

# The impact of smoking on HPV infection and the development of anogenital warts

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## Abstract

**Purpose** The worldwide prevalence of human papillomavirus (HPV) infection is estimated at 9–13 %. Persistent infection can lead to the development of malignant and nonmalignant diseases. Low-risk HPV types are mostly associated with benign lesions such as anogenital warts. In the present systematic review, we examined the impact of smoking on HPV infection and the development of anogenital warts, respectively.

**Methods** A systematic literature search was performed using MEDLINE database for peer-reviewed articles published from January 01, 1985 to November 30, 2013. Pooled rates of HPV prevalence were compared using the  $\chi^2$  test.

**Results** In both genders, smoking is associated with higher incidence and prevalence rates for HPV infection, whereas the latter responds to a dose-effect relationship. The overall HPV prevalence for smoking patients was 48.2 versus 37.5 % for nonsmoking patients ( $p < 0.001$ ) (odds ratio (OR)=1.5, 95 % confidence interval (CI) 1.4–1.7). Smoking does also increase persistence rates for high-risk HPV infection, while this correlation is debatable for low-risk HPV. The incidence and recurrence rates of anogenital warts are significantly increased in smokers.

**Conclusions** Most current data demonstrate an association between smoking, increased anogenital HPV infection, and development of anogenital warts. These data add to the long

list of reasons for making smoking cessation a keystone of patient health.

**Keywords** Smoking · Human papillomavirus · Anogenital warts

## Introduction

According to the World Health Organization (WHO), 630 million people are infected with genital human papillomavirus (HPV), resulting in an estimated worldwide prevalence of 9–13 % [1, 2]. HPV is transmitted via genital contact and is the most common sexually transmitted infection worldwide [3, 4]. There is no consensus on a gender-specific risk of acquiring HPV [5]. Whereas at least 40 % of HPV infections are asymptomatic and transient, with subsequent clearance by the immune system, some infections persist [2, 5]. Persistent infection can lead to the development of malignant and premalignant or nonmalignant diseases, so-called “anal intraepithelial neoplasia” (AIN). Over 100 HPV types have been identified. Approximately 40 of these affect the anogenital region [2, 6]. HPV infections are detected by collecting material with brushes or swabs, followed by polymerase chain reaction analysis, genotyping, and HPV classification according to their risk of causing cervical cancer [2]: Low-risk HPV types are mostly associated with benign lesions such as anogenital warts (AIN grade I), and high-risk or oncogenic types are also associated with cancers and their precursors (AIN grade II/III) [6]. More than 90 % of anogenital warts are caused by low-risk HPV types 6 and 11 [7, 8]. Infected basal cells move toward the surface layer, where they ultimately develop to anogenital warts [2]. The worldwide prevalence of visible anogenital warts ranges from 0.13 to 5.1 % [9]. These may regress spontaneously, with reported

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clearance rates varying widely from 0 to 55 % [10–12]. However, even with therapy (topical, surgical, and/or destructive), the recurrence rate within 3 months is 25–67 % [10].

Apart from genital contact, risk factors for HPV acquisition include younger age, early coitarche, number of lifetime sexual partners, failure to use condoms consistently, marital status, history of sexually transmitted infections, immunosuppression (including patients with human immunodeficiency virus), history of other HPV-mediated neoplasia, and low socioeconomic status [13, 4]. Furthermore, smoking is postulated to be an additional risk factor, due to increased susceptibility to the acquisition of HPV [14].

In the present systematic review, we examined the impact of smoking on the incidence, persistence, and prevalence of HPV and of anogenital warts.

## Methods

A systematic literature search was performed using MEDLINE database for peer-reviewed articles published in English. The search was carried out for articles published from January 01, 1985 to November 30, 2013, using the following keywords: smoking AND human papillomavirus AND/OR incidence AND/OR prevalence AND/OR persistence AND/OR condylomata acuminata AND/OR anogenital warts AND/OR genital warts. The references in the identified articles were also reviewed. Titles and abstracts, when available, were scrutinized to select relevant studies addressing the relation of smoking and HPV infection and/or the occurrence of anogenital warts. All studies addressing the relation in the abstract and/or the full text manuscript were subsequently included. Case reports, letters to editors, and review articles were excluded. In addition, studies restricted to patients with cervical or AIN and cervical or anal cancer were excluded. Furthermore, studies examining HPV infection or warts in other regions than the genital or anal were excluded.

