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HIV Infection, Cancer Treatment Regimens, and Cancer Outcomes Among Elderly Adults in the United States

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IMPORTANCE HIV-infected patients with cancer have an elevated cancer-specific mortality rate compared with HIV-uninfected patients with cancer. However, to our knowledge, studies describing this association have not adjusted in detail for cancer treatment, despite evidence of suboptimal cancer treatment in the setting of HIV.

OBJECTIVE To compare cancer-specific mortality in HIV-infected and HIV-uninfected patients with cancer after adjusting for available data on receipt of specific cancer treatments.

DESIGN, SETTING, PARTICIPANTS We used Surveillance, Epidemiology, and End Results–Medicare linked data to identify 308 268 patients in the United States (age, ≥65 years), including 288 with HIV infection, with nonadvanced cancers of the colorectum, lung, prostate, or breast diagnosed between 1996 and 2012 who received standard, stage-appropriate cancer treatment during the year after cancer diagnosis. Data analysis was done from August 2016 to September 2018.

EXPOSURES HIV infection identified by the presence of Medicare claims.

MAIN OUTCOMES Overall mortality, cancer-specific mortality, and relapse or cancer-specific mortality after initial treatment.

RESULTS In this database study of 308 268 patients with nonadvanced cancer (168 998 men and 139 270 women; age, ≥65 years), HIV-infected patients (n = 288) had significant elevations in the overall mortality rate compared with HIV-uninfected patients for cancers of the colorectum (hazard ratio [HR], 1.73; 95% CI, 1.11-2.68; $P = .02$), prostate (HR, 1.58; 95% CI, 1.23-2.03; $P < .01$), and breast (HR, 1.50; 95% CI, 1.01-2.24; $P = .05$). Cancer-specific mortality was elevated for prostate (HR, 1.65; 95% CI, 0.98-2.79; $P = .06$) and breast cancer (HR, 1.85; 95% CI, 0.96-3.55; $P = .07$). Compared with their HIV-uninfected counterparts, HIV-infected men with prostate cancer also experienced significantly higher rates of relapse or death (HR, 1.32; 95% CI, 1.03-1.71; $P = .03$) as did HIV-infected women with breast cancer (HR, 1.63; 95% CI, 1.09-2.43; $P = .02$).

CONCLUSIONS AND RELEVANCE In the United States, elderly HIV-infected patients with cancer, particularly prostate and breast cancers, have worse outcomes than HIV-uninfected patients with cancer. This disparity persists even after adjustment for administered first-course cancer treatments and will become increasingly relevant as the HIV population in the United States continues to age.

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Supplemental content

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Mortality rates following a cancer diagnosis are higher in HIV-infected patients than in HIV-uninfected patients.[1,2] Poorer survival is not limited to malignant neoplasms with a viral etiology,[3,4] and worse outcomes persist after adjustment for differences in patient demographics and cancer stage. Recent findings from the National Cancer Database have indicated that elevated mortality rates in HIV-infected patients with cancer also remain after adjustment for receipt of health insurance and the type of facility administering cancer care.[5] Together, these results suggest that HIV infection itself, likely because of associated immunosuppression, may contribute to elevated mortality in patients with cancer.

However, the possibility that outcome differences are explained by variation in cancer treatment remains, to some extent, unaddressed. This issue is important given lower cancer treatment rates reported for HIV-infected patients across multiple studies.[6-8] Prior research that attempted to account for cancer treatment differences used databases containing limited information (ie, whether any surgery occurred). Finer adjustment for the type and timing of cancer treatments is needed to rule out the possibility that variable cancer treatment is the primary driver of the HIV-related cancer survival deficit.

The Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database offers an opportunity to address this question using administrative claims for cancer treatments from Medicare, which provides health insurance for individuals 65 years or older in the United States. The association between HIV and survival in these elderly patients is particularly important given the aging HIV population.[9] We used this database to compare mortality following a cancer diagnosis in HIV-infected and HIV-uninfected patients who had a similar cancer stage and received stage-appropriate cancer treatment during the year following diagnosis.

Key Points

Question Can the elevated mortality rate in HIV-infected patients with cancer vs HIV-uninfected patients with cancer be explained by receipt of suboptimal cancer treatment?

Findings Data from the US Surveillance, Epidemiology, and End Results–Medicare linked database indicated that elevated cancer-specific mortality among HIV-infected patients diagnosed with cancer between 1996 and 2012 persisted after adjustment for administered first-course cancer treatments; evidence was strongest for prostate and breast cancers.

