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Risk Factors for Human Papillomavirus-Associated Cancers Among People Living with HIV in Washington, District of Columbia

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Abstract

District of Columbia (DC) has high rates of HIV infection and human papillomavirus (HPV)-associated cancers. People living with HIV (PLWH) are at risk for developing HPV-associated cancers. Previous studies identified factors that may further increase the risk of HPV-associated cancer among PLWH such as age, race/ethnicity, sex, risk factor for HIV transmission, stage of HIV infection, and age at HIV diagnosis. The extent to which PLWH in DC are affected by HPV-associated cancers has not previously been well described, and to our knowledge, the relationship between bacterial sexually transmitted infections (STIs) and subsequent development of HPV-associated cancer among PLWH in DC has not been explored. This was a retrospective case–control analysis of surveillance data on cancer, STIs, and HIV in Washington, DC from 1996 to 2015. There were 20,744 PLWH included in this study, of whom 335 (1.6%) had been diagnosed with an HPV-associated cancer. Among males living with HIV (MLWH), for every additional STI per 10 person-years, risk of developing an HPV-associated cancer increased by 11%. Exposure to STIs was not a significant risk factor for HPV-associated cancer among

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Authors' Contributions

All authors collaborated to conceive this research project. A.V.W., K.A.D., B.W.F., and R.K.D. developed the analytical plan. A.A. and A.W. verified the analytical methods. A.V.W. completed the analysis with assistance from K.A.D. B.W.F. and R.K.D. supervised the findings of this research and contributed to this research equally. All authors have discussed and reviewed the results and contributed to the final article.

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females. Ever being diagnosed with stage three HIV infection increased risk of HPV-associated cancers among males by 109% and females living with HIV by 111%. STI exposures were associated with HPV-associated cancers among MLWH in DC and ever being diagnosed with advanced HIV infection was associated with HPV-associated cancers among all PLWH. Clinicians treating MLWH should ensure their patients receive primary HPV infection prevention and HPV-associated cancer screenings.

Keywords

HIV; HPV-associated cancer; sexually transmitted infection

Introduction

Prior research has documented an increased incidence of several human papillomavirus (HPV)-associated cancers among people living with HIV (PLWH).[1–4] However, this association has yet to be examined in the District of Columbia (DC), which has high rates of both HPV-associated cancers and HIV.[1,5] Among DC residents, the incidence of HPV-associated cancers was 14.3 cases per 100,000 population from 2008 to 2012, tied for the second highest rate in the United States.[1] One reason for DC's high rate of HPV-associated cancers may be its high rate of HIV infection, as 1.8% of the population in DC is living with HIV, and its new diagnosis rate was the highest in the United States at 39.1 per 100,000 people in 2018.[5,6] The incidence rate of HPV-associated cancers is higher for PLWH than the general population.[2–4,7]

Older White men with HIV are diagnosed with anal cancer more frequently than other age/ethnicity groups, whereas Black and Hispanic men of all ages with HIV are at higher risk for penile cancer.[4] Men who have sex with men (MSM) have increased risk for anal cancer, and men who acquired HIV through injection drug use (IDU) had increased risk for penile cancer compared with PLWH with other HIV transmission risk factors.[4] Among PLWH, the incidence of anal and cervical cancer is rising.[7–10] Anal cancer among PLWH has been associated with being male, stage three HIV disease, MSM transmission, and longer duration of HIV infection.[8–15] People living with stage three HIV are at increased risk for HPV-associated cancer, which may be partially explained by immunodeficiency increasing risk for HPV infection.[4]

HPV-associated cancers are often attributable to infection with a high-risk strain of HPV at that anatomical site.[16,17] PLWH are also at increased risk for HPV infection.[2,3] Compromised immune systems may be the mediator behind this increased risk as the odds of a prevalent HPV infection at the anus, cervix, oropharynx, penis, vagina, and vulva increase as an individual's CD4 level decreases.[2]