Pooled rates of HPV prevalence were compared between smoking and nonsmoking patients, using the  $\chi^2$  test. For this analysis, only prospective studies were included. As time intervals for incidence and persistence were different between studies with an analysis of different HPV types, comparison of these pooled rates was not practicable. To assess the clinical significance of differences in prevalence rates between smoking and nonsmoking patients, the 95 % confidence interval (CI) for the difference was derived. Statistical Package for Social Sciences (SPSS Windows) version 21.0 (SPSS, Chicago, IL) was used for all analyses.

## Results

### Incidence of HPV

Fifteen studies (14 prospective and one retrospective) are available on the impact of smoking on the incidence of HPV [15–29]. The retrospective study—including 1,880 patients—did not reveal an association [17]. Of the 14 prospective studies, 12 investigated genital [15, 16, 18–26, 29], one anogenital [27], and one solely anal [28] HPV infections. Nine of these 14 studies demonstrated a significant [15, 16, 18, 19, 21, 22, 24, 26, 27], one a nonsignificant [20], and four no association between HPV incidence and smoking (Table 1) [28, 30, 25, 29].

A gender-specific analysis revealed that three out of four prospective studies including a total of 5,376 male patients found a significant association between smoking and the incidence of HPV [16, 27, 21]. Only one prospective study with 374 male patients did not reveal an association [23]. Similarly, six out of ten prospective studies comparing 27,508 smoking and nonsmoking female patients found a significant association [15, 18, 19, 22, 24, 26]. Additionally, Oh et al. found a statistically nonsignificant trend toward an association among female patients [20]. Three remaining prospective studies, including 1,339 female patients, did not reveal an association [28, 25, 29].

Whereas the above-mentioned studies focused on the association of HPV incidence to current smoking, Partridge et al. found an association solely between past smoking and HPV infection (hazard ratio (HR)=1.6, 95 % CI 1.1–2.4) [21].

### Persistence of HPV

Thirteen prospective studies including a total of 18,529 patients investigated the impact of smoking on the persistence rate of anogenital HPV during time intervals of 4 [31], 6 [27, 32–34, 23, 35, 16], or more [36, 37, 20, 38] months (one missing specification of time interval [39]). Nevertheless, the association between smoking and the persistence of HPV is not conclusive with regard to the number of patients in the two groups: Eleven of these 13 studies, including a total of 10,503 patients, found a statistically significant association (seven studies [27, 32, 33, 36, 31, 39, 38]) between HPV persistence and smoking or a trend (four studies [16, 20, 34, 23]) toward higher rates among smokers compared to nonsmokers [16, 27, 32, 33, 36, 31, 20, 34, 23, 39, 38]. Maucourt-Boulch et al. even found a dose-effect relationship: Smoking >20 cigarettes per day was associated with a significantly increased risk of persistence of HPV infection among women, when compared with women who smoked <10 cigarettes per day (odds ratio (OR)=1.43, 95 % CI 1.02–2.01) [33]. The remaining two studies prospectively included a total of 8,026 patients but could not establish a positive relationship between smoking

