41.7	76.5
Skin (including basal and squamous)	140.4	104.7	176.3	163.1	112.7	228.3
Basal and squamous	94.1	64.6	123.7	114.9	71.6	170.8
Melanoma	45.3	40.1	50.6	46.9	41.1	54.7
Breast	80.9	161.3	0.0	87.1	169.2	0.0
Female genital system	-	50.6	-	-	53.6	-
Endometrium and corpus uteri	-	24.2	-	-	26.3	-
Ovary	-	14.2	-	-	14.9	-
Male genital system	-	-	138.1	-	-	175.3
Prostate	-	-	127.9	-	-	167.7
Urinary system [c]	25.2	18.2	32.3	30.1	20.0	41.3
Urinary bladder [c]	18.2	14.2	22.2	21.9	15.9	27.8
Brain and other nervous system	4.0	6.0	2.1	3.7	4.9	2.6
Endocrine system	2.0	2.0	2.1	1.8	1.1	2.4
Lymphomas	25.2	30.2	20.2	26.3	29.3	20.9
Hodgkin disease	7.1	10.1	4.1	5.3	7.4	3.0
Non-hodgkin lymphomas	16.1	18.1	14.1	18.0	19.5	14.5
Multiple myeloma	2.0	4.0	0.0	2.5	4.1	0.0
Leukemia	8.1	4.1	12.2	9.6	4.2	19.1
Lymphocytic	2.0	0.0	4.1	2.8	0.0	7.8
Myeloid	6.1	4.1	8.1	6.8	4.2	11.2
Other and unspecified primary sites	9.1	8.1	10.2	11.9	9.2	14.5

[a] Age-adjusted to the 2000 United States standard population by 5-year age groups.
[b] Excluding basal and squamous skin cancers and in-situ carcinomas.
[c] Including reports of transformed cells in urine without evidence of a urinary tumor (C67.9 – urinary bladder, NOS).

Comparison with U.S. data

Because incidence data for United states were available for 1997-2001, the comparisons with Bermudian rates were done for the same years. Only cancer site with more than 25 cases in 1997-2001 were analyzed. Figures 2, 3, and 4 show the rate ratios for selected cancer sites for both sexes, for females, and for males, respectively. When comparison between the Bermudian and American figures were performed, it was noted that important differences existed according to race. Results will therefore be discussed separately for Blacks and for Whites.

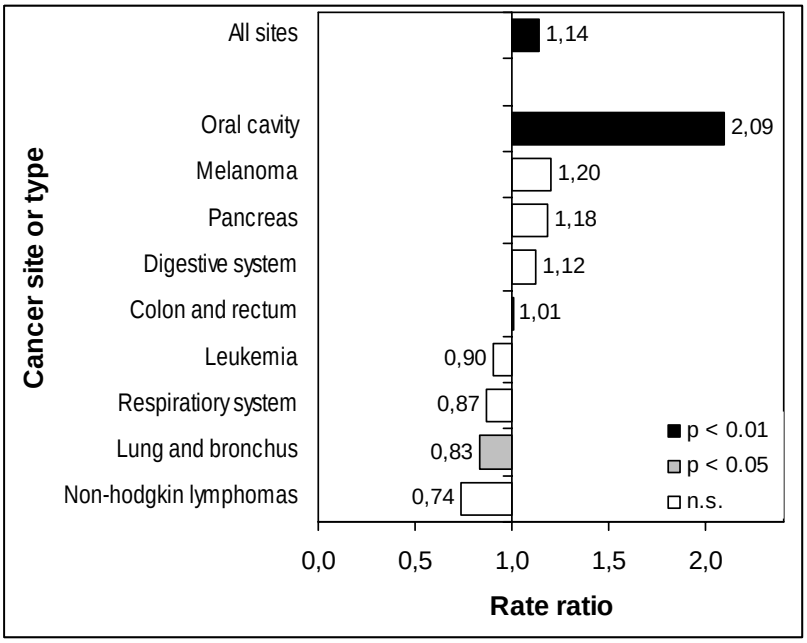

Figure 2 : Rate ratios for Bermuda compared to United States for all races and both sexes

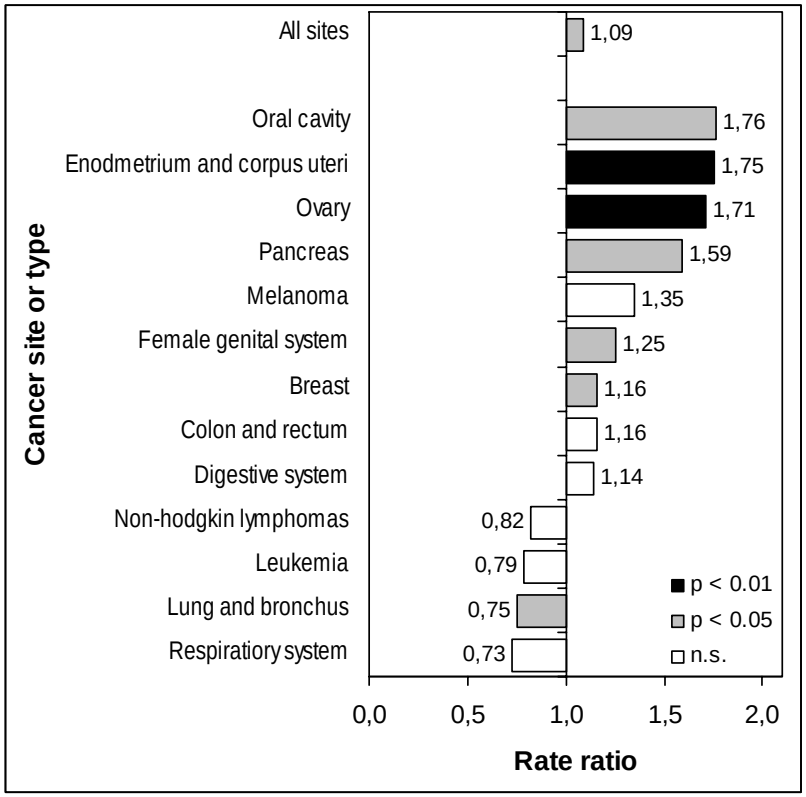

Figure 3 : Rate ratios for Bermuda compared to United States for females (all races)