In addition to HPV infection, PLWH are at high risk for gonorrhea, chlamydia, and syphilis.[18–22] Increased risk for bacterial sexually transmitted infections (STIs) may be associated with immune dysfunction as well as certain sexual behaviors among PLWH.[18–20] For PLWH, having an STI is an independent risk factor for HPV infection and HPV-associated cancer.[23–25] History of gonorrhea and/or chlamydia infection increases

the likelihood of prevalent HPV infection and HPV-associated cancers among the general population; however, this association is not yet well understood among PLWH.[23–25]

Owing to the established associations between STIs, HPV infection, and HIV infection, it is plausible that the height-ened risk for HPV-associated cancers among PLWH could be assessed by exposure to bacterial STIs. To our knowledge, the relationship between STIs and HPV-associated cancer development among PLWH has not been explored, nor has the extent to which PLWH in DC are affected by HPV-associated cancers. We quantified the prevalence of HPV-associated cancers among PLWH in DC and examined history of STIs, HIV transmission risk factors, and HIV infection stage as potential risk factors for cancer development.

Materials and Methods

Study design

This was a retrospective case–control analysis of surveillance data from the DC Cancer Registry, HIV, and STD surveillance databases at the DC Department of Health. Matching across the databases was based on name, date of birth, and address.

Human subjects protections

All procedures, including a waiver of informed consent, were approved by the DC Department of Health Institutional Review Board (IRB) before implementation. The George Washington University IRB deemed its review was not necessary.

Inclusion criteria

The study sample included people diagnosed with HIV in the DC on or before December 31, 2014 (n = 20,744), verified and documented in the DC HIV surveillance system (Enhanced HIV/AIDS Reporting System), and had evidence of DC residence in the HIV surveillance system from 1996 to 2015. Data from HIV surveillance (through 2018) or the cancer registry (through 2015) were used to approximate current residence at the end of the analytical follow-up time (2015). If there was any evidence of DC residence at the end of the analysis period, individuals were included. The study population was limited to DC residents because if someone moved away, DC Department of Health may not receive reports of STIs or cancers.

HPV-associated cancer outcome

The outcome variable was the first HPV-associated cancer diagnosis for an individual at least 1 year after HIV diagnosis (Fig. 1), between 1997 and 2015. HPV-associated cancer was a composite group of anal, cervical, oropharyngeal, penile, vaginal, or vulvar cancer. Cases were those with an HPV-associated cancer between 1997 and 2015 (n = 335). Controls were those without an HPV-associated cancer (n = 20,409). For individuals with HPV-associated cancer, we described age at HPV-associated cancer diagnosis and calculated survival time after cancer diagnosis.

STI exposure

Cases and controls were retrospectively assessed to determine exposure to STIs. STI events were defined as an incident case of gonorrhea, chlamydia, or primary or secondary syphilis occurring during the STI exposure period as defined hereunder. The STI surveillance data contained specimen collection dates for all positive STI laboratory results. If a repeat STI laboratory occurred within 7 days of the specimen collection date of the first STI laboratory report, it was not counted as a separate event. To be considered a unique STI exposure and not a concurrent (single) exposure, gonorrhea (or chlamydia) and syphilis infection had to occur separately for one individual by >7 days.[26] To be considered unique and sequential STI exposures, gonorrhea and chlamydia infection diagnosis date had to occur separately for one individual by >30 days.[26]

The STI rate was calculated as the number of diagnosed STIs per 10 person-years of STI exposure time starting in 1996, which was the earliest year that STI data were available. For cases, the STI exposure period start date was the later date of 1996 or age 16, and the STI exposure period end date was 1 year before cancer diagnosis. This was due to the nature of the outcome, as cancer is slow-growing and may not be immediately identified. An STI within 1 year of cancer diagnosis may not have contributed to the cancer's development. For controls, the STI exposure period start date was the later date of 1996 or age 16, and the STI exposure period end date was December 31, 2014. STI exposure time began after age 16 because, based on data from the Youth Behavioral Risk Surveillance survey conducted in the DC, sexual debut occurs most commonly at age 16.[27]

Covariates

Covariates included age at HIV diagnosis, race/ethnicity, sex, stage of HIV infection, pre-highly active antiretroviral therapy (HAART) era HIV diagnosis, risk factor for HIV transmission, and history of an STI (primary, secondary, or latent syphilis, gonorrhea, and chlamydia). Age at HIV diagnosis was used to estimate age during the follow-up period as follow-up did not start until HIV was diagnosed. Race/ethnicity categories were non-Hispanic Black, non-Hispanic White, Hispanic, and Other. "Other" race category combined the following races due to low frequencies (<3% of sample): Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, legacy Asian/Pacific Islander, and Multiracial groups. Sex was defined as birth sex; if birth sex was missing, then current gender was used to define sex.