Meaning Elevated cancer-specific mortality in HIV-infected patients was not entirely explained by differences in cancer treatment and may instead reflect an association between immunosuppression and cancer control.

Methods

The National Institutes of Health Office of Human Subjects Research deemed that research using SEER-Medicare data was exempt from institutional review board review, and patient written informed consent was not required. The SEER-Medicare database links individuals who have been diagnosed with cancer in SEER registry catchment areas (approximately 26% of the US population) to Medicare administrative claims.[10,11] From SEER cancer registries, we identified invasive cancers of the colorectum (*International Classification of Diseases for Oncology,* 3rd edition [*ICD-O3*] site codes C180-189, C199, C209), lung (*ICD-O3* C340-349), prostate (*ICD-O3* C619) and female breast (*ICD-O3* C500-509). Lung cancer was limited to non–small cell lung cancer (NSCLC) (histology codes 8010-8576). Patients with cancer diagnosed between 1996 and 2012, no prior or subsequent cancers, and Medicare parts A and B coverage (without enrollment in a health maintenance organization) from the time of their cancer diagnosis through death or end of follow-up in December 2014 were included in our study. We excluded patients whose cancer was diagnosed at autopsy or documented only on the death certificate.

The present study focused on patients diagnosed with local- or regional-stage cancer, which was defined using the SEER summary variable,[12] who received stage-appropriate treatment during the year after cancer diagnosis. To allow for unbiased inclusion of first-year cancer treatment data, patients were required to survive 1 year to be eligible. Stage-appropriate treatment was defined in 2 steps. First, eligible treatment codes for each cancer site were determined by comparing frequently reported codes with National Comprehensive Cancer Network guidelines, as described previously.[8] These codes were ascertained from the National Claims History, Medicare Provider Analysis and Reviewer, Outpatient, and durable medical equipment files. Eligible treatment codes for each cancer site are included in eTable 1 in the Supplement.

Second, we classified a patient as receiving stage-appropriate treatment only if the patient had at least one eligible treatment code reported from the following treatment categories by cancer site and stage: colorectal cancer (local stage: surgery; regional stage: chemotherapy), NSCLC (local stage: surgery or radiation; regional stage: chemotherapy), prostate cancer (surgery, radiation or hormone therapy), breast cancer (surgery). Surgery claims for diagnostic rather than procedures performed with curative intent were removed.

Mortality in HIV-Infected Patients With Cancer

HIV infection was identified by the presence of 1 Medicare claim for *ICD-9* codes 042 to 044 or V08 in the Medicare Provider Analysis and Reviewer file or 2 such claims at least 30 days apart in the National Claims History or Outpatient files. We used Cox proportional hazards regression to examine the association between HIV status and both overall mortality (death from any cause) and cancer-specific mortality. Mortality was defined as cancer-specific if the listed cause of death was cancer at any site (eg, anal cancer in a patient with colorectal cancer). Given the requirement that all patients in the study had a history of only 1 cancer diagnosis, the assumption was that any cancer-related death was due to the presenting cancer.[13] Follow-up time was calculated starting 12 months after cancer diagnosis and ending either at death or the end of follow-up in December 2014. Regression models were adjusted for patient age (continuous), sex, race/ethnicity (white, nonwhite, defined using

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the SEER race recode variable[14]), year of cancer diagnosis (1996-2004, 2005-2012), median census tract income (<$30 000, $30 000-59 000, >$59 000), and cancer stage (local, regional). Stage adjustment was not applied to prostate cancer because SEER combines local and regional stage prostate cancer into 1 nonadvanced category.

Treatment Adjustment

All eligible patients received stage-appropriate treatment during the year after diagnosis, but we further adjusted regression models for specific treatment details to address potential residual confounding. Adjustment was based on common regimens observed in the study population (eTable 2 in the Supplement). Specific adjustments by cancer site and stage included colorectal cancer (local stage: time to surgery; regional stage: time to surgery and fluorouracil chemotherapy doses), NSCLC (local stage: time to treatment; regional stage: time to treatment and receipt of platinum-based chemotherapy), prostate cancer (primary treatment modality and time to treatment), breast cancer (time to surgery and receipt of radiation or cyclophosphamide).