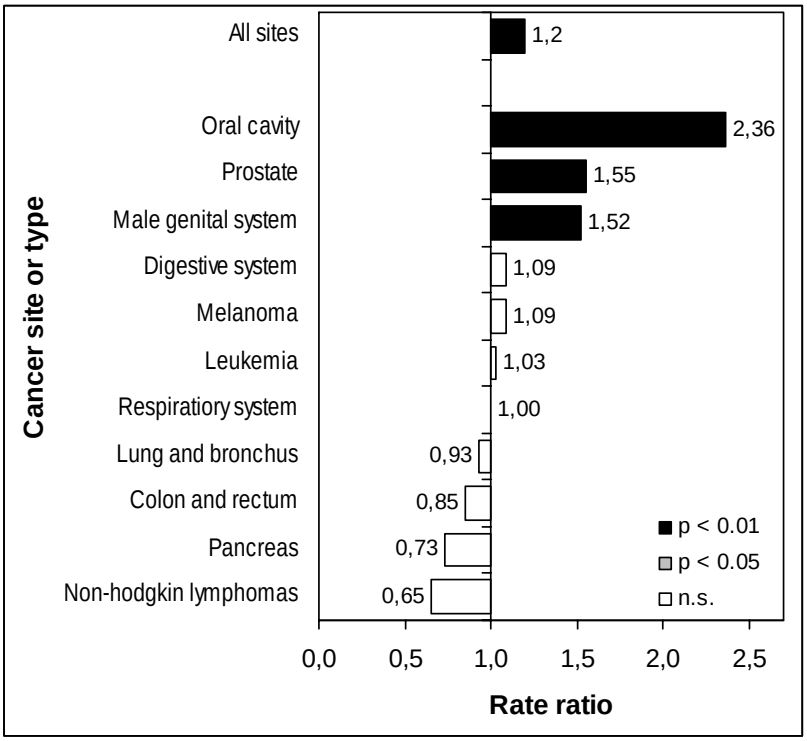

Figure 4 : Rate ratios for Bermuda compared to United States for male (all races)

Blacks

Figures 5, 6, and 7 show the rate ratios for selected cancer sites in Blacks for both sexes, for females, and for males, respectively. Globally, the incidence rate of cancer were similar in Bermuda and United States (RRs = 0.94 in females and 1.01 in males). Cancer sites that showed a significantly higher incidence compared to the U.S. rates in blacks included ovary (RR = 2.24), and oral cavity for males (RR = 1.82). Cancer of the respiratory system, mainly due to lung and bronchus, had a significantly lower rate compared to that of the U.S. (RRs = 0.44 for females and 0.67 for males). Colorectal cancer also had a lower incidence rate but the rate ratio was statistically significant only for both sexes combined (RR = 0.66).

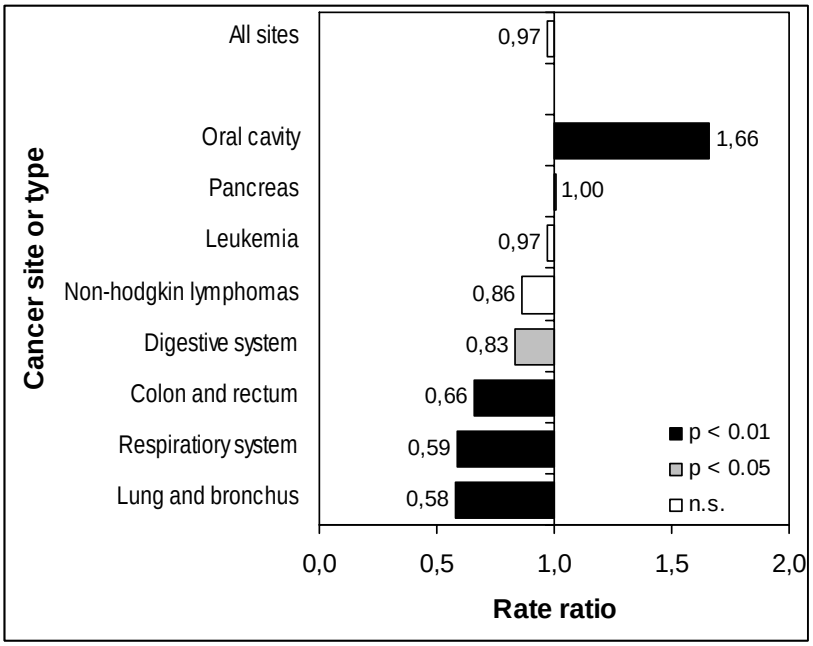

Figure 5 : Rate ratios for Bermuda compared to United States for both sexes (Blacks)