Stage of HIV infection was dichotomized as ever stage three (AIDS) versus never stage three; criteria used to define stage were based on the 2014 surveillance case definition.[28] Pre-HAART era HIV diagnosis was dichotomized as HIV diagnosis on or before December 31, 1996, versus on or after January 1, 1997. Invasive cervical cancer is considered an AIDS-defining illness[29]; however, this would not necessarily documented at the time of stage three classification. HIV transmission categories were MSM, heterosexual contact, IDU, other, or unknown. "Other" risk factors for HIV transmission were hemophilia or transfusion, perinatal transmission, and child other confirmed risk. Those with both an MSM and IDU risk factor were included in the MSM category for this analysis because we

believed MSM as a transmission risk factor would be more related to HPV-related cancers versus IDU.

Statistical analysis methods

All analysis procedures were carried out using SAS 9.4 (SAS Institute, Cary NC). Descriptive statistics were generated to illustrate the sample's demographics and disease characteristics. Survival time was calculated for those with cancer (time from cancer diagnosis to death) and without cancer (time from HIV diagnosis to death); curves are not shown. Chi-square *p*-values were generated for demographic and HIV disease characteristics to examine significant associations at the $p < .05$ level. Unadjusted and adjusted Poisson regression models were generated to estimate each association of interest.

Sex was found to be an effect modifier of the association between STIs and HPV-associated cancer based on stratum-specific analyses, so all regression models were stratified by sex. For males and females, unadjusted models were created to determine the effect of predictors (history of STIs, risk factor for HIV transmission, HIV infection stage, and pre-HAART era HIV diagnosis) on HPV-associated cancer development. Adjusted models controlled for all predictors, age at HIV diagnosis, and race/ethnicity based on confounders controlled for in similar studies,[7,9–11] and significant differences identified through chi-squares and confounder risk ratios.

Results

There were 20,744 PLWH residing in DC from 1996 to 2015 who were included in analyses and an additional 14,593 PLWH without evidence of DC residence who were eliminated from analyses. Most PLWH included in analyses were male (71.3%) and Black (75.9%) (Table 1). A total of 1.6% were diagnosed with an HPV-associated cancer, and 23.8% had experienced an STI (Fig. 1). MSM status was the most common risk factor for HIV transmission (42.5%), and a majority had ever had stage three HIV infection (67.3%) (Table 1). Among those with an HPV-associated cancer (1.6%), the median time from HIV to cancer diagnosis was >9 years. Anal cancer was the most common HPV-associated cancer (59.1%) (Table 2). Median age at cancer diagnosis was the youngest for cervical (39 years) and the oldest for penile (54 years) cancer. Males accounted for the most cancer diagnoses (60.3%), as did Black individuals (71.1%) (Table 2).

Rate of STIs per 10 person-years was significantly associated with HPV-associated cancer development among males (Table 3). Among males, after adjusting for HIV transmission risk factor, stage of HIV infection, pre-HAART HIV diagnosis (on or before December 31, 1996), race/ethnicity, and age at HIV diagnosis, every STI per 10 person-years increased risk for an HPV-associated cancer by 11% (adjusted risk ratio: 1.11, 95% confidence interval [CI]: 1.05 to 1.18) (Table 3). Among females, rate of STIs per 10 person-years was not significantly associated with increased risk of an HPV-associated cancer.

