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Cancer Incidence in New York State Acquired Immunodeficiency Syndrome Patients

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To identify cancers that occur at higher rates in acquired immunodeficiency syndrome (AIDS) patients, the cancer experience of New York State (NYS) AIDS patients aged 15–69 years who were diagnosed between 1981 and 1994 was compared with that of the NYS general population. Sex and HIV risk group-specific standardized incidence ratios (SIRs), post-AIDS relative risks, and trends of relative risks were calculated to determine cancer risk. Among non-AIDS-related cancers, elevated SIRs were found for Hodgkin's disease (male, 8.0; female, 6.4; heterosexually infected males, 31.3); cancer of the rectum, rectosigmoid, and anus (male, 3.3; female, 3.0); trachea, bronchus, and lung (male, 3.3; female, 7.5); and brain and central nervous system (male, 3.1; female, 3.4; heterosexually infected females, 23.8) cancers. Moreover, significant trends of increasing relative risks from the pre-AIDS to the post-AIDS period were found for cancers of the rectum, rectosigmoid, and anus; trachea, bronchus, and lung; skin; and connective tissues (all sites, $p < 0.05$) among males. For AIDS-related cancers in women, invasive cervical cancer had an overall SIR of 9.1 (95% confidence interval: 6.9, 10.8) and a post-AIDS relative risk of 6.5 (95% confidence interval: 4.1, 9.7). This population-based registry linkage analysis evaluates cancer risk in AIDS patients by sex and risk factors and adds evidence that HIV-associated immunosuppression increases the risks of specific types of cancer. *Am J Epidemiol* 2001;154:544–56.

acquired immunodeficiency syndrome; HIV; lymphoma, AIDS-related; lung neoplasms; registries; risk factors

Cancer incidence in acquired immunodeficiency syndrome (AIDS) patients has been evaluated by population-based registry linkage analysis in the Unites States (1–3), Italy (4), and Australia (5). Cancer incidence has also been evaluated by using clinical trial cohorts and small case series. These studies have identified an increased incidence of specific types of malignant disease in patients with human immunodeficiency virus (HIV) infection. Kaposi's sarcoma, non-Hodgkin's lymphoma (NHL), and invasive cervical cancer have been designated as AIDS-related cancers (6). However, there is a lack of consistency in reported elevated risks for other HIV-associated malignancies (7–17). In addition, current analysis of linked data has focused on overall measures of association, not on stratifying by gender or known risk factors, leading to an incomplete assessment of cancer risk for different groups of AIDS patients. New York State (NYS) is the epicenter for the AIDS epidemic in the United States, with the largest number of AIDS cases of any state for both adults and children. NYS adult AIDS patients represent approximately 19 percent of all cases in the United States. An examination of data from NYS provides a unique opportunity to explore the role of immune system deficiency in cancer expression in which HIV prevalence is high. With the improved survival of patients with HIV infection because of better prevention and treatment of infectious complications and the development of more effective antiretroviral therapies, there may be an increase in malignant tumors and, in particular, those nondiagnostic of AIDS (13–17). It is difficult to predict the magnitude of change to cancer incidence in this population, and it will become increasingly important to know more about the risk of cancer in these patients.

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Abbreviations: AIDS, acquired immunodeficiency syndrome; CNS, central nervous system; HIV, human immunodeficiency virus; IDU, injection drug user; MSM, men who have sex with men; NHL, non-Hodgkin's lymphoma; NYS, New York State; RR, relative risk; SIR, standardized incidence ratio.

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MATERIALS AND METHODS

Linkage procedure

To evaluate the risk of cancer among AIDS patients in NYS, we compared patients' cancer experience with that of the general population of NYS by matching the population-based NYS Cancer Registry with the combined NYS and New York City AIDS registries. A probabilistic algorithm was used to match name, birth date, and, when available, Social Security numbers between the AIDS and cancer registries. All cases of AIDS and cancer diagnosed between

1981 and 1994 were matched. Commercial matching software (18) was used by Oak Ridge National Laboratory staff to conduct the match as part of the National Cancer Institute's multistate AIDS/cancer match project.

Subjects and coding

Analysis of cancer incidence was restricted to AIDS and cancer cases diagnosed between 1981 and 1994 because these were the date ranges that were available. NYS residents aged 15–69 years were abstracted from the matched data set. Malignant disorders were grouped into types or sites of cancer by using the *International Classification of Diseases,* Ninth Revision codes (19). Although 57 separate sites or types of cancer were identified, analysis was limited to cancers with frequencies of four or more. Cancers were classified as AIDS defining if they were included in the 1993 AIDS case definition (6) or as non-AIDS defining if they were invasive malignancies not included in the AIDS case definition. Noninvasive neoplasms (*International Classification of Diseases,* Ninth Revision, codes 210–234) are also presented, although they are underreported to the cancer registry, and the results may be attenuated.

Data analysis

This study was limited to cancers diagnosed between 60 months before and 60 months after an AIDS diagnosis. This time interval was selected to make our results comparable with those of other published studies. The time interval before AIDS was also selected because there is evidence that the median duration of HIV infection before AIDS is at least 5 years (20–22). While cancers that occur in a patient prior to AIDS are, strictly speaking, HIV, not AIDS, related, we denote this period prior to an AIDS diagnosis as the pre-AIDS period. For the post-AIDS period, the median duration of survival post-AIDS diagnosis has been reported within the range of 3–26 (21) and 2–22 months (23). While these findings indicate that a short post-AIDS follow-up period may be sufficient to capture the majority of cancers that occur in AIDS patients after AIDS diagnosis, we have chosen to use an extended post-AIDS period to capture as many observations of cancer as possible in this time interval. Examining the NYS data, we found a small number of cancers occurring up to 5 years after AIDS diagnosis, and we chose to include these observations in the analysis. The calculation of person-time for the period at risk for cancer was defined as beginning in 1981 or 5 years prior to an AIDS diagnosis, whichever occurred later, and ending 5 years post-AIDS diagnosis, at the date of death, or on December 31, 1994, whichever occurred earliest. The observed number of cancers by type or site among people with AIDS was compared with the expected number of cases by calculating standardized incidence ratios (SIRs). Expected incident cases at the time of AIDS diagnosis or after AIDS diagnosis were calculated by multiplying NYS age-, sex-, region-, and race-specific cancer incidence rates from the NYS Cancer Registry by the corresponding person-years at risk for these time periods. However, calculation of the expected number of cancer cases preceding AIDS was complicated because HIV-infected subjects who develop cancer might die before progression to AIDS and therefore would never be recorded in the AIDS registry. In our study, the cohort that was matched to the cancer registry was diagnosed with AIDS; therefore, they survived until AIDS diagnosis. All of the cancer cases observed in this cohort diagnosed before AIDS survived to an AIDS diagnosis. Since the observed cancer cases survived until AIDS diagnosis, the expected cancer cases must be adjusted to reflect survival to AIDS diagnosis. Therefore, the joint probability of developing cancer and of surviving cancer was applied to the person-year distribution, and NYS cancer incidence rates and Surveillance, Epidemiology, and End Results differential survival rates for specific malignancies were used to calculate the expected number of cancer cases prior to AIDS diagnosis (24). All SIRs discussed in the results are adjusted. To calculate confidence intervals around the SIR, either the normal or the Poisson distribution was used, depending on the number of expected cases. If the number of expected cases was equal to or greater than 25, the normal distribution was used; otherwise, the Poisson distribution was used.