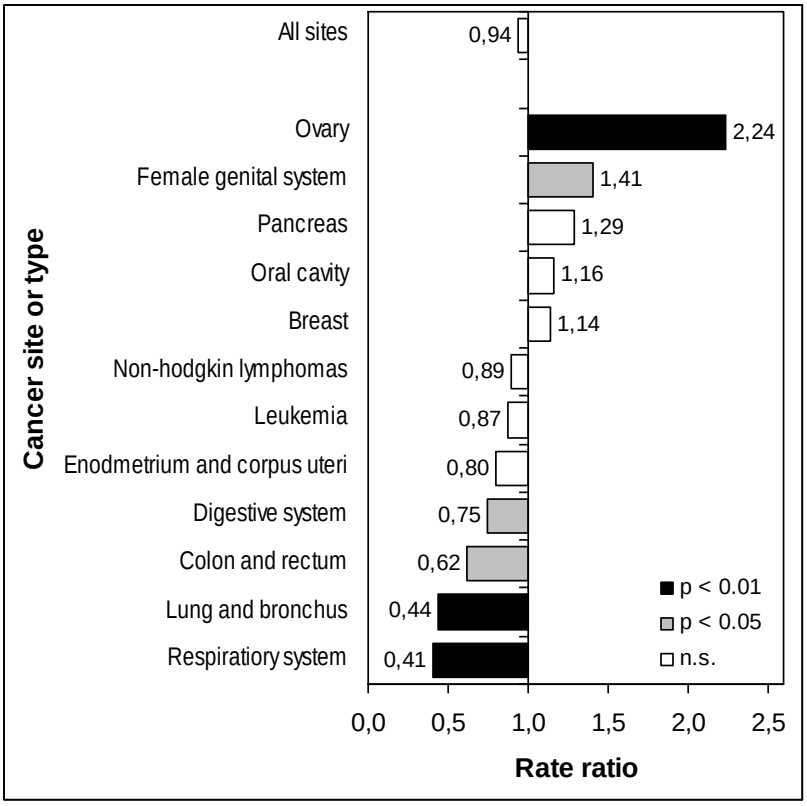

Figure 6 : Rate ratios for Bermuda compared to United States for female (Blacks)

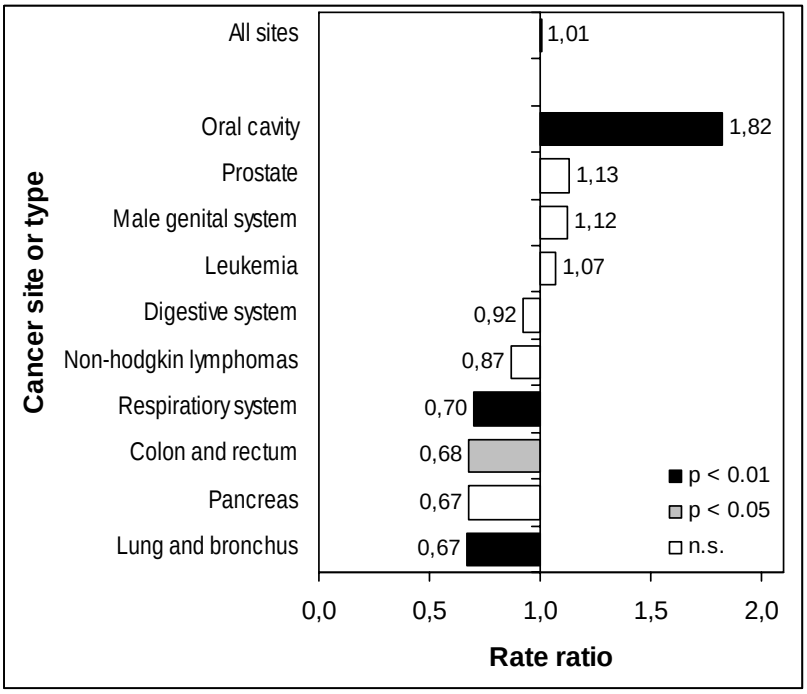

Figure 7 : Rate ratios for Bermuda compared to United States for male (Blacks)

Whites

Figures 8, 9, and 10 show the rate ratios for selected cancer sites in Whites for both sexes, for females, and for males, respectively. The incidence rate of cancer for all sites was significantly higher in Bermuda compared to U.S. (RR = 1.22). Rate ratios for all sites reached statistical significance for females (RRs = 1.35, $p < 0.001$) but not for males (RR = 1.12, $p = 0.07$). Cancer sites that had a significantly higher rate compared to that of the U.S. were oral cavity (RRs = 2.77 for females and 2.48 for males), melanoma (RRs = 2.85 for females and 2.06 for males), colon and rectum in females (RR = 1.77), digestive system in female (RR = 1.51), and breast in females (RR = 1.33). There was no statistically significant lower rates Bermuda compared to the U.S. rates. However, pancreas cancer in males (RR = 0.49, *p*-value = 0.35) and non-Hodgkin lymphoma in males (RR = 0.58, *p*-value = 0.17) had rate ratio quite below 1.0 without reaching statistical significance.

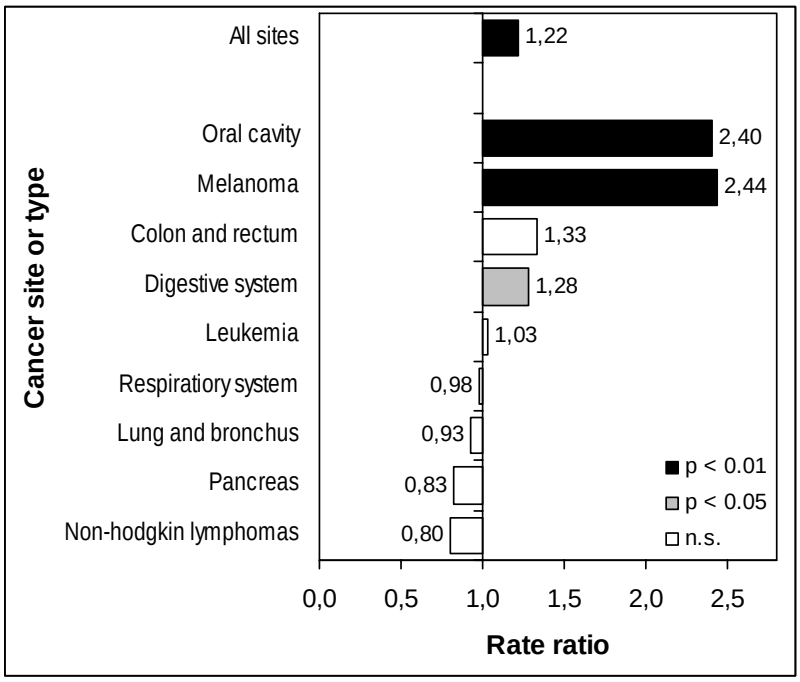

Figure 8 : Rate ratios for Bermuda compared to United States for both sexes (Whites)