Risk factors for HIV were significantly associated with HPV-associated cancer diagnosis among males and females. MSM had 2.85 (95% CI: 1.38 to 5.88) times the risk of cancer compared with those with heterosexual contact after adjusting for STIs per 10 person-years,

stage of HIV infection, pre-HAART era HIV diagnosis, race/ethnicity, and age at HIV diagnosis (Table 3). Female IDUs had 1.52 (95% CI: 1.03 to 2.25) times the risk of cancer compared with those with heterosexual contact after adjusting for STIs per 10 person-years, stage of HIV infection, pre-HAART HIV diagnosis, race/ethnicity, and age at HIV diagnosis (Table 3).

Ever having had stage three HIV infection was significantly associated with HPV-associated cancer among both males and females. Males who had ever had stage three HIV infection had 2.09 times the risk (95% CI: 1.41 to 3.09) of cancer and females who had ever had stage three HIV infection had 2.11 times the risk (95% CI: 1.27 to 3.49) of cancer compared with those who had never had stage three HIV infection after adjusting for STIs per 10 person-years, transmission risk factor, pre-HAART era HIV diagnosis, race/ethnicity, and age at HIV diagnosis (Table 3).

Pre-HAART era HIV diagnosis was significantly associated with HPV-associated cancer among males. Males diagnosed with HIV on or before December 31, 1996 had 2.33 times the risk (95% CI: 1.72 to 3.18) of HPV-associated cancer compared with those who were diagnosed on or after January 1, 1997, after adjusting for STIs per 10 person-years, HIV transmission risk factor, HIV infection stage, race/ethnicity, and age at HIV diagnosis (Table 3). Pre-HAART era HIV diagnosis was not associated with HPV-associated cancer among females.

Of the 335 individuals who developed an HPV-associated cancer, 100 died during follow-up (29.9%). This included 63 anal, 27 cervical, 3 oropharyngeal, 1 penile, 5 vaginal, and 1 vulvar cancer cases. Among those who died, the median survival time (time from cancer diagnosis to death) was 1.4 years (interquartile range [IQR]: 4.0). Vaginal cancer cases had the longest survival time ($\mu = 5.3$ years, IQR: 3.9) and oropharyngeal cancer cases had the shortest survival time ($\mu = 0.5$ years, IQR: 0.4). Approximately 31% of individuals without an HPV-associated cancer died during follow-up ($n = 6{,}324$). Of these individuals, the median survival time (time from HIV diagnosis to death) was 6.0 years (IQR: 8.9).

Discussion

HPV-associated cancers were identified among 1.6% of the PLWH in our sample, a higher rate than has previously been observed in the overall population.[1] We identified several risk factors for HPV-associated cancers among males living with HIV (MLWH) and females living with HIV in DC. Consistent with previous research, there were more MLWH in DC, and so most HPV-associated cancers occurred among males.[4,8–10] MLWH may have had more HPV-associated cancers as they account for the most HIV cases overall and are at higher risk for HPV-associated cancers that affect both men and women: anal and oropharyngeal cancers.[4]

This is discrepant from HPV-associated cancer distribution among the general population, where females were found to have a higher rate of anal cancer.[1] Females living with HIV may experience a higher rate of HPV-associated cancers due to their risk for cancer development in the female-specific reproductive organs: cervical, vaginal, and vulvar

cancers. Most (70%) individuals who developed an HPV-associated cancer were alive at the end of the follow-up period. Consistent with previous research, survival time was the shortest for oropharyngeal cancer cases, who lived <1 year after cancer diagnosis.[30] PLWH should routinely undergo screening for oropharyngeal cancer to ensure early detection and better outcomes.[31]

Racial disparities were present, with HPV-associated cancers occurring most frequently among Black individuals in DC. This was driven by higher proportions of cervical, penile, oropharyngeal, vaginal, and vulvar cancers among Black individuals, potentially aligning with previous studies that identified that Black people were at increased risk for HPV-associated cancers.[4] However, this differs from HPV-associated cancer distribution among the general population, where previous studies have observed that White people have higher rates of vulvar and oropharyngeal cancers compared with Black people.[1]

The high frequency of anal cancers that occurred among White people in this sample may have confounded the association between race/ethnicity and all types of HPV-associated cancer. This is consistent with previous literature, as older White men had the highest risk for anal cancer.[4] Future analyses should examine how this association affects individuals across multiple groups, including any differences among racial/ethnic groups by age and sex. In addition, clinical research could explore the extent of racial disparities for specific types of HPV-related cancers among PLWH, as well as reasons for these disparities. Contributing factors may include differential exposure to carcinogens, access to health care, care-seeking behaviors, and psychosocial stress.[32,33]