For determination of whether cancer risk increases with time, as the immune status of the HIV-infected patient declines, the time period between a cancer and AIDS diagnosis was divided into four intervals: early pre-AIDS diagnosis (–60 to –25 months), late pre-AIDS diagnosis (–24 to –7 months), at AIDS diagnosis (–6 to 3 months), and post-AIDS diagnosis (4–60 months) (figure 1). The trend in relative risk was analyzed over three time periods (the at AIDS time period was excluded) by using the Poisson trend statistic (25).

In this study, a non-AIDS-related cancer is considered to be AIDS related when the overall SIR for the period from 60 months before to 60 months after AIDS diagnosis is statistically significantly elevated and there is a statistically significant increasing trend in relative risks from the pre-AIDS to the post-AIDS period.

To explore the association between risk factors and malignant disease, SIRs were calculated for groups defined by HIV exposure group (men who have sex with men (MSM) combined with MSM and intravenous drug user (IDU), heterosexual contact with HIV/AIDS patients, IDUs, patients infected via transfusion or transplantation, and unknown or other HIV exposure).

All statistical analyses were performed by using the Statistical Analysis System (26).

RESULTS

Overall, 12,698 instances of cancer among 122,993 people with AIDS were identified through linkage of the AIDS and cancer registries. There were 11,371 cancers with diagnosis dates within 60 months before and 60 months after an AIDS diagnosis. The characteristics of the study cohort are displayed in table 1. Of the 11,371 persons with cancer in this cohort, 82.0 percent were NYC residents, 18.0 percent were Upstate New York residents, 88.7 percent were men, and 11.3 percent were women. Among 10,083 men with

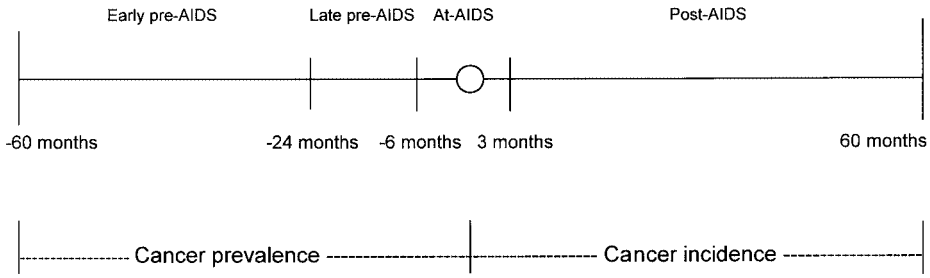

FIGURE 1. The period of 120 months during which cancer risk was assessed among people with acquired immunodeficiency syndrome (AIDS) in New York State, 1981–1994. Population-based AIDS and cancer registries were linked to identify people with AIDS who had ever had cancer reported to the cancer registry. The month of initial AIDS-related disease was defined as month +1 (○). Cancer prevalence and incidence rates among people with AIDS were compared with those expected to have occurred among people of the same age, race, and sex distribution as people with AIDS.

AIDS, 84.6 percent were diagnosed with AIDS between ages 25–49 years, 77.9 percent were non-Black, 22.1 percent were Black, 76.6 percent were MSM or MSM combined with IDUs, and 17.7 percent were IDUs. Of the 1,288 women with AIDS, 86.1 percent were diagnosed with AIDS between ages 25–49 years, 55.2 percent were non-Black, 44.8 percent were Black, 53.8 percent were IDUs, and 31.5 percent were women who had heterosexual contact. There were a total of 567,254 person-years at risk for cancer—453,270 for men and 113,984 for women.

TABLE 1. Demographic characteristics and route of human immunodeficiency virus acquisition among patients aged 15–69 years in the acquired immunodeficiency syndrome/cancer matched cohort, New York State, 1981–1994

Characteristic	Men		Women	
	No. of cases	%	No. of cases	%
Region				
New York City	8,265	82.0	1,059	82.2
Upstate	1,818	18.0	229	17.8
All	10,083	100	1,288	100
Racial group				
Non-Blacks	7,858	77.9	711	55.2
Blacks	2,225	22.1	577	44.8
Age at AIDS* diagnosis (years)				
15–19	10	0.1	6	0.5
20–24	238	2.4	54	4.2
25–29	1,172	11.6	167	13.0
30–34	2,178	21.6	327	25.4
35–39	2,318	23.0	280	21.7
40–44	1,721	17.1	234	18.2
45–49	1,145	11.4	101	7.8
50–54	659	6.5	46	3.6
54–59	371	3.7	36	2.8
60–64	188	1.9	20	1.6
65–69	83	0.8	17	1.3
Route of HIV* acquisition				
Homosexual contact	7,733	76.6		
Intravenous drug user	1,783	17.7	692	53.8
Heterosexual contact	87	0.9	406	31.5
Transfusion or transplantation	46	0.5	30	2.3
Unknown or others	434	4.3	160	12.4

* AIDS, acquired immunodeficiency syndrome; HIV, human immunodeficiency virus.

AIDS-related cancers and overall SIRs

Compared with incidence in the NYS general population, the incidence of Kaposi's sarcoma was increased 97.5-fold in men and 202.7-fold in women. The risk of NHL was increased 37.4-fold in men and 54.6-fold in women. Invasive cervical cancer was increased 9.1-fold (tables 2 and 3).

AIDS-related cancers and post-AIDS relative risks

The incidence of Kaposi's sarcoma was increased 86.3-fold in men and 266.2-fold in women. The risk of NHL was increased 48.6-fold in men and 96.3-fold in women. Invasive cervical cancer was increased 6.5-fold (table 4).