**Table 1** Summary of all prospective studies evaluating the association between the incidence of HPV and smoking

Author	Publication year	Study design	Population (sex, number of patients included)	Localization	Association with smoking	HPV incidence in nonsmoking subjects	HPV incidence in currently smoking subjects	OR or HR for currently smoking subjects	Specification of the association
Clarke et al. [15]	2013	Prospective	Female, n= 3,737	Genital	Yes	1,491/3,225 (46.2 %) [50.7 months]	317/499 (63.5 %) [50.7 months]	HR=1.2; 95 % CI 1.0–1.3	Evaluation of high-risk HPV infection
Schabath et al. [16]	2013	Prospective	Male, n= 4,026	Genital	Yes	812/2,326 (34.9 %) [12 months]	399/948 (42.1 %) [12 months]	HR=1.2; 95 % CI 1.0–1.5	Significantly higher association for current smokers compared to former and never smokers
Nyitray et al. [27]	2011	Prospective	Male, n= 1,110	Anogenital	(Yes)	–	–	–	Association in bivariate analysis among men who have sex with women
Nielsen et al. [18]	2009	Prospective	Female, n= 7,454	Genital	Yes	–	–	OR=1.5; 95 % CI 1.2–1.9	Association for acquiring a single high-risk HPV infection ( $\geq 10$ cigarettes per day)
Sarian et al. [19]	2009	Prospective	Female, n= 12,114	Genital	Yes	–	–	OR=1.6; 95 % CI 1.2–2.1	Evaluation of high-risk HPV infection
Goodman et al. [28]	2008	Prospective	Female, n= 431	Anal	No	137/276 (49.6 %) [16 months]	29/61 (47.5 %) [16 months]	OR=0.9; 95 % CI 0.5–1.6	
Oh et al. [20]	2008	Prospective	Female, n= 197	Genital	(Yes)	16/131 (12.2 %) [18 months]	5/12 (41.7 %) [18 months]	OR=3.3; 95 % CI 0.7–14.6	Statistically nonsignificant trend
Partridge et al. [21]	2007	Prospective	Male, n= 240	Genital	Yes	–	–	HR=1.0; 95 % CI 0.4–2.2	Association with past smoking but not with current smoking
Syrjänen et al. [22]	2007	Prospective	Female, n= 3,187	Genital	Yes	–	–	OR=1.5; 95 % CI 1.1–2.1	Evaluation of high-risk HPV infection
Kjaer et al. [23]	2005	Prospective	Male, n= 374	Genital	No	17/102 (16.7 %) [7 months]	6/42 (14.3 %) [7 months]	OR=0.6; 95 % CI 0.2–2.0	
Minkoff et al. [24]	2004	Prospective	Female, n= 2,293	Genital	(Yes)	–	–	–	Association in HIV-infected but not in HIV-uninfected women
Sellers et al. [25]	2003	Prospective	Female, n= 307	Genital	No	19/178 (10.7 %) [14 months]	9/72 (12.5 %) [14 months]	OR=0.6; 95 % CI 0.2–1.9	Evaluation of high-risk HPV infection
Winer et al. [26]	2003	Prospective	Female, n= 603	Genital	Yes	–	–	HR=1.5; 95 % CI 1.0–2.3	Association with current smoking
Moscicki et al. [29]	2001	Prospective	Female, n= 601	Genital	No	–	–	–	

OR odds ratio, HR hazard ratio

and the persistence rate of HPV [37, 35]. Interestingly, Ho et al. even found that smoking >5 cigarettes per day was

protective against persistent HPV infection (OR=0.3, 95 % CI 0.2–0.7) [35].

## Prevalence of HPV

With respect to the prevalence of anogenital HPV, most studies showed an association with smoking for both men and women. Forty-seven studies (four prospective [40, 19, 41, 24], one retrospective [42], and 42 cross-sectional [43–68, 14, 69–83] studies)—including a total of 83,480 patients—found a significant association (35 studies [19, 40–44, 46, 48–53, 55–59, 61–64, 66–68, 14, 69–71, 75–77, 79, 80, 83]) with smoking or a trend (12 studies [24, 45, 47, 54, 65, 72–74, 60, 78, 81, 82]) toward an association, whereas 16 studies (one prospective [84] and 15 cross-sectional [17, 85–98] studies)—with a total of 12,188 patients—did not. Four out of five prospective studies—including 19,581 patients—found a significant association (three studies) between HPV prevalence and smoking or a trend (one study) toward higher rates among smokers compared to nonsmokers (Table 2) [40, 19, 41, 24]. The remaining prospective study with 576 patients did not reveal an association [84].

A statistical analysis of all prospective studies evaluating association between the prevalence of HPV and smoking showed that the overall HPV prevalence for smoking patients was 48.2 versus 37.5 % for nonsmoking patients ( $p < 0.001$ )

(OR=1.5, 95 % CI 1.4–1.7). For female patients only, the prevalence was 40.8 % for smokers versus 25.2 % for non-smokers ( $p < 0.001$ ) (OR=2.0, 95 % CI 1.8–2.3) and for male patients 68.2 versus 63.2 % ( $p = 0.006$ ) (OR=1.2, 95 % CI 1.1–1.5).

There are ten studies comparing current with past smoking with regard to the prevalence of HPV [49, 51, 40, 61, 19, 14, 69, 72, 77, 90]. Except for one study, no impact of past smoking on the prevalence of HPV was shown [49, 51, 40, 61, 19, 14, 69, 72, 77].

Four cross-sectional studies among current smokers showed increasing prevalence of HPV with the number of cigarettes smoked [49, 50, 14, 69]. Nielson et al. found a stronger association between HPV detection and smoking  $\geq 10$  cigarettes than for smoking  $< 10$  cigarettes per day (OR=2.3, 95 % CI 1.0–5.3) [69]. In contrast, Roura et al. and Schabath et al. did not find any impact of the intensity of smoking on the prevalence of HPV [51, 40].