MSM and IDU risk categories for HIV transmission were both identified as risk factors for HPV-associated cancer among males and females, respectively, compared with the heterosexual risk category. This was consistent with previous research, which identified MSM and IDU as at increased risk for HPV-associated cancers.[4] MSM represented the largest risk factor for HIV transmission group, and anal cancer was the most common HPV-associated cancer, which is unsurprising as MSM status has been correlated with risk for anal cancer.[4]

IDU may be at higher risk because they are a medically underserved community who are less likely to receive early cancer screening and may engage in risky sexual behavior.[4,34] Ever being diagnosed with stage three HIV infection was also a significant risk factor for HPV-associated cancer among males and females, which supports previous findings that HIV disease severity, specifically immunosuppression, increases cancer risk.[8–10] HIV diagnosis in the pre-HAART era was significantly associated with cancer development among males only, which may be due in part to lack of effective antiretroviral therapy and treatment access difficulties in the early 1990s.[35]

Previous research has identified that having an STI may be associated with HPV coinfection.[23–25] In our analysis, the rate of STIs per 10 person-years was a risk factor for HPV-associated cancer among males, but not females, living with HIV. This indicates that higher rates of STIs increase the likelihood of concurrent HPV infection in men. This is significant for PLWH, as HPV infection continues longer and is more likely to result in

cancer when HIV is present.[2,3] Therefore, more exposure to HPV indicated by exposure to STIs increases the opportunity for HPV to cause cancer in a cancer-prone environment.

However, given that the association was observed among males but not females, exposures to HPV may differentially affect cancer development based on the site of disease. Research has suggested that biological sex differences in genetic expression may influence the course of HPV-associated cancers, which are known to be clinically distinct among males and females.[36] Given established sex differences, future research should aim to identify the biological interactions resulting from repeat STI exposure that occur differentially among the sexes and could lead to HPV-associated cancer.

The strengths of this study include the large sample size (n = 20,744) and jurisdiction-wide surveillance data. These data are subject to scrutiny by monitoring entities and are collected through validated methods to ensure accuracy and completeness. However, some incomplete data limited the scope of this study. Underreporting is inherent to surveillance data, and HIV surveillance data are more accurate after 2006 as a result of the switch to name-based reporting in DC.[5] The completeness of STI surveillance data has also improved over time: the data management system was upgraded in 2013 and electronic laboratory reporting started in 2017.

Bacterial STIs diagnosed during the early years of follow-up may be underestimated, which is significant as HPV-associated cancers are slow-growing. The cancer cases may have been underrepresented as a cancer case was mutually exclusive and the first event was the outcome. If an individual was diagnosed with multiple HPV-associated cancers, subsequent cancers that took longer to develop would not have been captured in this analysis. Cancer data were not available past 2015, and so cases that developed for those diagnosed with HIV in the later years of follow-up may similarly have been missed.

In addition, we accounted for out-migration by only including those individuals with a current DC residence after the follow-up period in the analytical sample, which may have resulted in an underestimation of the number of PLWH in DC through 2015. The possibility of underrepresentation of the population, outcome, and exposure in this study indicates that the observed estimates are conservative. Taking the limitations of surveillance data into consideration, the results should be understood through the perspective that they may provide an incomplete picture of the sample, outcome, or exposure.

Despite its limitations, this study identified that STI exposures, MSM or IDU status, and ever being diagnosed with stage three HIV infection could be potential risk factors for HPV-associated cancer among PLWH. There are current clinician guidelines available on screening, diagnosing, and treating HPV-associated cancers among PLWH.[37] Compared with the general population, PLWH should receive HPV-associated cancer screenings routinely throughout their lifespan.[37] The results of this study support strengthening HPV-associated cancer screening recommendations for PLWH, especially those who are MSM, IDU, have been diagnosed with stage three infection, and/or have a history of STIs. PLWH should also be prioritized for primary HPV infection prevention, including vaccination and STI prevention.

