Infection and Drug Resistance

Dovepress
Taylor & Francis Group

Open Access Full Text Article

REVIEW

Characteristics of HPV Infection in Women Cervical and Anal with HIV-Infected and the Advances in Epidemiological Research

Rong Xiao[1,2], Xue Yang[1], Rufei Duan[1], Hongping Zhang[1]

[1]Department of Gynecology, The Third Affiliated Hospital of Kunming Medical University, Yunnan Cancer Hospital, Peking University Cancer Hospital Yunnan, Kunming, Yunnan, People's Republic of China; [2]Department of Gynecology, Huize Maternal and Child Health Hospital, Huize, Yunnan, People's Republic of China

Correspondence: Hongping Zhang, Email kmzhp@126.com

Abstract: Antiretroviral therapy (ART) has significantly reduced the incidence and mortality of AIDS-related diseases, bringing the life expectancy of human immunodeficiency virus (HIV)-infected individuals close to that of uninfected individuals. However, the incidence and mortality rates of tumors associated with human papillomavirus (HPV) have not decreased. Persistent infection with high-risk HPV is a major cause of cervical cancer and other related malignancies, and the risk of HPV infection and the incidence of related diseases are higher among HIV-infected individuals. Although the World Health Organization provides screening recommendations for the general population, there is a lack of guidelines for cervical and anal cancer screening specifically in HIV-positive patients. Further research is urgently needed to develop effective preventive measures. This article reviews the epidemiological characteristics and associations of HPV infections and related cancers in HIV-infected women, providing reference for prevention and treatment.

Keywords: HIV, HPV, HR-HPV, cervical and anal infection

Introduction

As of the end of 2023, it is estimated that there are 39.9 million individuals infected with the human immunodeficiency virus (HIV) worldwide. In 2023, 630,000 people died from HIV-related diseases, and 1.3 million people new HIV infections were reported. Currently, 30.7 million HIV-positive individuals are receiving antiretroviral therapy (ART).[1] With the advent of highly effective antiretroviral therapies, the incidence and mortality of HIV-related diseases have significantly decreased, and the life expectancy of HIV-infected individuals has increased to nearly that of uninfected individuals.[2] However, the incidence and mortality of human papilloma virus (HPV)-related tumors in individuals with AIDS have not decreased. This may be due to the prolonged lifespan of AIDS patients post-treatment, allowing more time for precancerous lesions to progress to invasive cancer.[3] Persistent infection with high-risk human papillomavirus (HR-HPV) is the primary cause of cervical precancerous lesions and cervical cancer. While most HPV infections are self-limiting, persistent HR-HPV infection can lead to cervical cancer, other anogenital cancers, head and neck cancers.[4] Studies have shown that the prevalence of anal high-risk HPV infection and the rate of anal cytological abnormalities are elevated in cervical cancer patients,[5] and the risk of anal HR-HPV infection is higher in the context of ongoing HIV infection and cellular immunosuppression. HIV can increase the risk of HPV infection and promote the occurrence and progression of related diseases.[6] Although the World Health Organization (WHO) has provided screening recommendations for the general population, there is currently a lack of relevant guidelines and expert consensus regarding cervical and anal cancer screening for HIV-positive patients. Further research and practice in this area are needed to comprehensively understand the disease burden of HPV infection, cervical cancer, and anal cancer in HIV-positive women and to develop appropriate preventive measures. This article reviews and synthesizes relevant literature on HPV infection in the

Received: 11 December 2024
Accepted: 28 March 2025
Published: 8 April 2025

cervix and anus of women with HIV, highlighting the epidemiological characteristics and correlations, to provide references for the prevention and treatment of HPV-related cervical and anal tumors in HIV-infected patients.