Non-AIDS-related cancers and overall SIRs

For all non-AIDS-related cancers combined, the SIR was 2.6 for men and 2.2 for women, and significantly elevated SIRs were found for several sites and types of cancer in both men and women (tables 2 and 3). Cancers with significant SIRs were tongue (male, 1.8; female 7.1); gum and other mouth (male, 1.9; female, 11.1); rectum, rectosigmoid, and anus (male, 3.3; female, 3.0); larynx (male, 1.9; female, 5.9); trachea, bronchus, and lung (male, 3.3; female, 7.5); skin, excluding Kaposi's sarcoma (male, 20.9; female, 7.5); brain and central nervous system (CNS) (male, 3.1; female, 3.4); Hodgkin's disease (male, 8.0; female, 6.4); and multiple myeloma (male, 2.7; female, 7.2). We also found signif-

TABLE 2. Observed and expected cancer cases and standardized incidence ratios of specific types of cancer among men with acquired immunodeficiency syndrome aged 15–69 years in the acquired immunodeficiency/cancer matched cohort, New York State, 1981–1994

Type of cancer (ICD-9* code)	Observed cases	Adjusted for differential survival			Unadjusted		
		Expected cases	SIR*	95% CI*	Expected cases	SIR	95% CI
Kaposi's sarcoma (176)	5,583	57.3	97.5	94.95, 100.08	104.7	53.4	51.96, 54.76
Non-Hodgkin's lymphoma (200, 202)	2,434	65.0	37.4	35.97, 38.96	86.6	28.1	26.99, 29.23
Non-AIDS* related cancers							
Tongue (141)	17	9.3	1.8	1.07, 2.93	12.8	1.3	0.78, 2.13
Gum, other mouth (143–145)	20	10.6	1.9	1.15, 2.91	13.8	1.5	0.89, 2.24
Pharynx (146–148)	28	13.9	2.0	1.34, 2.91	19.7	1.4	0.95, 2.06
Esophagus (150)	7	9.4	0.7	0.30, 1.53	19.2	0.4	0.15, 0.75
Stomach (151)	25	14.3	1.8	1.13, 2.59	25.8	1.0	0.63, 1.43
Colon (153)	32	38.2	0.8	0.57, 1.18	47.7	0.7	0.46, 0.95
Rectum, rectosigmoid, and anus (154)	75	22.7	3.3	2.60, 4.15	28.1	2.7	2.10, 3.35
Liver, primary only (155)	36	7.1	5.1	3.57, 7.07	15.9	2.3	1.59, 3.14
Pancreas (157)	12	7.4	1.6	0.84, 2.83	17.5	0.7	0.35, 1.20
Larynx (161)	37	20.0	1.9	1.31, 2.56	23.7	1.6	1.10, 2.16
Trachea, bronchus, and lung (162)	217	66.1	3.3	2.86, 3.75	129.2	1.7	1.46, 1.92
Pleura, mediastinum, other respiratory (163–165)	8	3.0	2.7	1.15, 5.25	4.5	1.8	0.77, 3.50
Melanoma of the skin (172)	24	17.3	1.4	0.89, 2.06	18.9	1.3	0.81, 1.89
Skin, excluding Kaposi's sarcoma (173)	133	6.4	20.9	15.86, 24.76	6.7	19.8	15.04, 23.46
Prostate gland (185)	37	53.7	0.7	0.48, 0.95	58.2	0.6	0.45, 0.88
Testis (186)	38	25.6	1.5	1.05, 2.03	26.6	1.4	1.01, 1.96
Kidney and unspecified urinary (189)	18	18.0	1.0	0.59, 1.58	22.8	0.8	0.47, 1.25
Bladder (188)	11	24.3	0.5	0.23, 0.81	26.7	0.4	0.21, 0.74
Brain and CNS* (191–192)	42	13.4	3.1	2.26, 4.24	22.3	1.9	1.36, 2.55
Endocrine gland (194)	5	1.3	3.8	1.25, 8.97	1.7	2.9	0.95, 6.83
Connective tissue (164.1, 171)	50	9.0	5.6	4.13, 7.34	10.9	4.6	3.40, 6.03
Hodgkin's disease (201)	160	20.0	8.0	5.05, 9.33	22.5	7.1	4.49, 8.31
Multiple myeloma and immunoproliferative (203)	18	6.8	2.7	1.57, 4.19	9.4	1.9	1.14, 3.04
Leukemias (204–208)	23	16.6	1.4	0.88, 2.07	23.8	1.0	0.61, 1.45
All non-AIDS cancers†	1,279	501.2	2.6	2.41, 2.70	683.3	1.9	1.77, 1.98
Noninvasive neoplasms							
Other, in situ (230–234)	33	NA	NA	NA	7.7	4.3	2.97, 6.05
Benign (210–229)	12	NA	NA	NA	9.1	1.3	0.68, 2.29
Uncertain behavior and unspecified nature (235–239)	160	NA	NA	NA	8.9	18.1	11.41, 21.10

* ICD-9, *International Classification of Diseases*, Ninth Revision; SIR, standardized incidence ratio; CI, confidence interval; AIDS, acquired immunodeficiency syndrome; CNS, central nervous system.

† Including those malignancies not shown above.

TABLE 3. Observed and expected cancer cases and standardized incidence ratios of specific types of cancer in women with acquired immunodeficiency syndrome aged 15–69 years in the acquired immunodeficiency/cancer matched cohort, New York State, 1981–1994