The Health Resources and Services Administration should strongly consider including HPV vaccination as a performance measure for recipients of the Ryan White HIV/AIDS Program to ensure patients are being linked to this care.[38] Clinicians must be aware that their patients with HIV, especially those with advanced disease, have an increased risk of HPV-associated cancers and should follow more stringent prevention and screening guidelines.[38] This research should be replicated beyond DC and similar analyses should be completed in settings with more complete data. If confirmed, the associations identified here may help inform targeted screening and prevention measures to prevent a debilitating disease in an especially vulnerable population.

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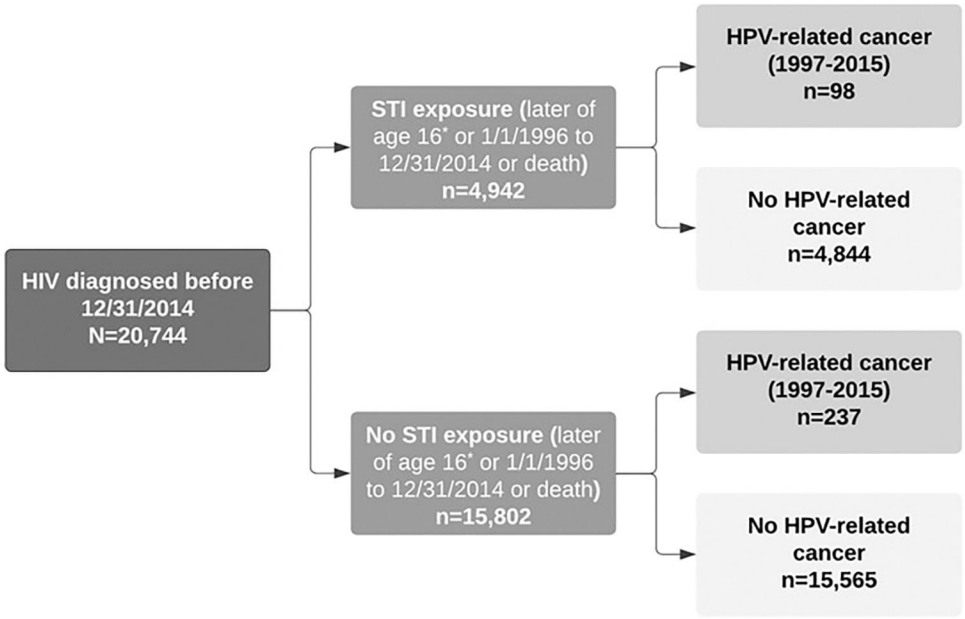

FIG. 1.

Case–control identification of STI exposures and HPV-associated cancers among PLWH in DC, 1996–2015 (*N* = 20,744). *If first STI occurred before age 16, that date was used as the start date of the STI exposure period. DC, District of Columbia; HPV, human papillomavirus; PLWH, people living with HIV; STI, sexually transmitted infection.

Table 1.

Demographic and Clinical Characteristics of People Living with HIV in District of Columbia from 1996 to 2015