HPV Infection in HIV-Infected Individuals

Correlation Between HIV Infection and HPV Infection

The relationship between HIV and HPV is complex, as both viruses share similar transmission routes, primarily through unprotected sexual contact with infected partners. Studies indicate that approximately 50% of young women will acquire HPV within three years of initiating sexual activity, with over 80% of infections being cleared by the immune system within 6 to 24 months. However, about 10% of women will experience persistent HR-HPV infections.[7] A multicenter study revealed that the risk of HPV infection approximately doubles in the presence of HIV, while the clearance rate of HPV is halved.[8] HIV promotes HPV infection by disrupting epithelial tight junctions.[9] Conversely, HPV infection can induce genital inflammation, compromise the vaginal barrier, and activate T cell influx, all of which are associated with an increased risk of HIV infection. HPV can also establish a latent state and reactivate, complicating HIV prevention strategies in high-risk individuals.[10] Among HIV-infected women, those with lower CD4+ cell counts are more likely to develop HPV-related female genital tumors compared to those with higher CD4+ counts, while patients with long-term undetectable HIV RNA levels exhibit a lower incidence of HPV-related female genital tumors.[11] Due to the targeting of CD4+ T cells by HIV, apoptosis and cellular exhaustion occur. HIV-related immunosuppression results in a reduced efficacy of cell-mediated, systemic, and local immunity, leading to a decreased pathogen clearance rate and consequently the persistent presence of one or more HPV genotypes in the anal-genital tract.[12] Another study involving 366,034 AIDS patients demonstrated that HIV-positive individuals have a significantly increased risk of all types of anogenital HPV-related tumors and their precursors compared to the general population, with this heightened risk primarily concentrated in the decade surrounding the diagnosis of AIDS.[13]

Characteristics of HPV-Related Tumors in HIV-Infected Individuals

Numerous researchers, including Tafadzwa G. Dhokotera, have conducted extensive studies on HPV-related tumors in HIV-infected individuals. A study involving 3,447,908 hIV-infected women in South Africa found that the risk of cervical cancer and other HPV-related cancers decreases as CD4 cell counts increase. Specifically, HIV-infected women with CD4 cell counts greater than 500 cells/μL have a cervical cancer risk ratio of 0.82 (95% CI: 0.77–0.88) compared to those with counts less than 200 cells/μL, the risk ratio for other HPV-related cancers is 0.62 (95% CI: 0.49–0.79). Similarly, HIV-infected women with an HIV RNA viral load greater than 1000 copies/mL have a higher risk of cervical cancer or other HPV-related cancers compared to those with a viral load of less than 1000 copies/mL (risk ratios: 1.32; 95% CI: 1.25–1.40 and 1.34; 95% CI: 1.11–1.63).[14] Persistent HR-HPV infection is a significant risk factor for the development of HPV-related vaginal cancer, penile cancer, anal cancer, head and neck cancers. Previous studies in the United States have shown that HPV DNA is detected in 91% of cervical cancers, 69% of vulvar cancers, 75% of vaginal cancers, 91% of anal cancers, 63% of penile cancers, 70% of oropharyngeal cancers, 32% of oral cancers, and 21% of laryngeal cancers.[15] A study conducted in Rwanda assessing the prevalence of HPV infection in various mucosal sites among HIV-infected individuals detected 12 types of high-risk HPV DNA (HPV 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59) and 2 types of low-risk HPV DNA in the cervix, oral cavity, penis, vagina, and anus. The results showed that all analyzed HPV DNA types were detected, with HPV 16, HPV 52, and HPV 35 being the most prevalent HR-HPV types. Specifically, HPV 16 accounted for 77%, 21%, 19%, 46%, 28%, 35%, and 11% of HR-HPV infections in the oral cavity, oropharynx, anus, cervix, vagina, and penis, respectively.[16] The prevalence of HPV infection in various mucosal sites among HIV-infected individuals is notably high. A 2020 study confirmed that HIV infection is associated with an increased risk of cervical cancer, oropharyngeal cancer, and anal cancer. In this cohort, each HIV-positive individual was matched with three HIV-negative controls based on gender, race, state, age, and year, followed for up to 10 years. A Cox proportional hazards model was established to compare the time to cancer diagnosis between HIV-positive and HIV-negative individuals, adjusting for demographic and comorbid attributes. The analysis included 110,898 hIV-positive and 332,694 hIV-negative women for cervical cancer; 226,837 hIV-positive and 680,511 hIV-negative individuals for