Type of cancer (ICD-9* code)	Observed cases	Adjusted for differential survival			Unadjusted		
		Expected cases	SIR*	95% CI*	Expected cases	SIR	95% CI
Kaposi's sarcoma (176)	200	1.0	202.7	102.36, 232.79	1.3	149.2	75.37, 171.40
Non-Hodgkin's lymphoma (200, 202)	342	6.3	54.6	16.13, 60.72	7.6	44.8	13.24, 49.86
Cervix, invasive (180)	133	14.7	9.1	6.90, 10.76	16.8	7.9	6.00, 9.36
Non-AIDS*-related cancers							
Tongue (141)	5	0.7	7.1	2.30, 16.53	0.9	5.6	1.81, 13.04
Gum, other mouth (143–145)	10	0.9	11.1	5.32, 20.42	1.1	9.4	4.52, 17.35
Esophagus (150)	5	0.6	8.7	2.81, 20.22	1.2	4.4	1.41, 10.15
Stomach (151)	4	1.6	2.6	0.70, 6.54	2.6	1.6	0.42, 3.97
Colon (153)	5	6.3	0.8	0.26, 1.86	7.9	0.6	0.21, 1.49
Rectum, rectosigmoid, and anus (154)	9	3.0	3.0	1.39, 5.77	3.5	2.5	1.16, 4.82
Larynx (161)	7	1.2	5.9	2.36, 12.11	1.4	4.9	1.95, 10.02
Trachea, bronchus, and lung (162)	50	6.7	7.5	5.57, 9.90	12.1	4.1	3.06, 5.44
Skin, excluding Kaposi's sarcoma (173)	8	1.1	7.5	3.23, 14.77	1.1	7.3	3.16, 14.44
Female breast (174)	47	59.9	0.8	0.58, 1.04	64.4	0.7	0.54, 0.97
Corpus uteri (182)	5	6.1	0.8	0.26, 1.90	6.6	0.8	0.25, 1.77
Ovary, fallopian tubes (183)	6	7.8	0.8	0.28, 1.67	10.0	0.6	0.22, 1.30
Kidney and unspecified urinary (189)	4	2.2	1.9	0.50, 4.74	2.7	1.5	0.40, 3.89
Brain and CNS* (191–192)	7	2.0	3.4	1.38, 7.05	3.3	2.1	0.86, 4.39
Thyroid gland (193)	5	6.3	0.8	0.26, 1.84	6.5	0.8	0.25, 1.81
Hodgkin's disease (201)	20	3.1	6.4	3.91, 9.90	3.4	6.0	3.65, 9.22
Multiple myeloma and immunoproliferative (203)	8	1.1	7.2	3.11, 14.21	1.5	5.3	2.31, 10.52
Leukemias (204–208)	16	2.6	6.1	3.48, 9.88	3.8	4.2	2.40, 6.82
All non-AIDS cancers†	290	131.1	2.2	1.96, 2.48	159.4	1.8	1.62, 2.04
Noninvasive neoplasms							
Cervix, in situ (233.1)	240	NA	NA	NA	45.8	5.2	4.60, 5.90
Other, in situ (230–234)	13	NA	NA	NA	7.3	1.8	0.95, 3.04
Uncertain behavior and unspecified nature (235–239)	21	NA	NA	NA	1.3	16.7	10.31, 25.45

* ICD-9, *International Classification of Diseases*, Ninth Revision; SIR, standardized incidence ratio; CI, confidence interval; AIDS, acquired immunodeficiency syndrome; CNS, central nervous system.
† Including those malignancies not shown above.

icantly elevated SIRs for the pharynx (2.0), stomach (1.8), liver (5.1), testis (1.5), endocrine gland (3.8), and connective tissue (5.6) in men and for the esophagus (8.7) and leukemias (6.1) in women.

Non-AIDS-related cancers and post-AIDS relative risks

For all non-AIDS-related cancers combined, the relative risk was 3.1 for men and 2.9 for women, and significantly elevated relative risks were found for several sites and types of cancer in both men and women (table 4). Cancers with significant relative risks for men and women were liver (relative risk (RR) = 3.6 and 9.2, respectively); trachea, bronchus, and lung (RR = 3.0 and 7.1, respectively); skin, excluding Kaposi's sarcoma (RR = 44.6 and 12.0, respectively); brain and CNS (RR = 4.0 and 6.2, respectively); Hodgkin's disease (RR = 5.3 and 7.2, respectively); and multiple myeloma (RR = 3.5 and 9.2, respectively). We also found significantly elevated relative risks for the rectum, rectosigmoid, and anus (RR = 4.0) and connective tissue (RR = 9.9) in men and for gum and other mouth (RR = 13.5), esophagus (RR = 8.7), stomach (RR = 5.4), larynx (RR = 10.6), and leukemias (RR = 5.2) in women.

Non-AIDS-related cancers and relative risk trend

Significant increases in relative risk over time were found for several sites in men and women. For some of the sites with significant trends, the changes in relative risks over time were not linear. For men, cancers with significant trends were digestive system ($p = 0.002$); Hodgkin's disease ($p = 0.0135$); rectum, rectosigmoid, and anus ($p = 0.0164$); trachea, bronchus, and lung ($p = 0.0046$); brain and CNS ($p = 0.0018$); melanoma of the skin ($p = 0.0478$); skin, excluding Kaposi's sarcoma ($p < 0.0000$); leukemias ($p = 0.0087$); and connective tissue cancers ($p < 0.0000$)

TABLE 4. Observed and expected cancer cases and relative risks of specific types of cancer after acquired immunodeficiency syndrome diagnosis in the acquired immunodeficiency syndrome/cancer matched cohort, New York State, 1981–1994

Type of cancer (ICD-9* code)	Men			Women		
	Observed/ expected cases	RR*	95% CI*	Observed/ expected cases	RR	95% CI
Kaposi's sarcoma (176)	1,911/22.1	86.3	4.56, 45.22	83/0.3	266.2	212.06, 330.05
Non-Hodgkin's lymphoma (200, 202)	990/20.4	48.6	4.95, 49.09	159/1.7	96.3	61.16, 112.46
Cervix, invasive (180)	NA*	NA	NA	23/3.6	6.5	4.09, 9.69
Non-AIDS* related cancers						
Tongue (141)	3/2.8	1.1	0.22, 3.18	1/0.2	5.3	0.13, 29.42
Gum, other mouth (143–145)	4/2.9	1.4	0.37, 3.52	3/0.2	13.5	2.78, 39.43
Pharynx (146–148)	8/4.5	1.8	0.77, 3.54	2/0.3	7.8	0.94, 28.18
Esophagus (150)	3/4.1	0.7	0.15, 2.15	2/0.2	8.7	1.05, 31.34
Stomach (151)	10/5.8	1.7	0.83, 3.19	3/0.6	5.4	1.11, 15.72
Colon (153)	9/10.2	0.9	0.40, 1.67	0/1.6		
Rectum, rectosigmoid, and anus (154)	24/6.0	4.0	2.57, 5.97	3/0.7	4.2	0.86, 12.17
Liver, primary only (155)	14/3.9	3.6	1.99, 6.10	2/0.2	9.2	1.11, 33.23
Pancreas (157)	3/3.8	0.8	0.16, 2.31	2/0.4	4.8	0.58, 17.41
Larynx (161)	10/5.0	2.0	0.95, 3.65	3/0.3	10.6	2.19, 31.04
Trachea, bronchus, and lung (162)	83/27.9	3.0	2.37, 3.69	18/2.5	7.1	4.21, 11.22
Melanoma of the skin (172)	6/3.9	1.6	0.57, 3.38	0/0.5		
Skin, excluding Kaposi's sarcoma (173)	78/1.8	44.6	35.25, 55.66	3/0.3	12.0	2.47, 35.09
Female breast (174)	NA	NA	NA	3/14.0	0.2	0.04, 0.63
Prostate gland (185)	12/14.7	0.8	0.42, 1.42	NA	NA	NA
Testis (186)	3/5.0	0.6	0.12, 1.76	NA	NA	NA
Kidney and unspecified Urinary (189)	0/5.3			1/0.6	1.7	0.04, 9.38
Brain and CNS* (191–192)	19/4.7	4.0	2.42, 6.26	4/0.7	6.2	1.68, 15.79
Connective tissue (171, 164.1)	22/2.2	9.9	6.18, 14.93	0/0.4		
Hodgkin's disease (201)	21/4.0	5.3	3.29, 8.12	4/0.6	7.2	1.96, 18.39
Multiple myeloma and immuno-proliferative (203)	7/2.0	3.5	1.39, 7.11	3/0.3	9.2	1.89, 26.85
Leukemias (204–208)	9/4.9	1.8	0.83, 3.46	4/0.8	5.2	1.40, 13.20
All non-AIDS cancers†	456/148.3	3.1	2.80, 3.37	97/33.6	2.9	2.34, 3.52
Noninvasive neoplasms						
Other, in situ (230–234)	8/1.9	4.2	1.81, 8.28	4/1.8	2.2	0.60, 5.68
Cervix, in situ (233.1)	NA	NA	NA	66/7.7	8.6	6.67, 10.97
Benign (210–229)	5/1.9	2.6	0.84, 6.05	NA	NA	NA
Uncertain behavior and unspecified nature (235–239)	118/2.0	60.3	49.91, 72.22	17/0.2	81.1	47.25, 129.88