		Cancer status			*STI history*		
	***Total sample*, n (%)**	***HPV-associated cancer*, n (%)**	***No HPV-associated cancer*, n (%)**	***Cancer vs. no cancer* (p)**	***History cf STI*, n (%)**	***No history cf STI*, n (%)**	***STIs vs. no STIs* (p)**
Total	20,744 (100)	335 (1.6)	20,409 (98.4)	N/A	4,942 (23.8)	15,802 (76.2)	N/A
Median age at HIV diagnosis (years) (IQR)	37.1 (15.9)	34.9 (14.6)	37.2 (16.0)	<.0001	32.3 (14.9)	38.6 (15.7)	<.0001
Median time from HIV diagnosis to cancer diagnosis in years (IQR) (among those with cancer)	N/A	9.5 (10.0)	N/A	N/A	9.3 (9.1)	9.6 (9.9)	.51
Sex[a]							
Male	14,792 (71.3)	202 (60.3)	14,590 (71.5)	<.0001	3,664 (74.1)	11,128 (70.4)	<.0001
Female	5,843 (28.2)	133 (39.7)	5,710 (27.9)		1,264 (25.6)	4,579 (28.9)	
Race/ethnicity[a]							
NH Black	15,752 (75.9)	238 (71.1)	15,514 (76.0)	.01	3,787 (76.6)	11,965 (75.7)	.002
NH White	2,804 (13.5)	67 (20.0)	2,737 (13.4)		668 (13.5)	2,136 (13.5)	
Hispanic	1,148 (5.5)	15 (4.5)	1,133 (5.55)		250 (5.1)	898 (5.7)	
Other[b]	812 (3.9)	14 (4.2)	798 (39.1)		205 (4.2)	607 (3.8)	
Risk factor for HIV transmission[c]							
MSM[d]	8,805 (42.5)	163 (48.7)	8,642 (42.3)	.0002	2,536 (51.3)	6,269 (39.7)	<.0001
Heterosexual contact	4,119 (19.9)	64 (19.1)	4,055 (19.9)		940 (19.0)	3,179 (20.1)	
IDU	3,925 (18.9)	73 (21.8)	3,852 (18.9)		609 (12.3)	3,316 (20.9)	
Other	3,895 (18.8)	35 (10.5)	3,860 (18.9)		857 (17.3)	3,038 (19.2)	
Stage of HIV infection							
Never diagnosed with stage 3 HIV infection	6,775 (32.7)	54 (16.1)	6,721 (32.9)	<.0001	2,014 (40.8)	4,761 (30.1)	<.0001
Ever diagnosed with stage 3 HIV infection	13,969 (67.3)	281 (83.9)	13,688 (67.1)		2,928 (59.3)	11,041 (69.9)	
Pre-HAART era HIV diagnosis							
Diagnosed on or before December 31, 1996	5,484 (26.4)	156 (46.6)	5,328 (26.1)	<.0001	809 (16.4)	4,675 (29.6)	<.0001
Diagnosed on or after January 1, 1997	15,260 (73.6)	179 (53.4)	15,081 (73.9)		4,133 (83.6)	11,127 (70.4)	

[a]Unknowns excluded from table where unknown <3% of sample.

[b] Other race category included Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, legacy Asian/Pacific Islander, and Multiracial groups.

[c] Other risk factor for HIV transmission includes hemophilia/transfusion, perinatal transmission, and child other confirmed risk.

[d] Risk factor of MSM and IDU was included in the MSM category for purposes of analysis.

HAART, highly active antiretroviral therapy; HPV, human papillomavirus; IDU, injection drug use; IQR, interquartile range; MSM, men who have sex with men; N/A, not applicable; NH, non-Hispanic; STI, sexually transmitted infection.

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Table 2.

Distribution of Human Papillomavirus-Associated Cancer Types Among People Living with HIV in District of Columbia from 1996 to 2015

	All HPV-associated cancers, n *(%)*	*Anal,* n *(%)*	*Cervical,* n *(%)*	*Oropharyngeal,* n *(%)*	*Penile,* n *(%)*	*Vaginal,* n *(%)*	*Vulvar,* n *(%)*
Total	335 (100)	198 (59.1)	95 (28.4)	13 (3.9)	6 (1.8)	10 (2.9)	13 (3.9)
Median age at cancer diagnosis (years) (IQR), overall and by cancer site	46.0 (11.0)	48.0 (11.0)	39.0 (15.0)	46.0 (8.0)	54.0 (15.0)	44.0 (22.0)	41.0 (11.0)
Sex							
Male	202 (60.3)	187 (94.4)	N/A	9 (69.2)	6 (100)	N/A	N/A
Female	133 (39.7)	11 (5.6)	95 (100)	4 (30.0)	N/A	10 (100)	13 (100)
Race/ethnicity[b]							
NH Black	238 (71.1)	114 (57.6)	86 (90.5)	11 (84.6)	6 (100)	9 (90.0)	12 (92.3)
NH White	67 (20.0)	64 (32.3)	2 (2.1)	1 (7.7)	0 (0)	0 (0)	0 (0)
Hispanic	15 (4.5)	11 (5.6)	3 (3.2)	0 (0)	0 (0)	0 (0)	1 (7.7)
Other[a]	14 (4.2)	8 (4.0)	4 (4.2)	1 (7.7)	0 (0)	1 (10.0)	0 (0)
Time from HIV diagnosis to cancer diagnosis (years)							
<5	81 (24.2)	37 (18.7)	36 (37.9)	2 (15.4)	0 (0)	3 (30.0)	3 (23.0)
5–10	95 (28.4)	54 (27.3)	26 (27.4)	5 (38.5)	1 (16.7)	4 (40.0)	5 (38.5)
>10	159 (47.5)	107 (54.0)	33 (34.7)	6 (46.2)	5 (83.3)	3 (30.0)	5 (38.5)
Pre-HAART era HIV diagnosis							
Diagnosed on or before December 31, 1996	156 (46.6)	105 (53.0)	30 (31.6)	7 (53.9)	4 (66.7)	4 (40.0)	6 (46.2)
Diagnosed on or after January 1, 1997	179 (53.4)	93 (47.0)	65 (68.4)	6 (46.2)	2 (33.3)	6 (60.0)	7 (53.9)