oropharyngeal cancer, and 226,654 hIV-positive and 679,962 hIV-negative individuals for anal cancer. The results indicated that the risk values for cervical cancer, oropharyngeal cancer, and anal cancer in HIV-positive women were 3.27, 2.55, and 12.88, respectively.[17] It indicates that individuals with HIV have a higher risk of developing HPV-related cancers, particularly anal cancer. According to statistics, cervical and anal cancers are the most common HPV-related tumors among HIV-infected individuals.[18]

Current Status of Cervical HPV Infection in HIV-Infected Individuals

Cervical cancer is the fourth most common malignancy tumor among women of reproductive age worldwide. The burden of this disease is particularly heavy in low- and middle-income countries, especially among women living with HIV.[19] Persistent infection with HR-HPV is the primary cause of cervical precancerous lesions and cervical cancer. It is estimated that there were 604,000 new cases and 342,000 deaths from cervical cancer in 2020, with the vast majority occurring in low-income countries and developing nations.[20] Since the advent of antiretroviral therapy for HIV, the incidence of HPV-related cancers has not decreased.[21] The co-infection of HIV and HPV significantly increases the risk of HPV-related cancers.[22] Reports indicate that in 2018, approximately 6% of new cervical cancer cases were co-infected with HIV globally, with 5% of these cases attributable to HIV infection.[23] Cervical cancer is also classified as an HIV-associated malignancy tumor.[24]

Studies have shown that the CD4+ T cell count in HIV-infected individuals is significantly lower than that in healthy populations. Consequently, if an HIV-positive individual also has HPV infection, the interval from HPV infection to the progression to cervical cancer is significantly shorter compared to HIV-negative individuals, and the incidence and mortality rates of cervical cancer are markedly increased.[25] The risk of cervical cancer in HIV-infected women is six times higher than that in uninfected women.[23] For cervical precancerous lesions or carcinoma in situ, evidence suggests that regardless of whether excisional or ablative treatments are used, the treatment failure rate is higher in HIV-infected women compared to HIV-negative women. A meta-analysis of literature published from January 1980 to May 2018 included HIV-infected women with cervical carcinoma in situ and precancerous lesions, analyzing the incidence of treatment failure (defined as residual and/or recurrent CIN2+/HSIL+ lesions post-treatment) and the odds ratio of treatment failure in HIV-infected versus uninfected women. The results indicated that the risk of treatment failure was doubled in HIV-infected women (n=821 hIV-positive) compared to HIV-negative women (n=1822 hIV-negative), with failure rates of 23.4% [95% CI 14.0–32.7] vs 9.5% [95% CI 5.8–13.2]; OR 2.7, 95% CI 2.0–3.5; I2: 0%; P = 0.7).[26] The World Health Organization has called for the elimination of cervical cancer, and HPV-based cervical cancer screening is recommended globally for both HIV-infected and uninfected women. However, specific screening strategies for women with AIDS are currently lacking, making it essential to explore cervical cancer screening strategies for this population.