* ICD-9, *International Classification of Diseases*, Ninth Revision; RR, relative risk; CI, confidence interval; NA, not applicable; AIDS, acquired immunodeficiency syndrome; CNS, central nervous system.
† Including those malignancies not shown above.

(table 5). The only site of non-AIDS-related cancer found to increase significantly over time in women was the digestive system ($p = 0.0176$) (table 6).

Noninvasive, non-AIDS-related cancers, overall SIRs, post-AIDS relative risks, and relative risk trend

Men had a significantly elevated SIR for other in situ neoplasms (SIR = 4.3) (table 2) and a post-AIDS relative risk of 4.2 (table 5). Women had an SIR of 5.2 (table 3) and a post-AIDS relative risk of 8.6 for cervix in situ (table 6). Significant trends in relative risks were found for benign neoplasms ($p = 0.0050$) (table 5) in men and for in situ cervical cancer ($p < 0.0000$) in women (table 6).

Non-AIDS-related cancers with SIRs lower than those of the general population

In men, prostate (SIR = 0.7) and bladder (SIR = 0.5) cancers both had SIRs below 1.0 (table 2). These sites had relative risks below 1.0 during all periods relative to AIDS diagnosis, including the AIDS period (table 5). For women, breast cancer had an SIR of 0.8 (95 percent confidence interval: 0.58, 1.04) (table 3). Relative risks for breast cancer in the

TABLE 5. Relative risks for selected types of cancer by time period among men with acquired immunodeficiency syndrome aged 15–69 years in the acquired immunodeficiency/cancer matched cohort, New York State, 1981–1994

Type of cancer (ICD-9† code)	Period in relation to AIDS diagnosis												*p* value*
	5–2 years before			2 years to 6 months before			Within 9 months			3 months to 5 years after			
	Observed	Expected‡	RR	Observed	Expected‡	RR	Observed	Expected‡	RR	Observed	Expected‡	RR	
Oral cavity and pharynx (140–149)	15	11.7	1.3	25	10.3	2.4	15	6.9	2.2	16	11.5	1.4	0.8995
Digestive system (150–153, 155–159)	9	20.0	0.5	10	19.2	0.5	60	17.8	3.4	40	29.5	1.4	0.0002
Rectum, rectosigmoid, and anus (154)	13	7.1	1.8	15	5.9	2.5	23	3.7	6.3	24	6.0	4.0	0.0164
Larynx (161)	5	6.7	0.8	11	5.2	2.1	11	3.1	3.6	10	5.0	2.0	0.1144
Trachea, bronchus, and lung (162)	12	8.4	1.4	25	12.7	2.0	97	17.1	5.7	83	27.9	3.0	0.0046
Melanoma of the skin (172)	2	6.8	0.3	7	4.3	1.6	9	2.3	3.9	6	3.9	1.6	0.0478
Skin, excluding Kaposi's sarcoma (173)	5	2.0	2.5	7	1.7	4.2	43	1.0	45.2	78	1.8	44.6	0.0000
Prostate (185)	8	15.1	0.5	11	14.9	0.7	6	9.0	0.7	12	14.7	0.8	0.3743
Kidney and unspecified urinary (189)	1	5.2	0.2	7	4.4	1.6	10	3.1	3.3	0	5.3	0.0	0.3367
Bladder (188)	4	8.8	0.5	3	6.2	0.5	2	3.5	0.6	2	5.7	0.4	0.7605
Brain and CNS† (191–192)	3	2.9	1.1	2	3.0	0.7	18	2.8	6.5	19	4.7	4.0	0.0018
Connective tissue (171, 164.1)	3	3.2	0.9	8	2.2	3.6	17	1.3	12.8	22	2.2	9.9	0.0000
Hodgkin's disease (201)	21	8.8	2.4	41	4.8	8.5	77	2.5	31.2	21	4.0	5.3	0.0135
Multiple myeloma (203)	2	1.7	1.2	3	1.8	1.7	6	1.2	4.9	7	2.0	3.5	0.1134
Leukemias (204–208)	1	4.8	0.2	3	4.0	0.8	10	2.9	3.4	9	4.9	1.8	0.0087
All non-AIDS cancers§	128	141.6	0.9	200	121.7	1.6	495	89.5	5.5	456	148.3	3.1	0.0000
Noninvasive neoplasms													
Other, in situ (230–234)	4	2.7	1.5	16	2.0	8.1	5	1.1	4.7	8	1.9	4.2	0.2234
Benign (210–229)	0	3.9	0.0	4	2.2	1.8	3	1.1	2.7	5	1.9	2.6	0.0050
Uncertain and unspecified (235–239)	1	3.5	0.3	0	2.2	0.0	41	1.1	36.0	118	2.0	60.3	0.0000

* *p* values for linear trend test for change in relative risks (RRs) over time periods, excluding acquired immunodeficiency syndrome (AIDS) period.
† ICD-9, *International Classification of Diseases*, Ninth Revision; CNS, central nervous system.
‡ Expected numbers adjusted for cancer deaths prior to AIDS (excluding benign, other in situ, and uncertain and unspecified cancers).
§ Including those malignancies not shown above.