[a] Other race category included Asian, American Indian/Alaskan Native, Native Hawaiian/Pacific Islander, legacy Asian/Pacific Islander, and Multiracial groups.

[b] Unknowns excluded from table where unknown <3% of sample.

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Table 3.

Risk Ratios (Unadjusted and Adjusted) of Human Papillomavirus-Associated Cancers Among People Living with HIV in District of Columbia from 1996 to 2015

	RR (95% CI)	p	*Adjusted RR[a] (95% CI)*	p
Model 1: Among males living with HIV				
STIs per 10 person-years	1.08 (1.01 to 1.16)	.03	1.11 (1.05 to 1.18)	.001
Risk factor for HIV transmission				
Heterosexual contact	REF		REF	
MSM[b]	3.59 (1.77 to 7.29)	.0004	2.85 (1.38 to 5.88)	.005
Other or unknown[c]	1.16 (0.48 to 2.81)	.74	1.31 (0.54 to 3.16)	.55
IDU	1.54 (0.67 to 3.54)	.31	1.17 (0.51 to 2.69)	.72
HIV infection stage				
Never diagnosed with stage 3 HIV infection	REF		REF	
Ever diagnosed with stage 3 HIV infection	2.37 (1.65 to 3.42)	<.0001	2.09 (1.41 to 3.09)	.0003
Pre-HAART era HIV diagnosis				
HIV diagnosed on or after January 1, 1997	REF		REF	
HIV diagnosed on or before December 31, 1996	3.00 (2.28 to 3.96)	<.0001	2.33 (1.72 to 3.18)	<.0001
Model 2: Among females living with HIV				
STIs per 10 person-years	1.07 (0.99 to 1.15)	.07	1.04 (0.95 to 1.13)	.39
Risk factor for HIV transmission				
Heterosexual contact	REF		REF	
Other or unknown[c]	0.62 (0.38 to 1.02)	.06	0.64 (0.38 to 1.06)	.08
IDU	1.52 (1.05 to 2.21)	.03	1.52 (1.03 to 2.25)	.04
HIV infection stage				
Never diagnosed with stage 3 HIV infection	REF		REF	
Ever diagnosed with stage 3 HIV infection	2.61 (1.60 to 4.23)	.0001	2.11 (1.27 to 3.49)	.004
Pre-HAART era HIV diagnosis				
HIV diagnosed on or after January 1, 1997	REF		REF	
HIV diagnosed on or before December 31, 1996	1.85 (1.29 to 2.64)	.0007	1.06 (0.71 to 1.57)	.79

[a]Each multivariable model included the variables of interest plus age at HIV diagnosis and race/ethnicity.

[b] Risk factor of MSM and IDU was included in the MSM category for purposes of analysis.

[c] Other risk factor for HIV transmission included hemophilia/transfusion, perinatal transmission, and child other confirmed risk. Unknown and other groups were combined for purposes of analysis, as there were no HPV-associated cancer cases in the "Other" category.

CI, confidence interval; RR, risk ratio.