## High-risk HPV

Four prospective studies focused on the incidence of high-risk HPV infection [15, 19, 22, 18]. These investigators

**Table 2** Summary of all prospective studies evaluating the association between the prevalence of HPV and smoking

Author	Publication year	Study design	Population (sex, number of patients included)	Localization	Association with smoking	HPV prevalence in nonsmoking subjects	HPV prevalence in currently smoking subjects	OR or HR for currently smoking subjects	Specification of the association
Schabath et al. [40]	2012	Prospective	Male, $n = 4,054$	Genital	Yes	1,485/2,348 (63.2 %)	655/960 (68.2 %)	OR=1.2, 95 % CI 1.0–1.4	Association with current but not past smokers. No association between intensity of smoking and HPV prevalence
Sarian et al. [19]	2009	Prospective	Female, $n = 12,114$	Genital	Yes	444/2,699 (16.5 %)	215/990 (21.7 %)	OR=1.6, 95 % CI 1.2–2.1	Evaluation of high-risk HPV infection. Association with current but not past smokers
Kliucinskas et al. [41]	2006	Prospective	Female, $n = 1,120$	Genital	Yes	109/892 (12.2 %)	25/128 (19.5 %)	OR=1.8, 95 % CI 1.2–2.8	Evaluation of high-risk HPV infection
Minkoff et al. [24]	2004	Prospective	Female, $n = 2,293$	Genital	(Yes)	516/966 (53.4 %)	735/1,294 (56.8 %)	OR=1.1, 95 % CI 1.0–1.4	Association in HIV-infected but not in HIV-uninfected women
Feldman et al. [84]	1997	Prospective	Female, $n = 576$	Genital	No	174/370 (47.0 %)	93/206 (45.1 %)	OR=0.9, 95 % CI 0.7–1.3	
Total						<b>2,728/7,275 (37.5%)</b>	<b>1,723/3,578 (48.2%)</b>	<b>OR=1.5, 95% CI 1.4–1.7</b>	

OR odds ratio, HR hazard ratio

consistently found a significant association between smoking and high-risk HPV incidence.

Regarding persistence of high-risk HPV infection, three out of four prospective studies with a total of 827 patients revealed a significant association with smoking [32, 39, 38], whereas one study with 7,418 patients did not [37].

An analysis of HPV types in female patients revealed no significant difference in prevalence of high- or low-risk HPV genotypes when comparing female smokers to nonsmokers

[99]. In two prospective studies including a total of 13,234 patients, a significant impact of smoking on the prevalence of high-risk HPV was found [19, 41].

#### Development of anogenital warts

Smoking has been shown to significantly increase the incidence of anogenital warts (Table 3). The risk of developing anogenital warts increases with the number

**Table 3** Summary of all published studies evaluating the association between the incidence of anogenital warts and smoking

Author	Publication year	Study design	Population (sex, number of patients included)	Localization	Association with smoking	Incidence of anogenital warts in nonsmoking subjects	Incidence of anogenital warts in currently smoking subjects	OR or HR for currently smoking subjects	Specification of the association
Massad et al. [103]	2011	Prospective	Female, $n=3766$	Genital	Yes	–	–	HR=1.8, 95 % CI 1.4–2.4	Association with current but not with former smoking
Wiley et al. [113]	2009	Prospective	Male, $n=2835$	Genital	Yes	–	–	–	
Massad et al. [104]	2004	Prospective	Female, $n=2031$	Genital	Yes	–	–	–	Association with current but not with former smoking
Feldman et al. [84]	1997	Prospective	Female, $n=576$	Genital	Yes	–	–	–	
Hansen et al. [102]	2010	Retrospective	Female, $n=58094$	Genital	Yes	–	–	HR=1.3, 95 % CI 1.2–1.4	Increasing risk with increasing number of cigarettes smoked per day
Kjaer et al. [114]	2007	Retrospective	Female, $n=69147$	Genital	Yes	2,936/35,799 (8.2 %)	2,251/15,965 (14.1 %)	OR=1.1, 95 % CI 1.0–1.2	Association with smoking for >59 pack-years
Wen et al. [13]	1999	Retrospective	Male and female, $n=1954$	Genital	Yes	89/631 (14.1 %)	154/644 (23.9 %)	OR=1.9, 95 % CI 1.0–2.3	Smokers of more than 10 cigarettes per day were twice as likely to have genital warts as were nonsmokers
Habel et al. [106]	1998	Retrospective	Female, $n=282$	Anogenital	(Yes)	45/118 (38.1 %)	35/67 (52.2 %)	OR=1.8, 95 % CI 1.0–3.3	Statistically nonsignificant association
Munk et al. [100]	1997	Retrospective	Female, $n=10838$	Genital	Yes	–	–	OR=1.5, 95 % CI 1.2–1.8	Increasing risk with increasing pack-years of cigarette smoking
Brisson et al. [101]	1988	Retrospective	Female, $n=520$	Genital	Yes	–	–	–	Increasing risk with increasing number of cigarettes smoked per day
Daling et al. [115]	1986	Retrospective	Female, $n=245$	Anogenital	Yes	–	–	–	