TABLE 6. Relative risks for selected types of cancer by time period among women with acquired immunodeficiency syndrome aged 15–69 years in the acquired immunodeficiency/cancer matched cohort, New York State, 1981–1994

Type of cancer (ICD-9† code)	Period in relation to AIDS diagnosis												*p* value*
	5–2 years before			2 years to 6 months before			Within 9 months			3 months to 5 years after			
	Observed	Expected‡	RR	Observed	Expected‡	RR	Observed	Expected‡	RR	Observed	Expected‡	RR	
Oral cavity and pharynx (140–149)	2	1.1	1.8	4	0.9	4.6	7	0.5	13.1	6	0.9	7.0	0.0852
Digestive system (150–153, 155–159)	2	3.0	0.7	3	2.6	1.1	4	2.2	1.8	10	3.3	3.0	0.0176
Rectum, rectosigmoid, and anus (154)	3	1.0	3.0	0	0.8	0.0	3	0.5	6.4	3	0.7	4.2	0.5559
Larynx (161)	3	0.4	7.1	0	0.3	0.0	1	0.2	5.4	3	0.3	10.6	0.5033
Trachea, bronchus, and lung (162)	4	1.1	3.8	7	1.4	4.9	21	1.7	12.7	18	2.5	7.1	0.2017
Skin, excluding Kaposi's sarcoma (173)	2	0.4	5.1	0	0.3	0.0	3	0.2	20.0	3	0.3	12.0	0.2313
Female breast (174)	15	21.7	0.7	18	15.5	1.2	11	8.6	1.3	3	14.1	0.2	0.0814
Female genital tract, excluding cervix (179, 181–184)	8	6.0	1.3	3	4.4	0.9	4	2.6	1.5	6	4.2	1.4	0.8480
Vagina and vulva (184.0, 184.4)	3	0.5	5.8	0	0.4	0.0	1	0.2	5.0	0	0.3	0.0	0.1082
Kidney and unspecified urinary (189)	2	0.7	3.0	0	0.5	0.0	1	0.4	2.7	1	0.6	1.7	0.6633
Brain and CNS† (191–192)	1	0.5	1.9	0	0.5	0.0	2	0.4	4.9	4	0.7	6.2	0.1146
Hodgkin's disease (201)	3	1.5	2.1	5	0.8	6.7	8	0.4	22.1	4	0.6	7.2	0.0992
Multiple myeloma (203)	1	0.3	3.7	1	0.3	3.4	3	0.2	14.2	3	0.3	9.2	0.3197
Leukemias (204–208)	4	0.7	5.4	3	0.6	4.8	5	0.5	10.4	4	0.8	5.2	0.9596
All non-AIDS cancers§	59	43.7	1.4	46	32.9	1.4	88	21.0	4.2	97	33.6	2.9	0.0000
Noninvasive neoplasms													
Cervix, in situ (233.1)	59	22.4	2.6	68	10.8	6.3	47	5.0	9.4	66	7.7	8.6	0.0000
Other, in-situ (230–234)	4	2.6	1.6	3	1.9	1.6	2	1.0	1.9	4	1.8	2.2	0.6043
Uncertain and unspecified (235–239)	1	0.6	1.6	0	0.3	0.0	3	0.1	21.5	17	0.2	81.1	0.0000

* *p* values for linear trend test for change in relative risks (RRs) over time periods, excluding acquired immunodeficiency syndrome (AIDS) period.
† ICD-9, *International Classification of Diseases*, Ninth Revision; CNS, central nervous system.
‡ Expected numbers adjusted for cancer deaths prior to AIDS (excluding cervix in situ, other in situ, and uncertain and unspecified cancers).
§ Including those malignancies not shown above.

early pre-AIDS and post-AIDS periods were below 1.0, with the post-AIDS period being especially low (RR = 0.2) (table 6).

Non-AIDS-related cancer risk by HIV exposure group

Cancers with significantly elevated overall SIRs were evaluated by HIV exposure group. All results are displayed in table 7. Results for groups with five or more observations are presented as follows.

Anal. Men who acquired HIV infection through homosexual contact had an SIR of 5.8.

Hodgkin's disease. Male homosexual contact (SIR = 8.7) and intravenous drug use (SIR = 7.8) had comparable risks, while the SIR for heterosexual contact was 31.3. For female heterosexual contact, there was a higher standardized incidence ratio (SIR = 12.3) than for injection drug use (SIR = 9.4).

Trachea, bronchus, and lung. There was a higher SIR for male injection drug use (SIR = 4.6) than for male homosexual contact (SIR = 2.6). For female injection drug use, there was an elevated standardized incidence ratio (SIR = 9.8) compared with female heterosexual contact (SIR = 6.4).

Brain and CNS. In men, the SIR for homosexual contact was 4.7, which was higher than that for intravenous drug use (SIR = 2.7), while for women, the SIR for heterosexual contact was 23.8.

Connective tissue. Among men who acquired HIV infection through homosexual contact, the risk was increased 10.5-fold.

Oral cavity and pharynx. The SIRs for male and female intravenous drug use were 1.9 and 8.2, respectively.

Digestive system. For male intravenous drug use, there was an elevated SIR of 1.8, and the SIR for female heterosexual contact (SIR = 3.1) was higher than that for female intravenous drug user (SIR = 2.4).

Invasive cervix. The SIR for heterosexual contact was higher (SIR = 10.7) than that for intravenous drug use (SIR = 8.7).

In situ cervix. The SIRs for heterosexual contact (SIR = 5.4) and intravenous drug use (SIR = 5.3) were comparable.

DISCUSSION

In this study, we assessed the risk of cancer among people diagnosed with AIDS in NYS. The matched AIDS/cancer data for NYS is included as a part of the National Cancer Institute's multistate AIDS/cancer match project. While the National Cancer Institute has conducted some analysis of the national data (27, 28), in this paper, we describe the results of analysis of the NYS subset of the data, including analysis by risk group. As expected, Kaposi's sarcoma and non-Hodgkin's lymphoma represented the majority of cancers found in this cohort. There is strong evidence in this study that the immunosuppression associated with HIV infection increases the risks of Kaposi's sarcoma, non-Hodgkin's lymphoma, and invasive

TABLE 7. Selected cancer risks by human immunodeficiency virus exposure group among patients with acquired immunodeficiency syndrome in the acquired immunodeficiency syndrome/cancer matched cohort, New York State, 1981–1994