Relapse/Mortality in HIV-Infected Patients With Cancer

In addition to mortality, we examined the association between HIV and a combined outcome of relapse or death, defined as either receipt of additional cancer treatment (retreatment) or death. The need for retreatment was used as a proxy for disease relapse, and Medicare claims indicating receipt of any treatment modality (surgery, radiotherapy, chemotherapy, or hormone therapy [prostate cancer only]) qualified. Patients were required to have a wash-out period during months 12 to 15 when no cancer treatment was reported. This period was selected to increase the likelihood that cancer treatment after month 15 represented second-round retreatment rather than continuation of initial therapy. Accordingly, patients had to survive at least 15 months after cancer diagnosis to start follow-up. This analysis was repeated for relapse or cancer-specific death, and we focused on retreatment as a distinct outcome for prostate and breast cancers.

Sensitivity Analysis

We conducted a sensitivity analysis to understand whether observed associations were unique to HIV or were instead attributable to a more general correlation between comorbidities and mortality in patients with cancer. We ran adjusted Cox regression models substituting each of the following control comorbidities for HIV: gastroesophageal reflux, essential hypertension, and migraine headaches. Data were analyzed from August 2016 to September 2018.

Associations between HIV and cancer patient outcomes were considered statistically significant if they met the $P \leq .05$ threshold.

Results

We evaluated 288 HIV-infected and 307 980 HIV-uninfected patients (168 998 men and 139 270 women) 65 years or older who were diagnosed with cancers of the colorectum, lung (NSCLC), prostate, or female breast (**Table 1**). HIV-infected patients with cancer were on average younger than their HIV-uninfected counterparts and more likely to be nonwhite. Prostate cancer represented greater than half (59%) of cancer diagnoses in HIV-infected patients (n = 170) compared with 43% in HIV-uninfected patients (133 016), reflecting the predominance of men among HIV-infected patients in the study cohort (78% HIV-infected patients [n = 224] vs 55% HIV-uninfected patients [168 774]).

As required for inclusion in the study, all patients received stage-appropriate treatment in the year after cancer diagnosis. eTable 2 in the Supplement presents treatment details ascertained from Medicare claims. Delivered treatments for HIV-infected and HIV-uninfected patients with cancer were largely similar. An exception was NSCLC—HIV-infected patients were more likely to receive radiotherapy or chemotherapy as opposed to surgery, and treatment delays were longer for those receiving radiotherapy.

During the period starting 1 year after cancer diagnosis, HIV-infected patients experienced significant elevations in overall mortality compared with HIV-uninfected patients for cancers of the colorectum (hazard ratio [HR], 1.73; 95% CI, 1.11-2.68; $P = .02$), prostate (HR, 1.58; 95% CI, 1.23-2.03; $P < .01$), and breast (HR, 1.50; 95% CI, 1.01-2.24; $P = .05$) (**Table 2**). Cancer-specific mortality was also elevated in HIV-infected patients with cancer compared with their HIV-uninfected counterparts for cancers of the breast (HR, 1.85; 95% CI, 0.96-3.55; $P = .07$) and prostate (HR, 1.65; 95% CI, 0.98-2.79; $P = .06$). The association between HIV and elevated cancer-specific mortality was statistically significant for women diagnosed with regional-stage breast cancer, with HIV-infected women being nearly 3 times more likely than HIV-uninfected women to die from breast cancer (HR, 2.91; 95% CI, 1.31-6.46; $P < .01$). This distinction in cancer-specific mortality by stage could not be evaluated for prostate cancer because all men were classified in SEER as having nonadvanced disease without further categorization.

We examined the risk of the combined outcomes of relapse or death and relapse or cancer-specific death in patients who survived at least 15 months after diagnosis (**Table 3**). Compared with HIV-uninfected patients, HIV-infected men with prostate cancer were significantly more likely to experience relapse or death (HR, 1.32; 95% CI, 1.03-1.71; $P = .03$), and more likely to experience relapse or cancer-specific death (HR, 1.28; 95% CI, 0.92-1.78; $P = .15$). More than half (53%) of these events were claims for retreatment. The association of HIV with retreatment alone was 1.23 (95% CI, 0.87-1.75; $P = .23$). Among women, HIV-infected patients with breast cancer were significantly more likely than their HIV-uninfected counterparts to experience both relapse or death (HR, 1.63; 95% CI, 1.09-2.43; $P = .02$) and relapse or cancer-specific death (HR, 1.90; 95% CI, 1.10-3.28; $P = .02$). Retreatment for breast cancer comprised approximately one-third of these events, and the association of HIV with retreatment alone was 1.59 (95% CI, 0.83-3.07; $P = .16$).