OR odds ratio, HR hazard ratio

of cigarettes smoked per day and the number of pack-years [13, 100–102]. However, this association only applies to current but not to past smoking [103, 104]. Luu et al. investigated the impact of current smoking on the size of anal warts but failed to find a relationship [105]. Smoking for 10 or more years has been found to increase the risk of recurrent genital warts (relative risk (RR)=4.5, 95 % CI 1.4–13.8) [106].

## Discussion

In both genders, smoking is associated with higher incidence and prevalence rates for HPV infection, whereas the latter responds to a dose-effect relationship. Smoking does also increase persistence rates for high-risk HPV infection, while this correlation is debatable for low-risk HPV. The incidence and recurrence rates of anogenital warts are significantly increased in current smokers.

Smoking has deleterious effects on systemic and local immunity, as it suppresses both cell-mediated and humoral immune responses, which might lead to the present finding of increased susceptibility to HPV infection and development of anogenital warts [107]. Nicotine, the addictive substance in cigarette smoke, has been shown to be the main immunosuppressive constituent of cigarette smoke [107]. Moreover, smoking has been found to increase metaplasia and DNA damage in various tissues [108–111].

Although most studies adjusted for sexual behavior, unmeasured high-risk sexual behavior might be a potentially important confounder in the association between smoking and the incidence of HPV infection [16, 15, 26]. This is supported by Herrero et al., who found that sex with multiple partners is more prevalent among smokers [112].

The prevalence of HPV infection seems to decrease in patients who quit smoking, but the time period after which nonsmoker levels are reached is not yet clear.

The association of smoking with HPV infection and development of anogenital warts, respectively, is well supported by current data. However, the cascade from HPV infection to the development of anogenital warts is still not well understood. Furthermore, prospective data on the impact of smoking on the spontaneous recovery rate of anogenital warts are still lacking.

Studies are more often performed for female than male patients, probably due to regular gynecologic controls. On the other hand, comparison of the studies did not reveal gender differences in the impact of smoking.

## Conclusion

Most current data demonstrate an association between smoking, increased anogenital HPV infection, and development of anogenital warts. These data add to the long list of reasons for making smoking cessation a keystone of patient health.