HIV* exposure group	Type of cancer											
	Anal†			Invasive cervix			In situ cervix			Hodgkin's disease		
	No. of observed cases	SIR*	95% CI*	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI
Men												
Homosexual contact	63	5.8	4.42, 7.36							81	8.7	6.87, 10.76
IDU*	7	1.2	0.49, 2.51							66	7.8	6.03, 9.93
Heterosexual contact										5	31.3	10.14, 72.93
Transfusion or transplantation	1	6.7	0.17, 37.15									
Unknown or other	4	2.7	0.75, 7.02							8	11.9	5.15, 23.53
All	75	3.3	2.60, 4.15							160	8.0	5.05, 9.33
Women												
IDU	4	3.7	1.01, 9.48	77	8.7	6.86, 10.86	150	5.3	4.48, 6.21	9	9.4	4.29, 17.80
Heterosexual contact	2	20.0	2.42, 72.25	43	10.7	7.72, 14.37	73	5.4	4.24, 6.79	7	12.3	4.94, 25.30
Transfusion or transplantation	1	20.0	0.50, 111.44									
Unknown or other	2	10.0	1.21, 36.12	13	16.1	8.54, 27.45	17	4.8	2.77, 7.61	4	23.5	6.41, 60.25
All	9	3.0	1.39. 5.77	133	9.1	6.90, 10.76	240	5.2	4.60, 5.94	20	6.4	3.91, 9.91

Table continues

TABLE 7. Continued

HIV exposure group	Type of cancer															
	Lung			Brain			Connective tissue			Oral cavity and pharynx			Digestive system‡			
	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI	No. of observed cases	SIR	95% CI	
Men																
Homosexual contact	80	2.6	2.08, 3.26	25	4.7	3.01, 6.87	42	10.5	7.57, 14.19	25	1.5	0.96, 2.18	43	1.4	0.98, 1.82	
IDU	120	4.6	3.78, 5.46	11	2.7	1.36, 4.86	5	1.7	0.57, 4.07	34	1.9	1.32, 2.67	62	1.8	1.39, 2.32	
Heterosexual contact	2	6.7	0.81, 24.08	2	100.0	12.10, 361.25	1	100.0	2.50, 557.20	1	25.0	0.63, 139.30	2	18.2	2.20, 65.68	
Transfusion or transplantation	2	4.9	0.59, 17.62				1	100.0	2.50, 557.20				4	7.0	1.91, 17.97	
Unknown or other	14	2.1	1.11, 3.57	4	5.9	1.60, 15.06	1	6.3	0.16, 34.82	11	3.2	1.59, 5.71	8	1.4	0.58, 2.67	
All	217	3.3	2.86, 3.75	42	3.1	2.26, 4.24	50	5.6	4.13, 7.34	71	1.8	1.37, 2.22	119	1.4	1.14, 1.65	
Women																
IDU	31	9.8	6.67, 13.93	2	3.0	0.36, 10.78				15	8.2	4.59, 13.52	10	2.4	1.16, 4.46	
Heterosexual contact	12	6.4	3.28, 11.09	5	23.8	7.73, 55.57	1	14.3	0.36, 79.60	3	10.0	2.06, 29.23	5	3.1	1.01, 7.25	
Transfusion or transplantation	2	12.5	1.51, 45.16										2	9.1	1.10, 32.84	
Unknown or other	4	6.4	1.73, 16.26				2	28.6	3.46, 103.21	1	12.5	0.31, 69.65	2	5.6	0.67, 20.07	
All	50	7.5	5.57, 9.90	7	3.4	1.38, 7.05	3	1.9	0.39, 5.57	19	5.7	3.42, 8.86	19	1.7	1.02, 2.67	

* HIV, human immunodeficiency virus; SIR, standardized incidence ratio; CI, confidence interval; IDU, injection drug users.
† Rectum, rectosigmoid, and anus.
‡ Excludes rectum.

cervical cancer. This study has also found elevated SIRs, post-AIDS relative risks, and increasing trends of relative risks in people with AIDS for several types of cancer that are not AIDS defining. It is possible that our results for tumors of the brain, digestive system, and lungs could be misdiagnosed NHL, but an examination of the histology codes for these sites did not reveal miscoded lymphomas.

Hodgkin's disease

Hodgkin's disease is one of the most common non-AIDS-related cancers found in this cohort. The overall SIRs (male, 8.0; female, 6.4; both, 7.8) in our study are consistent with studies from San Francisco (male, 8.8) (9), the United States and Puerto Rico (both 8.8) (2), and Italy (male, 9.3; female, 7.7) (4), but are lower than those in the paper by Grulich et al. (5) (both 18.3). The post-AIDS relative risks (male, 5.3; female, 7.2; both, 5.4) are also similar to those in the paper by Goedert et al. (2) (both 7.6), but are much lower than those found by Franceschi et al. (4) (both 20.4) and Grulich et al. (5) (both 29.9). A significant, but nonlinear, increase in relative risk over time was found in male AIDS patients in this study ($p = 0.0135$). Goedert et al. (2) previously found a significant increase in relative risk over time for both sexes; therefore, our study contributes to the evidence that the risk of Hodgkin's disease increases as males with HIV disease advance in their immunodeficiency.

Rectal and anal cancer

There is strong evidence of a relation between HIV-related immunodeficiency, human papilloma virus infection, and development of anal cancer (29–34). Carcinomas of the anus and anal intraepithelial neoplasia occur at increased rates among homosexual men with HIV. The incidence among MSM was elevated in 1973–1979, which preceded the HIV epidemic (35). In our study, elevated overall SIRs for rectal and anal cancer were found (male, 3.3; female, 3.0), while post-AIDS relative risks were significant for men (RR = 4.0) but not for women. We also detected an elevated relative risk in male AIDS patients with declining immune status ($p = 0.0164$). Several other studies have also found an increased incidence of anal cancer in men but not in women (10, 36, 37).

Lung cancer

Lung cancer is the second most common cancer in both men and women in the general population. In our study, we found a significant overall SIR (male, 3.3; female, 7.5; both, 3.7), similar to a report by Grulich et al. (5) (both 3.8). Post-AIDS relative risks were also significantly elevated (male, 3.0; female, 7.1; both, 3.3), and this is also similar to the post-AIDS result from Grulich et al. (5) (both 3.9). A significant ($p = 0.0046$) increase in the trend in relative risk was also found in men.

This study found a significantly increased risk of lung cancer with advancing immunodeficiency. However, this result may be confounded, since it is widely known that lung cancer is related to tobacco use, and it is likely that HIV-

infected patients smoke more cigarettes per day than do persons in the general population.