Current Status of Anal HPV Infection in HIV-Infected Individuals

Anal squamous cell carcinoma is a rare tumor in the general population,[27] yet the risk of anal cancer is significantly elevated in HIV-infected individuals. Research shows that the incidence of anal cancer is low in the general population (<1/100,000),[28,29] but among HIV-infected individuals, the incidence can be as high as 46/100,000.[30] Annually, anal cancer accounts for approximately 20,000 new cancer cases globally, with nearly 90% attributed to HPV.[20,28] In meta-analyses of HPV-related cancers in HIV-infected populations, anal cancer has the highest standardized incidence rate.[31] Persistent infection with high-risk anal HPV, particularly HPV 16, can lead to high-grade squamous intraepithelial lesions (HSIL) and may progress to anal squamous cell carcinoma (ASCC).[32] Similar to other HPV-related cancers, the risk of anal cancer is increased by factors such as sexual contact with HPV-infected individuals, particularly through anal intercourse, HIV-related immunosuppression, and smoking.[33] In a study involving 2,229,234 hIV-infected individuals, the risk of anal cancer was found to be 85/100,000.[34] A study of 200 hIV-infected individuals, including 169 men and 31 women, revealed a 59.8% positivity rate for anal HPV PCR testing (62.6% in men and 45.2% in women), identifying 17 different genotypes. The most common high-risk HPV types found in the anal canal are HPV 33 (35.3%), HPV 58 (20.6%), HPV 66 (18.6%), HPV 45 (17.6%), and HPV 16 (14.7%), with over 80% of participants harboring multiple genotypes.[35] The risk of progression to anal cancer due to persistent anal HPV infection is significantly increased in HIV-infected individuals. A two-year study involving 229 hIV-positive women collected anal swabs for cytological

examination every six months. The results showed that the incidence and cumulative risk of anal HSIL were notably high at 65.6% for those with anal cytological abnormalities and HR-HPV infection. Compared to those who were anal HPV-negative or cytologically negative, anal HR-HPV infection or anal cytological abnormalities were associated with an increased risk of developing HSIL after two years.[36] Research by Ingeborg et al indicated that nearly all HIV carriers with high-grade anal squamous intraepithelial lesions tested positive for high-risk HPV in both anal and urethral samples.[37]

Furthermore, the clearance rate of HPV infection is significantly lower in HIV-infected individuals. A study from China demonstrated that compared to HIV-negative individuals, HIV-positive patients exhibited lower clearance rates or higher persistence of HPV infections. This study recruited and followed 675 male HIV-infected patients, revealing that the three high-risk HPV types with the lowest clearance rates among baseline infections were HPV 52 (32.2/100 person-years), HPV 58 (38.1/100 person-years), and HPV 16 (43.5/100 person-years).[38] In high-income countries, the incidence of anal cancer among HIV-positive individuals has increased since the introduction of antiretroviral therapy and the subsequent rise in life expectancy.[39] This may be related to the prolonged duration of HR-HPV infection in HIV-infected individuals. However, there is currently limited data and few screening methods specifically for anal cancer in HIV-infected populations, necessitating further research.

Correlation Between Cervical and Anal HPV Infection in HIV-Infected Individuals

Current research has confirmed that women who test positive for cervical HR-HPV have a higher risk of developing vulvar, vaginal, and anal cancers, as well as precancerous lesions, compared to those who test negative for HR-HPV.[40] This suggests a close relationship between anal HPV infection and lower genital tract HPV infection, likely due to their anatomical proximity and similar mucosal tissue structure. This correlation aids in identifying at-risk populations for HPV-related anal and genital tumors and in risk assessment. A study conducted in Denmark observed that among cervical HR-HPV-positive women, older age, a history of high-grade anal or genital intraepithelial lesions, and lack of HPV vaccination were associated with a higher risk of vulvar, vaginal, and anal cancers.[40] Another retrospective study from Puerto Rico included 9489 women diagnosed with primary cervical, vaginal, or vulvar tumors between 1987 and 2013, finding that women with HPV-related primary gynecological tumors had a 3.3-fold increased risk of being diagnosed with secondary anal cancer compared to those with non-HPV-related primary gynecological tumors.[5] Research involving HIV-positive patients has also been conducted, with one study comprising 36 studies involving 15,521 women showing a strong correlation between cervical high-risk HPV positivity and anal high-risk HPV prevalence. In HIV-negative women, the prevalence of anal high-risk HPV was 43% among those with cervical high-risk HPV positivity, compared to 9% among those who were cervical high-risk HPV negative. In HIV-positive women, these proportions were 62% for HPV-positive women and 33% for HPV-negative women. Among HIV-negative women, the prevalence of anal HPV 16 was 41% in those who were cervical HPV 16 positive, compared to 2% in those who were cervical HPV 16 negative; in HIV-positive women, the corresponding proportions were 46% and 11%.[41] This not only indicates a strong correlation between cervical and anal HPV infections but also highlights that this association is stronger in HIV-positive patients. The study further revealed that single infections had a higher correlation than multiple infections, with HPV 16 being the most prominent. Among women with cervical HPV 16 positivity, the prevalence of anal HPV 16 in cervical cancer cases reached 66%, and HSIL was more common among cervical HPV 16-positive women compared to those with non-HPV 16 high-risk types. In this study, cervical high-risk HPV infection, cervical cytological diagnoses, HIV status, and their combinations are significant determinants of anal cancer risk in women. The strongest determinant identified is cervical cancer and cervical HPV 16 positivity.[19]