Finally, we conducted a sensitivity analysis substituting 3 different comorbidities for HIV. Elevations in cancer-

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Table 1. Characteristics of Patients Diagnosed With Nonadvanced Cancers of the Colorectum, Lung, Prostate, or Breast Who Received Stage-Appropriate Treatment, by HIV Status[a]

	HIV Status, No. (%)	
	Infected (n = 288)	Uninfected (n = 307 980)
Sex		
Male	224 (77.8)	168 774 (54.8)
Female	64 (22.2)	139 206 (45.2)
Age at diagnosis, y		
65-69	134 (46.5)	88 369 (28.7)
70-75	94 (32.6)	100 794 (32.7)
≥76	60 (20.8)	118 817 (38.6)
Race/ethnicity		
White, non-Hispanic	163 (56.6)	264 604 (85.9)
Black, non-Hispanic	106 (36.8)	24 352 (7.9)
Hispanic	NR[b]	4167 (1.4)
Asian	NR	7599 (2.5)
Other/unknown	NR	7258 (2.4)
Year of cancer diagnosis		
1996 to 2004	106 (36.8)	123 215 (40.0)
2005 to 2012	182 (63.2)	184 765 (60.0)
Cancer site		
Colorectum	34 (11.8)	49 623 (16.1)
Local[c]	22 (64.7)	32 745 (66.0)
Regional	12 (35.3)	16 878 (34.0)
Lung (NSCLC)	34 (11.8)	29 217 (9.5)
Local	>20 (>70.0)[d]	17 663 (60.5)
Regional	<11 (<30.0)	11 554 (39.6)
Nonadvanced prostate	170 (59.0)	133 016 (43.2)
Female breast	50 (17.4)	96 124 (31.2)
Local	37 (74.0)	69 054 (71.8)
Regional	13 (26.0)	27 070 (28.2)
Median income (by census tract), $[e]		
<30 000	85 (29.5)	42 202 (13.7)
30 000-59 000	138 (47.9)	174 148 (56.6)
>59 000	64 (22.2)	90 309 (29.3)
Vital status[f]		
Alive	157 (54.5)	174 499 (56.7)
Deceased	131 (45.5)	133 481 (43.3)
Cancer death[g]	46 (35.1)	43 336 (32.5)

Abbreviations: NR, not reported; NSCLC, non–small cell lung cancer.

[a] Data were obtained from the Surveillance, Epidemiology, and End Results (SEER)–Medicare linked database. Patients survived more than 1 year after cancer diagnosis and underwent the following treatment to be classified as receiving stage-appropriate treatment: (1) colorectal cancer—surgery for local disease, chemotherapy for regional-stage cancer; (2) NSCLC—surgery or radiation for local-stage cancer, chemotherapy for regional-stage cancer; (3) prostate cancer—receipt of surgery, radiation, or hormone therapy for nonadvanced cancer (no differentiation in SEER between local or regional-stage); (4) breast cancer—surgery for local- or regional-stage cancer.

[b] Numbers lower than 11 are not reported in accordance with the SEER-Medicare data use agreement, but HIV-infected and HIV-uninfected patients did not differ substantially regarding these categories of racial/ethnic distribution.

[c] Percentages calculated among diagnoses at the given cancer site.

[d] Exact number not reported in accordance with the SEER-Medicare data use agreement, but approximate categories are shown to illustrate differences in NSCLC stage distribution by HIV status.

[e] Percentages do not sum to 100% due to fewer than 1% of missing values for both HIV-infected and uninfected patients with cancer.

[f] Vital status as of December 2014 was ascertained using Medicare and SEER death records.

[g] Percentages were calculated among deceased patients.

specific mortality were not observed for gastroesophageal reflux (HR, 0.99; 95% CI, 0.96-1.02), essential hypertension (HR, 0.95; 95% CI, 0.93-0.97), or migraines (HR, 0.94; 95% CI, 0.85-1.04).

Discussion

Elderly HIV-infected patients with cancer experience poorer cancer outcomes than HIV-uninfected patients receiving similar stage-appropriate cancer treatment. People living with HIV are expected to die at higher overall rates due to the contribution of AIDS-related comorbidities, but we report that HIV-infected patients with cancer who are 65 years or older are also at increased risk of cancer-specific death and relapse after initial therapy.