Brain and CNS cancer

In recent years, incidence of brain and CNS cancer has risen strikingly, and CNS lymphoma in people with AIDS is thought to represent much of the recent increase (38–40). In our study, we found elevated SIRs (male, 3.1; female, 3.4; both, 3.2), which is higher than the findings in the study by Goedert et al. (2) (both 2.0). Our analysis also revealed elevated post-AIDS relative risks (male, 4.0; female, 6.2; both, 4.3), which are higher than those in the study by Goedert et al. (5) (both 3.5) and a significant, but nonlinear, trend in relative risks over time for men ($p = 0.0018$). The trend in the paper by Goedert et al. was significant (both $p = 0.006$) and linear. Other studies that have examined the relation between brain and CNS cancer and HIV illness have had mixed results (41–43), and brain and CNS cancer has not been clearly linked to immunodeficiency. The etiology of CNS lymphoma among persons with and those without AIDS remains unknown, and infectious viral agents such as Epstein-Barr virus might contribute to lymphoma.

Skin cancer

For skin cancer, we found relatively high SIRs (male, 20.9; female, 7.5), even higher relative risks in the post-AIDS period (male, 44.6; female, 12.0), and an increased risk over time in men ($p < 0.0001$). The two most common forms of skin cancer, basal and squamous cell carcinomas, are not reportable to the registry. Consequently, most nonmelanomatous skin cancers reported to the registry are sarcomas, followed by adenocarcinomas. It is possible that Kaposi's sarcoma cases might have been misclassified as non-Kaposi's sarcoma skin cancers.

Connective tissue

Cancer of connective tissues occurred in statistically significant excess among men. The overall SIR was 5.6, the post-AIDS relative risk was 9.9, and the p value was less than 0.0001. Grulich et al. (5) have also found an elevated SIR of 9.2 for both sexes combined.

Noninvasive neoplasms

An increased risk for in situ cancers was found in this study (tables 2 and 3). We present findings from our data to allow comparison with other published data; however, there are serious potential biases relating to the interpretation of in situ cancer results. Reporting of in situ cancers is incomplete in the cancer registry. This is especially true for in situ cervical cancer. In fact, most state cancer registries have dropped in situ cervical cancer from their reportable list. Thus, rates for in situ cancers based on registry data would be artificially low, and the number of expected cases would also be low, so the SIRs would not be accurate and would tend to be elevated among a population with an increased likelihood of hospitalization.

Non-AIDS-related cancers with SIRs lower than the general population

While the focus of the analysis is ascertaining cancers with elevated SIRs, we found a few sites with SIRs below 1.0. In men, prostate (SIR = 0.7) and bladder (SIR = 0.5) cancers had SIRs below 1.0 (table 2). These sites had relative risks below 1.0 during all periods relative to AIDS diagnosis. In women, breast cancer relative risks during the early pre-AIDS and post-AIDS periods were below 1.0, with the post-AIDS period especially low (RR = 0.2) (table 6).

Risk factors

A person's risk of developing a specific cancer is affected by various factors, including age, sex, race, and exposure to environmental agents. As yet, there is only limited information about which characteristics and exposures of HIV-infected people promote the development of cancer. The association between risk factors for acquiring HIV infection and selected malignant disease in people with AIDS was examined in this study. Sex between men and intravenous drug use are the major behavioral risk factors for men in our study cohort. For six cancer types or sites (rectum, rectosigmoid, and anus; connective tissue; Hodgkin's disease; brain and CNS; oral cavity and pharynx; and trachea, bronchus, and lung), our study contains sufficient observations to detect meaningful differences between these two risk groups for men and six cancer types or sites for women (invasive cervix; in situ cervix; Hodgkin's disease; trachea, bronchus, and lung; oral cavity and pharynx; and digestive system).

Rectum, rectosigmoid, and anus

Our study confirms that the risk of anal cancer among homosexual men with HIV infection is higher than that in the general population.

Trachea, bronchus, and lung

Both male (SIR = 4.6) and female (SIR = 9.8) IDUs had increased SIRs for trachea, bronchus, and lung cancer compared with other risk groups. This finding is not surprising, since IDUs are known to be heavy smokers, which may confound the relation between HIV and trachea, bronchus, and lung cancer.

Brain and CNS

SIRs varied by route of HIV acquisition in men, MSM (SIR = 4.7), and IDUs (SIR = 2.7), although the confidence intervals overlap for these point estimates. While differences by risk group are noteworthy, it is likely that route of HIV infection is a proxy for other risks, such as coinfection with Epstein-Barr virus, hepatitis B or C, or human herpes virus 8. Women infected heterosexually had a relative risk of 23.8.

Connective tissue

In this study, risk of this cancer appeared almost exclusively among HIV-infected men with homosexual contact, and therefore, this may be a result of misdiagnosis of Kaposi's sarcoma as hemangiosarcoma.

Hodgkin's disease

The relative risk for the MSM risk group, 8.7, is comparable with that in the study by Reynolds et al. (9) (RR = 8.8). The relative risk for male IDUs, 7.8, is similar to the that of 8.1 for males and females in the study by Franceschi et al. (4). Heterosexually infected men had a greatly elevated relative risk (RR = 31.3), which was significantly higher than that for the intravenous drug use risk group.

Oral cavity and pharynx

SIRs were elevated for IDUs (1.9) but not for any other risk group.

Limitations

There are several potential biases in this study. First, it is possible that cancers with a higher incidence were detected because of intensive medical scrutiny among AIDS patients. Second, this cohort is the result of a match between two registries. If records are erroneously matched, the measures of association may be inaccurate. Third, in this study, Surveillance, Epidemiology, and End Results differential survival rates were applied to expected frequencies of cancer that occurred preceding AIDS. These adjusted relative risks for pre-AIDS expected cancers were then used to calculate the pre-AIDS relative risk and overall SIRs. However, this adjustment was approximate and could have resulted in overestimates of the early pre-AIDS prevalence and expected cancer cases.

Another potential limitation relates to the method we used to calculate post-AIDS relative risk. For types and sites of cancer that did not contribute a large number of observed cases in the 60-month post-AIDS period, the relative risks for this period will be attenuated due to the large number of expected cases that are derived with no or few corresponding observed cases.

This analysis was conducted on heterogeneous case definition data, with 1993 and 1987 AIDS definition cases analyzed together. Patients classified as 1987 definition cases are at a more advanced stage of HIV infection compared with 1993 definition cases, as indicated by significant differences in survival probabilities between the two groups (44, 45). A final potential limitation is that pulmonary and neurologic complications of HIV illness may have been misdiagnosed as tumors at these sites.

In a large, heterogeneous cohort of AIDS patients, we have confirmed that cancer occurs in excess for AIDS-related cancers, and for non-AIDS-related cancers, our results support previous findings for Hodgkin's disease, rectal and anal cancer, and brain and CNS system cancer. This analysis has contributed to the knowledge of the relation between AIDS and cancer by analyzing incidence by gender and risk group. Our analysis revealed an increasing relative risk of trachea, bronchus, and lung cancer in men over time and an increase in risk of cancer of connective tissues for MSM.

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