A domestic study also indicated that among HIV-infected women in China, the prevalence of cervical and anal HPV infections, abnormal cytology, and cervical intraepithelial neoplasia grade II or higher (CIN2+) is notably high. Furthermore, cervical and anal HPV infections are closely related, with markers of HIV-related immunodeficiency, including short duration of combined antiretroviral therapy (cART), low CD4 counts, and high initial HIV viral loads, all increasing the risk of anal and genital HPV infections and associated tumors.[42] Some researchers suggest that there may

be differences in susceptibility to cervical and anal infections and related lesions among HIV-positive patients. Despite the high incidence of anal HPV, the progression of HPV-related lesions in the cervix and anus does not occur in the same manner. In a study involving HIV patients, cervical and anal cytology and HPV DNA testing were performed, revealing a ratio of 4.3 for the number of anal HPV infections to anal HPV-related lesions, compared to a ratio of 2.5 for cervical HPV infections to cervical HPV-related lesions. This suggests a higher prevalence of cervical HPV-related lesions, potentially linked to the dynamic changes in the cervical squamocolumnar junction epithelium due to hormonal fluctuations.[33] It may also be related to the differences in HPV infection types at the cervical and anal sites in HIV-infected individuals. A study involving 409 women with HIV showed significant differences in the distribution of HPV genotypes at the cervical and anal regions. Specifically, the most common HPV genotypes in the cervix were HPV-52 (18.8%), HPV-16 (12.1%), and HPV-58 (10.1%), while the anal region was primarily dominated by HPV-52 (22.1%), HPV-53 (13.4%), and HPV-39 (9.7%).[42] These differences in genotype distribution may further influence the progression mechanisms of cancers at the cervical and anal sites.

Conclusion and Outlook

In recent years, significant progress has been made in the study of cervical HPV infections, from viral detection to exploration of infection mechanisms, yielding substantial results. However, research on anal HPV infections remains relatively lagging, with various complex factors contributing to this delay, including difficulties in case collection, limitations in research methodologies, and insufficient societal awareness. When both cervical and anal HPV infections coexist, the situation becomes even more complicated. Questions arise as to whether this co-infection exacerbates the condition, whether there is a correlation in viral loads between the two, and whether they jointly affect patient prognosis. These issues warrant thorough investigation. For special populations, such as HIV-infected individuals, does immune system impairment lead to more severe HPV infections? Additionally, does co-infection with HIV and HPV trigger more complications or increase the risk of carcinogenesis? These are critical issues that require focused attention in the current research landscape.