We previously reported that HIV-infected patients with cancer in the United States had elevated cancer-specific mortality for melanoma and cancers of the colorectum, pancreas, larynx, lung, breast, and prostate.[2] Recent findings in a study of data from the National Cancer Database suggest that this survival deficit persists for each of these cancers after adjustment for receipt of health insurance and the type of facility administering cancer care.[5] However, those studies lacked

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Table 2. Mortality After Diagnosis in Patients With Nonadvanced Cancers Who Received Stage-Appropriate Treatment and Survived 1 Year or More After Diagnosis[a]

	Colorectal Cancer	NSCLC	Prostate Cancer	Breast Cancer
Overall mortality				
HIV-infected patients	34	34	170	50
Deaths (% patients)	20 (58.8)	24 (70.6)	63 (37.1)	24 (48.0)
HIV-uninfected patients	49 623	29 217	133 016	96 124
Deaths (% patients)	27 599 (55.6)	20 966 (71.8)	46 588 (35.1)	38 328 (39.9)
Treatment-adjusted HR	1.73 (1.11-2.68)	1.17 (0.79-1.75)	1.58 (1.23-2.03)	1.50 (1.01-2.24)
P value	.02	.44	<.01	.05
Cancer-specific mortality				
HIV-infected cancer deaths (%)[b]	NR[c]	14 (41.2)	14 (8.2)	NR
HIV-uninfected cancer deaths (%)	10 180 (20.5)	13 967 (47.8)	9439 (7.1)	9750 (10.1)
Treatment-adjusted HR	1.68 (0.87-3.23)	1.04 (0.62-1.76)	1.65 (0.98-2.79)	1.85 (0.96-3.55)
P value	.12	.88	.06	.07

Abbreviations: HR, hazard ratio; NR, not reported; NSCLC, non–small cell lung cancer.

[a] Models were adjusted for age, sex, race/ethnicity (white, nonwhite), median census tract income (<$30 000, $30 000-59 000, >$59 000, missing), year (1996-2004, 2005-2012), and stage at diagnosis, but sex adjustment was not applied to prostate and breast cancer. Models were further adjusted for treatment specific to each cancer type. Colorectal cancer: time between cancer diagnosis and surgery (local and regional stage) and number of cycles of fluorouracil (regional stage); NSCLC: time between cancer diagnosis and treatment initiation (local and regional stage) and receipt of platinum-based chemotherapy (regional stage); prostate cancer: treatment type (surgery, RT, or hormonal therapy) and time to treatment initiation; breast cancer: time between cancer diagnosis and surgery, and receipt of radiation or cyclophosphamide.

[b] The percentage of overall deaths due to cancer for each cancer site was as follows: 36.9% in HIV-uninfected vs 45.0% in HIV-infected with colorectal cancer; 66.6% in HIV-uninfected vs 58.3% in HIV-infected with NSCLC; 20.3% in HIV-uninfected vs 22.2% in HIV-infected with prostate cancer; and 25.4% in HIV-uninfected vs 37.5% in HIV-infected with female breast cancer. The percentage of HIV-related deaths was fewer than or equal to 11% across all cancer sites.

[c] Numbers lower than 11 are not reported in accordance with the Surveillance, Epidemiology, and End Results–Medicare data use agreement.

Table 3. Relapse or Mortality Among Patients Who Survived More Than 15 Months After Cancer Diagnosis[a]

	Colorectal	NSCLC	Prostate	Breast
Relapse or death[b]				
HIV-infected patients	29	26	138	44
Long-term outcomes (% patients)	16 (55.2)	19 (73.1)	60 (43.5)	24 (54.6)
HIV-uninfected patients	43 167	21 932	104 465	88 591
Long-term outcomes (% patients)	25 512 (59.1)	15 487 (70.6)	43 205 (41.4)	41 639 (47.0)
Adjusted HR (95% CI)	1.58 (0.97-2.58)	1.23 (0.79-1.93)	1.32 (1.03-1.71)	1.63 (1.09-2.43)
P value	.07	.36	.03	.02
Relapse or cancer-specific death				
Cancer outcomes in HIV-infected, No. (%)	NR[c]	12 (46.2)	35 (25.4)	13 (29.6)
Cancer outcomes in HIV-uninfected, No. (%)	11 431 (26.5)	10 655 (48.6)	24 242 (23.2)	17 512 (19.8)
Adjusted HR (95% CI)	1.51 (0.78-2.90)	1.17 (0.67-2.07)	1.28 (0.92-1.78)	1.90 (1.10-3.28)
P value	.22	.58	.15	.02

Abbreviations: HR, hazard ratio; NR, not reported; NSCLC, non–small cell lung cancer.