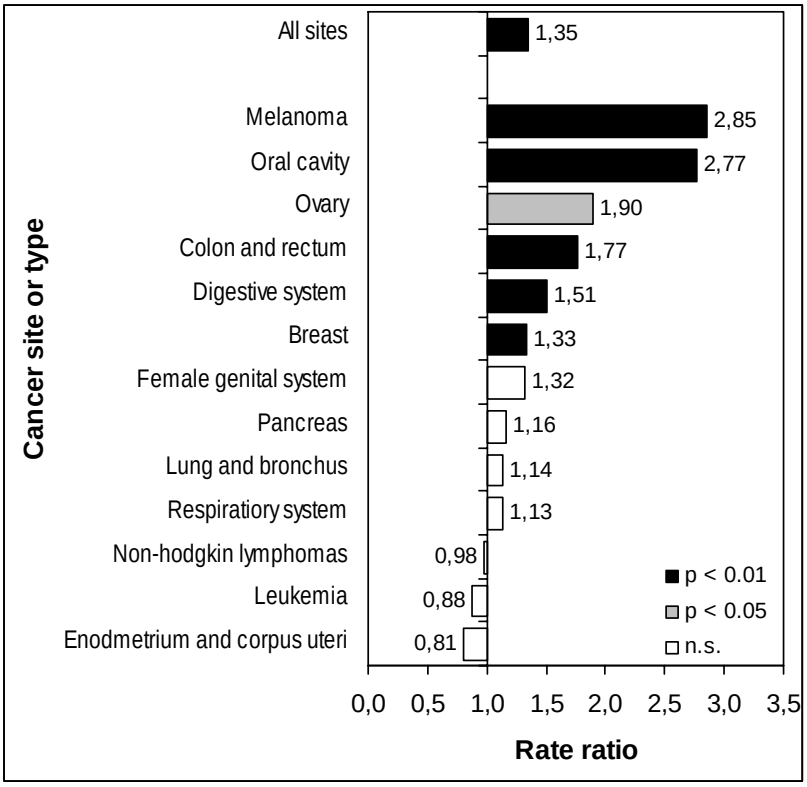

Figure 9 : Rate ratios for Bermuda compared to United States for female (Whites)

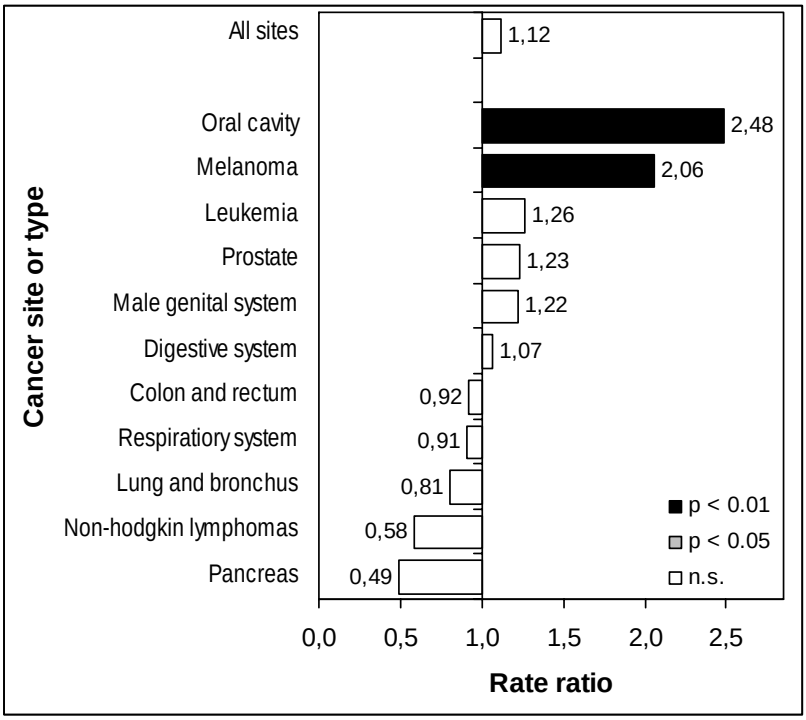

Figure 10 : Rate ratios for Bermuda compared to United States for male (Whites)

Mortality rate

Table 6 shows the crude and age-adjusted mortality rate according to cancer site and sex for 1997-2000. Only cancer sites for which more than 15 deaths occurred in 1997-2000 are shown. The age-adjusted mortality rate for neoplasm's in 1997-2000 was 291.8 deaths per 100 000 persons-years. As in other industrial countries, lung cancer had the highest mortality rate. Figure 11 shows the rate ratio of age-adjusted cancer mortality in Bermuda in 1997-2000 compared to U.S. mortality in 1997-2001. The graph shows that the mortality rates for cancer of the prostate (RR = 2.65), ovary (RR = 1.96), pancreas (RR = 1.83), and breast (RR = 1.82) were higher in Bermuda, compared to United States. Race-specific mortality data in Bermuda were not available at the time these analyses were performed and mortality rates adjusted on race could not be performed. Therefore, these results must be interpreted with caution because important differences in mortality rate exists according to race in the United States. As an example, the RRs for prostate and breast cancers in Blacks compared to White in the U.S. was 2.44 and 1.37 respectively. Overall, in the U.S., the mortality rate for cancer in Blacks was 28% higher than that of Whites. Because the proportion of Blacks is smaller in the U.S. compared to Bermuda (13.7% vs. 54.8% in 2000), cancers with a higher rate in Blacks will be over-represented in Bermuda. Similarly,

cancers less frequent in Blacks, such as non-Hodgkin lymphoma (RR = 0.65 for Blacks compared to Whites), will be under-represented in Bermuda, compared to the Unites States.