Currently, there are numerous challenges in studying HPV and HIV co-infection. The scarcity of case resources and societal neglect of these issues significantly hinder research progress. Moving forward, we should place greater emphasis on the distribution characteristics of HPV types, transmission routes, and treatment methods in HIV-infected populations. By conducting more epidemiological studies in diverse populations, we can clarify the infection characteristics, risk factors, and interrelatedness of these infections in such patients. Only then can we provide more precise and effective medical services for these individuals.

Funding

1. Kunming Medical University 2024 Master's Degree Graduate Innovation Fund Project - Prediction of Risk for Cervical Lesions in HIV-Infected Women by Local Immunity Combined with Vaginal Microbiome, NO: 2024S348. 2. Yunnan Revitalization Talent Support Program-Top Physician Project, iD: XDYC-MY-2022-0056; innovative research team of Yunnan province, ID202305AS350020.

Disclosure

The authors report no conflicts of interest in this work.

References

1. UNAIDS. *Global HIV Data and Statistics*. UNAIDS/WHO estimates; 2024.
2. May MT, Gompels M, Delpech V, et al. Impact on life expectancy of HIV-1 positive individuals of CD4+ cell count and viral load response to antiretroviral therapy. *AIDS*. 2014;28(8):1193–1202. doi:10.1097/QAD.0000000000000243
3. Oliver NT, Chiao EY. Malignancies in women with HIV infection. *Curr Opin HIV AIDS*. 2017;12(1):69–76. doi:10.1097/COH.0000000000000332
4. Berman TA, Schiller JT. Human papillomavirus in cervical cancer and oropharyngeal cancer: one cause, two diseases. *Cancer*. 2017;123 (12):2219–2229. doi:10.1002/cncr.30588
5. Acevedo-Fontánez AI, Suárez E, Torres Cintrón CR, et al. Risk of anal cancer in women with a human papillomavirus-related gynecological neoplasm: Puerto Rico 1987-2013. *J Low Genit Tract Dis*. 2018;22(3):225–230. doi:10.1097/LGT.0000000000000395