## References

1. WHO Vaccines against human papilloma virus. <http://www.who.int/vaccines/en/hpvr.d.shtml>. Accessed April 01, 2014
2. Forcier M, Musacchio N (2010) An overview of human papillomavirus infection for the dermatologist: disease, diagnosis, management, and prevention. *Dermatol Ther* 23(5):458–476. doi:10.1111/j.1529-8019.2010.01350.x
3. Markowitz LE, Dunne EF, Saraiya M, Lawson HW, Chesson H, Unger ER (2007) Quadrivalent human papillomavirus vaccine: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recommendations and reports: Morbidity and mortality weekly report Recommendations and reports / Centers for Disease Control* 56 (Rr-2):1–24
4. Hathaway JK (2012) HPV: diagnosis, prevention, and treatment. *Clin Obstet Gynecol* 55(3):671–680. doi:10.1097/GRF.0b013e31825caa36
5. Fleischer AB Jr, Parrish CA, Glenn R, Feldman SR (2001) Condylomata acuminata (genital warts): patient demographics and treating physicians. *Sex Transm Dis* 28(11):643–647
6. Stanley M (2007) Prophylactic HPV vaccines: prospects for eliminating ano-genital cancer. *Br J Cancer* 96(9):1320–1323. doi:10.1038/sj.bjc.6603695
7. Gross G, Pfister H (2004) Role of human papillomavirus in penile cancer, penile intraepithelial squamous cell neoplasias and in genital warts. *Med Microbiol Immunol* 193(1):35–44. doi:10.1007/s00430-003-0181-2
8. Tay EH, Garland S, Tang G, Nolan T, Huang LM, Orloski L, Lu S, Barr E (2008) Clinical trial experience with prophylactic HPV 6/11/16/18 VLP vaccine in young women from the Asia-Pacific region. *Int J Gynaecol Obstet Off Organ Int Fed Gynaecol Obstet* 102(3):275–283. doi:10.1016/j.ijgo.2008.03.021
9. Patel H, Wagner M, Singhal P, Kothari S (2013) Systematic review of the incidence and prevalence of genital warts. *BMC Infect Dis* 13:39. doi:10.1186/1471-2334-13-39
10. Scheinfeld N, Lehman DS (2006) An evidence-based review of medical and surgical treatments of genital warts. *Dermatol Online J* 12(3):5
11. Wiley DJ, Douglas J, Beutner K, Cox T, Fife K, Moscicki AB, Fukumoto L (2002) External genital warts: diagnosis, treatment, and prevention. *Clin Infect Dis Off Publ Infect Dis Soc Am* 35(Suppl 2):S210–S224. doi:10.1086/342109
12. Kodner CM, Nasraty S (2004) Management of genital warts. *Am Fam Physician* 70(12):2335–2342
13. Wên LM, Estcourt CS, Simpson JM, Mindel A (1999) Risk factors for the acquisition of genital warts: are condoms protective? *Sex Transm Infect* 75(5):312–316
14. Vaccarella S, Herrero R, Snijders PJ, Dai M, Thomas JO, Hieu NT, Ferreccio C, Matos E, Posso H, de Sanjose S, Shin HR, Sukvirach S, Lazcano-Ponce E, Munoz N, Meijer CJ, Franceschi S (2008) Smoking and human papillomavirus infection: pooled analysis of