[a] Models were adjusted for age, sex, race/ethnicity (white, nonwhite), median census tract income (<$30 000, $30 000-59 000, >$59 000, missing), year (1996-2004, 2005-2012), and stage at diagnosis, but sex adjustment was not applied to prostate and breast cancer.

[b] Overall relapse/mortality outcome was defined as death (from any cause) or receipt of additional cancer treatment that occurred at least 15 months after cancer diagnosis; the relapse/cancer-specific mortality outcome was defined as death due specifically to cancer or receipt of additional treatment in this time frame. Follow-up time was calculated from cancer diagnosis until the earlier of either event.

[c] Numbers lower than 11 are not reported in accordance with the Surveillance, Epidemiology, and End Results–Medicare data use agreement.

detailed cancer treatment data, perhaps the most important determinant of prognosis. Our use of the SEER-Medicare linked database allowed us to adjust for the treatment effect of first-course cancer regimens on patient outcomes. This approach is important given the lower cancer treatment rates often observed in the HIV-infected patient population with cancer.[6-8] Our observation of a persistent survival disparity after adjusting for available first-year cancer treatment data suggests that health care differences are not the sole driver of poor cancer outcomes in the HIV population.

The SEER-Medicare data set also offered the opportunity to examine HIV in relation to relapse after initial cancer therapy.

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It must be noted that using administrative claims for classifying retreatment will not capture relapse in patients with poor prognosis for whom cancer-directed treatment is withheld. We therefore chose to combine retreatment with mortality after initial therapy to capture relapses even in patients offered palliative care. Incorporation of this additional cancer-specific metric is important because relapse has direct clinical implications, and future work should consider using more precise approaches to examining relapse/recurrence. For example, a prior clinical series of patients with cervical cancer in Brazil used a detailed medical record review to document high rates of relapse in HIV-infected women.[15]

We hypothesize that HIV-associated immunosuppression plays a direct role in affecting tumor behavior and patient outcomes. This is supported by the ever-growing body of evidence demonstrating the utility of immunotherapies for improving cancer outcomes,[16-19] as well as data demonstrating impaired cancer survival in immunosuppressed transplant recipients.[20] Of note, HIV is associated with worse outcomes across a range of cancers with different etiologies, implying a broad role for HIV-associated immunosuppression in controlling cancer after a tumor has been diagnosed.

Strengths of the present study include its nationally representative sample of elderly patients with cancer. As the HIV population in the United States continues to age, studies of this age group (≥65 years) are becoming increasingly relevant. In addition, the availability of detailed treatment data was an important and novel contribution of this study. Finally, the inclusion of control comorbidities allowed us to verify the unique association between HIV, rather than generally poor health, and elevated cancer-specific mortality.

Limitations

This study was not without limitations. Although nationally representative, the SEER-Medicare database includes claims only for adults 65 years or older who do not have health maintenance organization coverage, potentially limiting its generalizability. In addition, the SEER-Medicare data set overrepresents urban regions.[10,11] Another potential limitation is that treatment data derived from Medicare administrative claims may be prone to coding variation across time and location and/or hospital. Finally, we lacked information on specific metrics of immunosuppression (eg, CD4 T-cell counts); this information should be included in future studies to establish a direct biological link between the severity of HIV infection and worse cancer outcomes.

Conclusions

In this nationally representative sample of the aging HIV population in the United States, HIV was associated with an elevated risk of overall and cancer-specific mortality. HIV-infected patients with prostate or breast cancer appeared to be at particularly increased risk of worse outcomes, even after adjustment for available data on first-year cancer treatments. As the HIV population continues to age, the association of HIV infection with poor breast and prostate cancer outcomes will become increasingly relevant, especially because prostate cancer is projected to become the most common malignant neoplasm in the HIV population in the United States by 2030.[21] Research on clinical strategies to improve outcomes in HIV-infected patients with cancer is warranted.

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Drafting of the manuscript: Coghill.
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Study supervision: Engels.
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