6. Badial RM, Dias MC, Stuqui B, et al. Detection and genotyping of human papillomavirus (HPV) in HIV-infected women and its relationship with HPV/HIV co-infection. *Medicine*. 2018;97(14):e9545. doi:10.1097/MD.0000000000009545
7. Jiangli D, Xiaosong Z, Gengli Z, et al. Interpretation of the comprehensive prevention and control guidelines for cervical cancer (2nd Edition). *Chin J Women Child Health*. 2024;15(02):1–5.
8. Looker KJ, Rönn MM, Brock PM, et al. Evidence of synergistic relationships between HIV and Human Papillomavirus (HPV): systematic reviews and meta-analyses of longitudinal studies of HPV acquisition and clearance by HIV status, and of HIV acquisition by HPV status. *J Int AIDS Soc*. 2018;21(6):e25110. doi:10.1002/jia2.25110
9. Brickman C, Palefsky JM. Human papillomavirus in the HIV-infected host: epidemiology and pathogenesis in the antiretroviral era. *Curr HIV/AIDS Rep*. 2015;12(1):6–15. doi:10.1007/s11904-014-0254-4
10. Zayats R, Murooka TT, McKinnon LR. HPV and the risk of HIV acquisition in women. *Front Cell Infect Microbiol*. 2022;12:814948. doi:10.3389/fcimb.2022.814948
11. Clark E, Chen L, Dong Y, et al. Veteran women living with human immunodeficiency virus have increased risk of human papillomavirus (HPV)-associated genital tract cancers. *Clin Infect Dis*. 2021;72(9):e359–e366. doi:10.1093/cid/ciaa1162
12. Reusser NM, Downing C, Guidry J, et al. HPV carcinomas in immunocompromised patients. *J Clin Med*. 2015;4(2):260–281. doi:10.3390/jcm4020260
13. Frisch M, Biggar RJ, Goedert JJ. Human papillomavirus-associated cancers in patients with human immunodeficiency virus infection and acquired immunodeficiency syndrome. *J Natl Cancer Inst*. 2000;92(18):1500–1510. doi:10.1093/jnci/92.18.1500
14. Dhokotera TG, Muchengeti M, Davidović M, et al. Gynaecologic and breast cancers in women living with HIV in South Africa: a record linkage study. *Int J Cancer*. 2024;154(2):284–296. doi:10.1002/ijc.34712
15. Saraiya M, Unger ER, Thompson TD, et al. US assessment of HPV types in cancers: implications for current and 9-valent HPV vaccines. *J Natl Cancer Inst*. 2015;107(6):djv086. doi:10.1093/jnci/djv086
16. Uwamungu S, Nigussie B, Muvunyi CM, et al. Prevalence of human papillomavirus in different mucous membranes in HIV concordant couples in Rwanda. *Viruses*. 2023;15(4):1005. doi:10.3390/v15041005
17. Michaud JM, Zhang T, Shireman TI, et al. Hazard of cervical, oropharyngeal, and anal cancers in HIV-infected and HIV-uninfected medicaid beneficiaries. *Cancer Epidemiol Biomarkers Prev*. 2020;29(7):1447–1457. doi:10.1158/1055-9965.EPI-20-0281
18. Chamseddine AN, Loulergue P, Loulergue MO, Mir O. HIV-associated cancers and related diseases. *N Engl J Med*. 2018;378(22):2144.
19. Sharma K, Machalek DA, Toh ZQ, et al. No woman left behind: achieving cervical cancer elimination among women living with HIV. *Lancet HIV*. 2023;10(6):e412–e420. doi:10.1016/S2352-3018(23)00082-6
20. Sung H, Ferlay J, Siegel RL, et al. Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2021;71(3):209–249. doi:10.3322/caac.21660
21. Poljak M, Šterbenc A, Lunar MM. Prevention of human papillomavirus (HPV)-related tumors in people living with human immunodeficiency virus (HIV). *Expert Rev Anti Infect Ther*. 2017;15(11):987–999. doi:10.1080/14787210.2017.1392854
22. Krankowska D, Mazzitelli M, Ucak HA, et al. Screening and prevention of HPV-related anogenital cancers in women living with HIV in Europe: results from a systematic review. *HIV Med*. 2024;25(7):769–793. doi:10.1111/hiv.13602
23. Stelzle D, Tanaka LF, Lee KK, et al. Estimates of the global burden of cervical cancer associated with HIV. *Lancet Glob Health*. 2021;9(2):e161–e169. doi:10.1016/S2214-109X(20)30459-9
24. Shiels MS, Pfeiffer RM, Hall HI, et al. Proportions of Kaposi sarcoma, selected non-Hodgkin lymphomas, and cervical cancer in the United States occurring in persons with AIDS, 1980-2007. *JAMA*. 2011;305(14):1450–1459. doi:10.1001/jama.2011.396
25. Huanhuan W, Ping L, Yaping X. A study on the factors associated with persistent positive human papillomavirus infection after surgery in patients with high-grade cervical intraepithelial neoplasia. *Maternal Child Health Care China*. 2019;34(21):5021–5023.
26. Debeaudrap P, Sobngwi J, Tebeu PM, et al. Residual or recurrent precancerous lesions after treatment of cervical lesions in human immunodeficiency virus-infected women: a systematic review and meta-analysis of treatment failure. *Clin Infect Dis*. 2019;69(9):1555–1565. doi:10.1093/cid/ciy1123
27. Davis KG, Orangio GR. Basic science, epidemiology, and screening for anal intraepithelial neoplasia and its relationship to anal squamous cell cancer. *Clin Colon Rectal Surg*. 2018;31(6):368–378. doi:10.1055/s-0038-1668107
28. de Martel C, Plummer M, Vignat J, et al. Worldwide burden of cancer attributable to HPV by site, country and HPV type. *Int J Cancer*. 2017;141(4):664–670. doi:10.1002/ijc.30716
29. Wilkinson JR, Morris EJ, Downing A, et al. The rising incidence of anal cancer in England 1990-2010: a population-based study. *Colorectal Dis*. 2014;16(7):O234–239. doi:10.1111/codi.12553
30. Park IU, Palefsky JM. Evaluation and management of anal intraepithelial neoplasia in hiv-negative and hiv-positive men who have sex with men. *Curr Infect Dis Rep*. 2010;12(2):126–133. doi:10.1007/s11908-010-0090-7
31. Jin F, Vajdic CM, Poynten IM, et al. Cancer risk in people living with HIV and solid organ transplant recipients: a systematic review and meta-analysis. *Lancet Oncol*. 2024;25(7):933–944. doi:10.1016/S1470-2045(24)00189-X
32. Wei F, Xia N, Ocampo R, et al. Age-specific prevalence of anal and cervical human papillomavirus infection and high-grade lesions in 11 177 women by human immunodeficiency virus status: a collaborative pooled analysis of 26 studies. *J Infect Dis*. 2023;227(4):488–497. doi:10.1093/infdis/jiac108
33. Lin C, Slama J, Gonzalez P, et al. Cervical determinants of anal HPV infection and high-grade anal lesions in women: a collaborative pooled analysis. *Lancet Infect Dis*. 2019;9(8):880–891. doi:10.1016/S1473-3099(19)30164-1
34. Clifford GM, Georges D, Shiels MS, et al. A meta-analysis of anal cancer incidence by risk group: toward a unified anal cancer risk scale. *Int J Cancer*. 2021;148(1):38–47. doi:10.1002/ijc.33185
35. Conde-Ferráez L, Chan-Mezeta A, Gómez-Carballo JG, et al. Human papillomavirus genotypes infecting the anal canal and cervix in HIV+ men and women, anal cytology, and risk factors for anal infection. *Pathogens*. 2023;12(2):252. doi:10.3390/pathogens12020252
36. Stier EA, Jain M, Joshi H, et al. Two-year incidence and cumulative risk and predictors of anal high-grade squamous intraepithelial lesions (anal precancer) among women with human immunodeficiency virus. *Clin Infect Dis*. 2024;78(3):681–689. doi:10.1093/cid/ciad614
37. Liu Y, Sigel KM, Westra W, et al. HIV-infected patients with anal cancer precursors: clinicopathological characteristics and human papillomavirus subtype distribution. *Dis Colon Rectum*. 2020;63(7):890–896. doi:10.1097/DCR.0000000000001671