Table 6 : Crude and age-adjusted mortality rates of cancer in Bermuda (1997-2000) by primary site and sex (all races)

Cancer site or type	Crude mortality rate (per 100 000 persons-years)			Age-adjusted mortality rate [a] (per 100 000 persons-years)		
	Total	Female	Male	Total	Female	Male
All sites	229.8	207.1	254.3	291.8	234.8	378.9
Colon and rectum	15.1	16.5	13.6	20.6	20.3	21.2
Pancreas	13.5	16.5	10.2	19.3	21.0	15.9
Lung and bronchus	40.4	25.2	56.7	48.5	26.6	81.1
Breast	-	45.7	-	-	49.2	-
Ovary	-	14.9	-	-	17.4	-
Prostate	-	-	49.2	-	-	83.5
Non-hodgkin lymphomas	6.1	6.3	5.9	7.1	7.6	6.5

[a] Age-adjusted to the 2000 United States standard population by 5-year age groups.

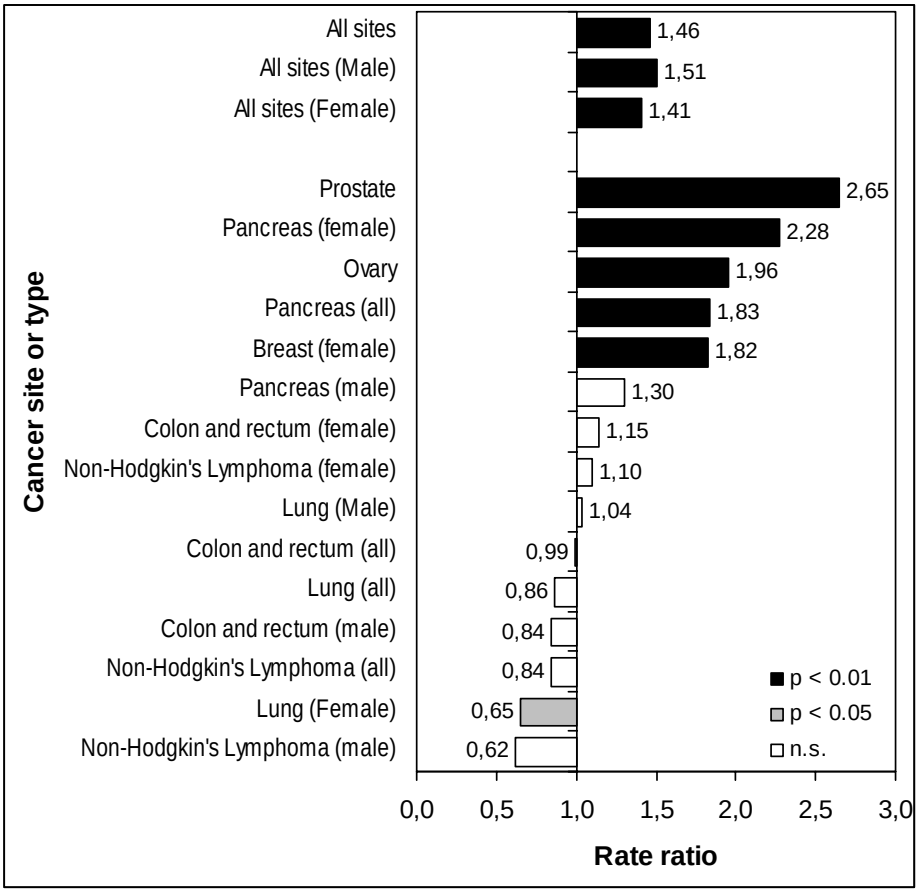

Figure 11 : Mortality rate ratios for Bermuda compared to United States (all races)

Time trends of common cancers

Table 7 shows the annual percent change for the most frequent cancer site between 1991-2003. Figure 12 to 15 shows the incidence rate and time trend according to the year of diagnosis for all sites, breast and prostate cancers, lung cancer, and colorectal cancer, respectively. For all sites, Poisson regression yielded a statistically significant annual increase of 2.7% for females and 2.6% for males. This is in contrast with U.S. figures where rates decreased in American males (1.6% annual decreased) and stayed constant in females between 1992-2001. The trends for specific cancer site must be viewed with caution since the number of cases was relatively small for this type of analysis. A significant increase for prostate cancer and lung cancer in female was found.

Table 7 : Annual percent change for the most frequent cancer sites

Cancer site	Annual percent change	*p*-value
All sites (females)	2.7	< 0.01
All sites (males)	2.6	< 0.01
Breast (females)	1.8	0.10
Prostate	7.7	< 0.01
Lung (females)	12.2	< 0.01
Lung (males)	4.0	0.02
Colon and rectum (females)	6.1	0.06
Colon and rectum (males)	0.1	0.95