38. Zhang J, Sun Y, Chen X, et al. Incidence, clearance, and factors associated with anal human papilloma virus infection among men with HIV. *AIDS*. 2024;38(1):9–20. doi:10.1097/QAD.0000000000003755
39. Hidalgo-Tenorio C, de Jesus SE, Esquivias J, et al. High prevalence and incidence of HPV-related anal cancer precursor lesions in HIV-positive women in the late HAART era. *Enferm Infecc Microbiol Clin*. 2018;36(9):555–562. doi:10.1016/j.eimc.2017.10.014
40. Lindquist S, Frederiksen K, Petersen LK, et al. The risk of vaginal, vulvar and anal precancer and cancer according to high-risk HPV status in cervical cytology samples. *Int J Cancer*. 2024;155(1):61–70. doi:10.1002/ijc.34896
41. Stier EA, Lensing SY, Darragh TM, et al. Prevalence of and risk factors for anal high-grade squamous intraepithelial lesions in women living with human immunodeficiency virus. *Clin Infect Dis*. 2020;70(8):1701–1707. doi:10.1093/cid/ciz408
42. Duan R, Zhang H, Wu A, et al. Prevalence and risk factors for anogenital HPV infection and neoplasia among women living with HIV in China. *Sex Transm Infect*. 2022;98(4):247–254. doi:10.1136/sextrans-2021-055019