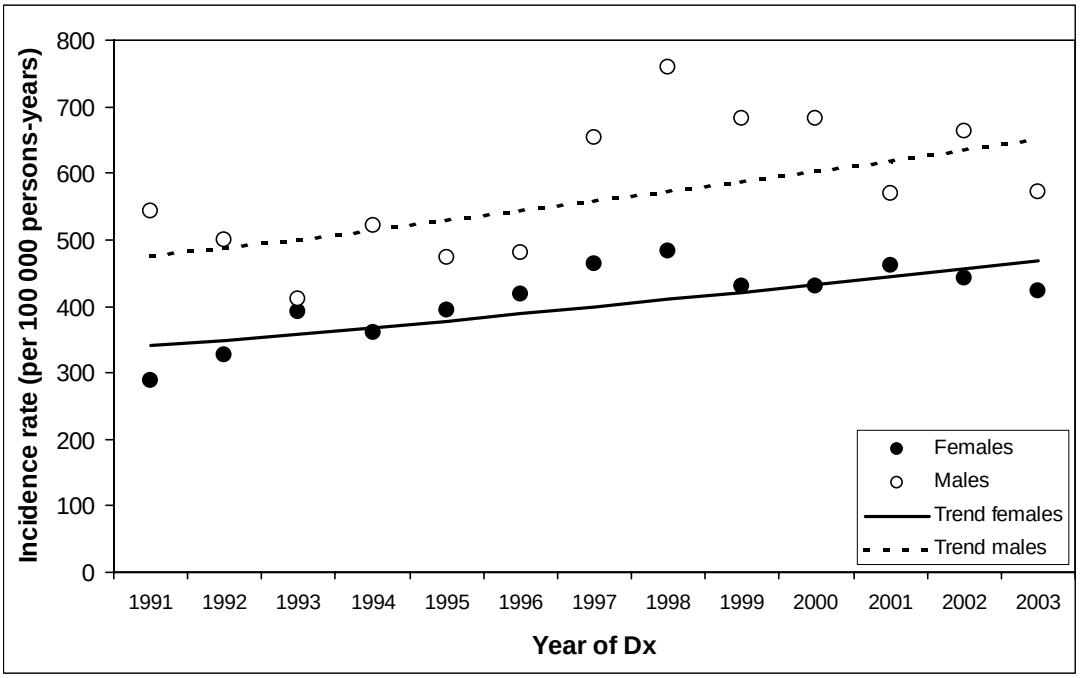

Figure 12 : Time trends for all sites from 1992 to 2003

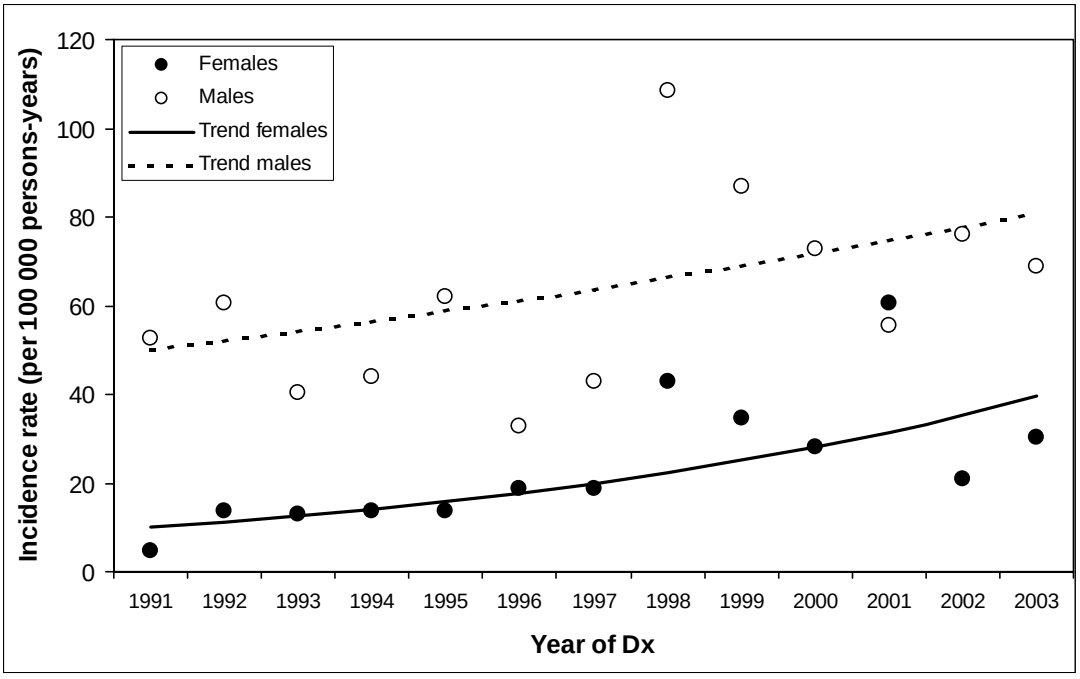

Figure 13 : Time trends for lung cancer from 1992 to 2003

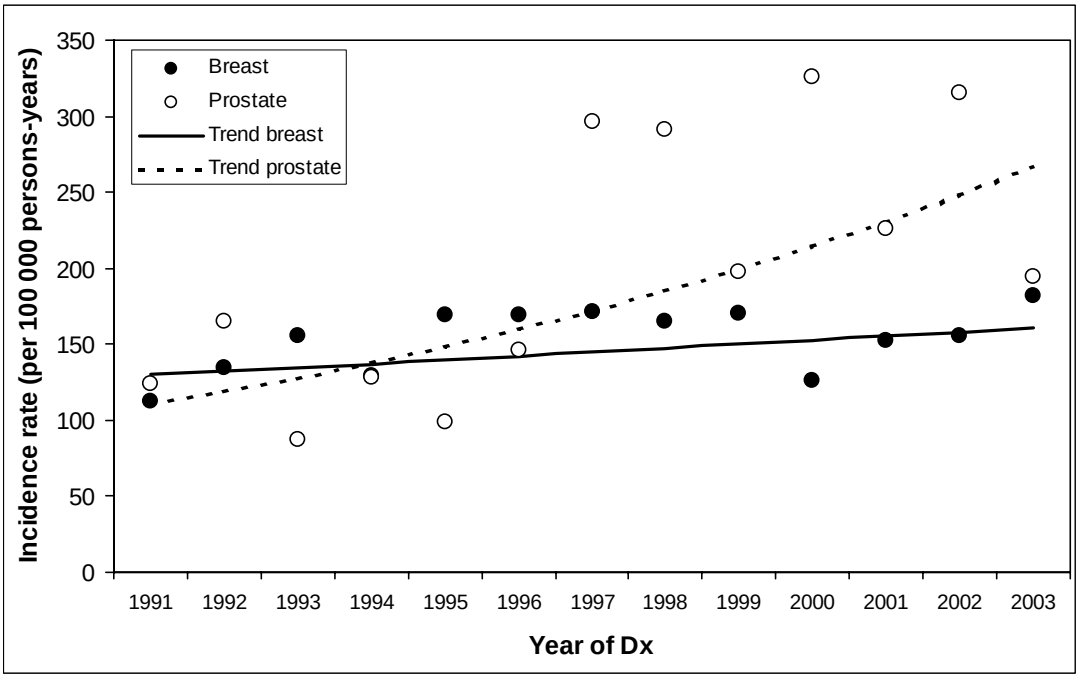

Figure 14 : Time trends for breast and prostate cancers from 1992 to 2003

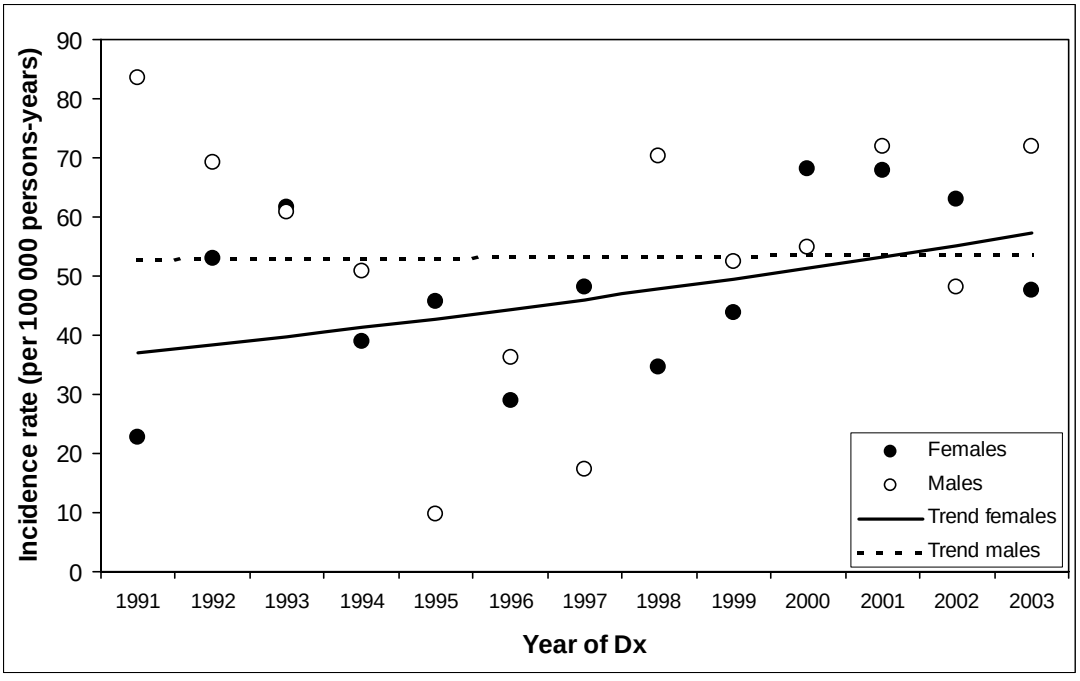

Figure 15 : Time trends for colorectal cancers from 1992 to 2003

4. INTERPRETATION AND DISCUSSION

Valid comparison of age-adjusted rates between two countries requires cancer registries of similar completeness. In this study, we did not assess the procedure used to gather cancer cases in Bermuda. Such an analysis was previously performed in 2001 by a team from the University of Texas Southwestern Medical Center at Dallas (1). The authors concluded that "*overall, the tumor registry in Bermuda can be rated as excellent as compared to registries in the U.S.*". Based on this conclusion, we assumed that the Bermuda registry was comparable with those in the U.S. Access to health care through a more widespread insurance coverage might however be higher in Bermuda. This could account for the increased rate found in Bermuda, or at least shift the diagnoses toward earlier stages. On the other hand, death certificates do not seem to be routinely sent to the oncology department. Such a method is often used in the U.S. to complete registries with cases that could have been missed, often called "death certificate only" cases, or DCO cases. It is possible, although impossible to precisely determine, that the rate in the U.S. could be slightly higher because of systematic screening of DCO cases. Nevertheless, overall, the Bermudian and American registries are expected to be of comparable completeness.

In this study, it was shown that in general, cancer rate were not significantly higher in Bermuda compared to United States, except for white females. However, some cancer sites were shown to be different in the two countries, namely oral cavity, melanoma, breast, ovary, colon and rectum, and lung and bronchus. Table 8 shows the known major risk factors associated with these cancer sites. The following discussion offers some hypotheses for the divergence between Bermuda and United States. However, only well-designed epidemiological studies will help to clarify the factors actually involved in the differences observed between Bermuda and the Unites States.

Table 8 : Known risk and protective factors for cancer site significantly different between Bermuda and the United States

Cancer site	Major risks factors [a]	References
Oral cavity	Tobacco use (smoking and chewing) Alcohol consumption Diet poor in fruits and vegetables	Llewellyn et al., 2004 (5) La Vecchia et al., 1997 (6) Reichart, 2001 (7)
Melanoma	Sun and UV exposure Fair skin High number of nevi Family history	Tucker and Goldstein, 2003 (8) Bataille, 2003 (9) Mancini, 2004 (10)
Colon and rectum	Family history Red meat intake Smoking Alcohol consumption Diet poor in vegetables, fibers, calcium and folate Sedentarity Non-steroidal anti-inflammatory drugs (protective)	Wilmink, 1997 (11) Heavey et al., 2004 (12)
Breast	Family history Early menarche Late menopause Late full-term pregnancy Nulliparity Hormone replacement therapy Diet poor in folate and carotenoids Alcohol consumption	Brekelmans, 2003) (13) Hulka and Moorman, 2001 (14) Stephens, 1999 (15)
Ovary	Family history Low parity Oral contraceptive (protective)	Purdie et al., 2003 (16) Brekelmans, 2003 (13)
Lung and bronchus	Cigarette smoking Second-hand smoke exposure Radon exposure Occupational exposure to several industrial agents Vitamin A, C, E (protective) Diet poor in fruits and vegetables Family history	Bilello et al., 2002 (17) Ernster, 1996 (18) Hackshaw et al., 1997 (19) Osann, 1998 (20)

[a] Factors are listed in no particular order

The most striking difference between rates in Bermuda and United States was undoubtedly for oral cavity cancers. Only black females did not have a statistically significant rate ratio. The increased rate in Bermuda was mostly due to tongue, salivary gland, floor of mouth, and tonsil cancers. The most recognized risk factors for oral cavity cancers are tobacco use (smoking and chewing), alcohol consumption, and a diet poor in fruits and vegetables. A higher rate of exposure to smoke (first-hand or second-hand) in Bermuda seems unlikely because rate of lung cancer was

found to be lower in Bermuda. Differences in diet and/or alcohol consumption (quantity or type of liquor) might be involved.

As for other cancer sites, effective preventive measures for oral cavity cancer are first based on a reduction of avoidable risk factors. Primary prevention can be achieved by promoting non-smoking, non-drinking and healthy diet, both at the community and clinical levels. Proactive screening of at-risk populations (smokers and drinkers) has been reported to be effective and could help identify tumors at an earlier stage. In any case, routine examination of oral soft tissue remains advisable (7).

As expected, rate of melanoma was higher in Bermuda. The analysis was conducted only for Whites because very few cancer cases were found in Blacks. Exposure to UV rays is likely higher in Bermuda compared to United States and could explain most of the difference observed. As suggested by Tucker and Goldstein, "*the largest public health benefit is likely to come from enhanced sun and UV education and protection programs, both for children and adults*" (8). To that, it could be added that UV protection is especially important during childhood and for at-risk populations such as white and fair-skinned people with multiple nevi (8, 10).

Hormonal cancer rates in females were higher in Bermuda, but the patterns differ between Blacks and Whites. Ovarian cancer were higher in both races, but reached statistical significance only in Blacks. Breast cancer was significantly higher in Whites, but not in Blacks. Low parity and late first pregnancy, two factors that are usually associated with higher socioeconomic status, are risk factors for hormonal cancer in women. Because the socioeconomic status in Bermuda is generally higher compared to United States, it could explain part of the difference observed. In the case of breast cancer, a better rate of diagnosis following an aggressive screening program in Bermuda could also be involved.

Modifiable risk factors for primary prevention of hormonal cancer in women include physical exercise and abstinence from alcohol and cigarettes. Although the link between these factors and hormonal cancer is sometimes weak or unclear, their avoidance "*is advisable as it might also decrease the risk of a number of other diseases, such as other cancer type and cardiovascular diseases*" (13). Of course, aggressive screening by promoting self-examination and regular mammography remains crucial.

White female had a significantly higher rate of colorectal cancer, while the rate was similar in white males and lower in blacks. We found this result puzzling. Besides distinctive diet, a higher rate of smoking compared to Blacks, reflected by the higher rate of lung cancer, could be involved. Differences in alcohol consumption could also play a role, which would be consistent with the higher rate of oral cancer.

The rate of lung cancer was similar in Whites, but significantly lower in Blacks. The most important risk factors for lung cancer is cigarette smoking. Rates of smoking could be lower in Bermudian Blacks compared to American Blacks. A lower exposure to industrial carcinogens might also be involved.

Cancer mortality rate is significantly higher in Bermuda compared to that in the Unites States. As stated in the results section, race-specific mortality rate could not be calculated. It should therefore be kept in mind that the mortality rate ratio could be (and are most likely) severely biased by the confounding effect of race. That being said, some site-specific mortality rate ratio seem higher than what could be expected, even when one considers the race bias. Therefore, it is suggested that further studies are initiated concerning the mortality rate for prostate, pancreas, ovary and breast cancer. In particular, it should be addressed whether the increased mortality rate is compatible with the increased diagnosis rate, and whether these cancer sites are diagnosed at later stages in Bermuda, as compared to the Unites States.

Time trend analysis has shown a statistically significant increased cancer rate since 1991. This is in contrast with United States. Although statistically significant, an ACP of 2.6-2.7 % in a population such as Bermuda's represents an increase of 5 to 10 cases annually. Such an increase could be due to several factors, including better screening or the arrival of new specialist physicians on the Island, which would both increase the rate of diagnosis for several years. Nevertheless, the increase in cancer rate should remain closely monitored.

5. ACKNOWLEDGMENTS

We thank Margo Rego (Bermuda Tumor Registry) and Lise Outerbridge (Department of Health) for providing data on Bermuda cancer cases and mortality, Melinda Williams and Vincent William-Savery (Statistics Department) for the data on Bermuda census and population projections, the Bermuda Biological Station for Research for help on stay and travel logistics, Cynthia Cameron for literature review on cancer risk factors, XL Foundation for the funding of this project, and John Cann (Bermuda Chief Medical Officer).

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