- the International Agency for Research on Cancer HPV Prevalence Surveys. *Int J Epidemiol* 37(3):536–546. doi:10.1093/ije/dyn033
15. Clarke M, Schiffman M, Wacholder S, Rodriguez AC, Hildesheim A, Quint W (2013) A prospective study of absolute risk and determinants of human papillomavirus incidence among young women in Costa Rica. *BMC Infect Dis* 13:308. doi:10.1186/1471-2334-13-308
  16. Schabath MB, Villa LL, Lin HY, Fulp WJ, Lazcano-Ponce E, Salmeron J, Abrahamsen ME, Papenfuss MR, Quiterio M, Giuliano AR (2013) A prospective analysis of smoking and human papillomavirus infection among men in the HPV in Men Study. *Int J Cancer J Int Cancer*. doi:10.1002/ijc.28567
  17. Almonte M, Silva Idos S, Asare A, Gilham C, Sargent A, Bailey A, Turner A, Desai M, Kitchener HC, Peto J (2011) Sexual behavior and HPV infection in British women, by postal questionnaires and telephone interviews. *J Med Virol* 83(7):1238–1246. doi:10.1002/jmv.22085
  18. Nielsen A, Iftner T, Munk C, Kjaer SK (2009) Acquisition of high-risk human papillomavirus infection in a population-based cohort of Danish women. *Sex Transm Dis* 36(10):609–615. doi:10.1097/OLQ.0b013e3181a96d0e
  19. Sarian LO, Hammes LS, Longatto-Filho A, Guarisi R, Derchain SF, Roteli-Martins C, Naud P, Erzen M, Branca M, Tatti S, de Matos JC, Gontijo R, Maeda MY, Lima T, Costa S, Syrjanen S, Syrjanen K (2009) Increased risk of oncogenic human papillomavirus infections and incident high-grade cervical intraepithelial neoplasia among smokers: experience from the Latin American screening study. *Sex Transm Dis* 36(4):241–248. doi:10.1097/OLQ.0b013e3181935a7d
  20. Oh JK, Ju YH, Franceschi S, Quint W, Shin HR (2008) Acquisition of new infection and clearance of type-specific human papillomavirus infections in female students in Busan, South Korea: a follow-up study. *BMC Infect Dis* 8:13. doi:10.1186/1471-2334-8-13
  21. Partridge JM, Hughes JP, Feng Q, Winer RL, Weaver BA, Xi LF, Stern ME, Lee SK, O'Reilly SF, Hawes SE, Kiviat NB, Koutsky LA (2007) Genital human papillomavirus infection in men: incidence and risk factors in a cohort of university students. *J Infect Dis* 196(8):1128–1136. doi:10.1086/521192
  22. Syrjanen K, Shabalova I, Petrovichev N, Kozachenko V, Zakhareva T, Pajanidi J, Podistov J, Chemeris G, Sozaeva L, Lipova E, Tsidaeva I, Ivanchenko O, Pshepurko A, Zakharenko S, Nerovjina R, Kljukina L, Erokhina O, Branovskaja M, Nikitina M, Grunberga V, Grunberg A, Juschenko A, Santopietro R, Cintonino M, Tosi P, Syrjanen S (2007) Smoking is an independent risk factor for oncogenic human papillomavirus (HPV) infections but not for high-grade CIN. *Eur J Epidemiol* 22(10):723–735. doi:10.1007/s10654-007-9180-8
  23. Kjaer SK, Munk C, Winther JF, Jorgensen HO, Meijer CJ, van den Brule AJ (2005) Acquisition and persistence of human papillomavirus infection in younger men: a prospective follow-up study among Danish soldiers. *Cancer Epidemiol Biomark Prev Publ Am Assoc Cancer Res Cosponsored Am Soc Prev Oncol* 14(6):1528–1533. doi:10.1158/1055-9965.epi-04-0754
  24. Minkoff H, Feldman JG, Strickler HD, Watts DH, Bacon MC, Levine A, Palefsky JM, Burk R, Cohen MH, Anastos K (2004) Relationship between smoking and human papillomavirus infections in HIV-infected and -uninfected women. *J Infect Dis* 189(10):1821–1828. doi:10.1086/383479
  25. Sellors JW, Karwalajtys TL, Kaczorowski J, Mahony JB, Lytwyn A, Chong S, Sparrow J, Lorincz A (2003) Incidence, clearance and predictors of human papillomavirus infection in women. *CMAJ: Can Med Assoc J* 168(4):421–425
  26. Winer RL, Lee SK, Hughes JP, Adam DE, Kiviat NB, Koutsky LA (2003) Genital human papillomavirus infection: incidence and risk factors in a cohort of female university students. *Am J Epidemiol* 157(3):218–226
  27. Nyitray AG, Carvalho da Silva RJ, Baggio ML, Smith D, Abrahamsen M, Papenfuss M, Lin HY, Quiterio M, Salmeron J, Lazcano-Ponce E, Villa LL, Giuliano AR (2011) Six-month incidence, persistence, and factors associated with persistence of anal human papillomavirus in men: the HPV in men study. *J Infect Dis* 204(11):1711–1722. doi:10.1093/infdis/jir637
  28. Goodman MT, Shvetsov YB, McDuffie K, Wilkens LR, Zhu X, Ning L, Killeen J, Kamemoto L, Hernandez BY (2008) Acquisition of anal human papillomavirus (HPV) infection in women: the Hawaii HPV cohort study. *J Infect Dis* 197(7):957–966. doi:10.1086/529207
  29. Moscicki AB, Hills N, Shiboski S, Powell K, Jay N, Hanson E, Miller S, Clayton L, Farhat S, Broering J, Darragh T, Palefsky J (2001) Risks for incident human papillomavirus infection and low-grade squamous intraepithelial lesion development in young females. *JAMA: J Am Med Assoc* 285(23):2995–3002
  30. Kjaer SK, Breugelmans G, Munk C, Junge J, Watson M, Iftner T (2008) Population-based prevalence, type- and age-specific distribution of HPV in women before introduction of an HPV-vaccination program in Denmark. *Int J Cancer* 123(8):1864–1870. doi:10.1002/ijc.23712
  31. Shvetsov YB, Hernandez BY, McDuffie K, Wilkens LR, Zhu X, Ning L, Killeen J, Kamemoto L, Goodman MT (2009) Duration and clearance of anal human papillomavirus (HPV) infection among women: the Hawaii HPV cohort study. *Clin Infect Dis: Off Publ Infect Dis Soc Am* 48(5):536–546. doi:10.1086/596758
  32. Schmeink CE, Melchers WJ, Siebers AG, Quint WG, Massuger LF, Bekkers RL (2011) Human papillomavirus persistence in young unselected women, a prospective cohort study. *PLoS One* 6(11):e27937. doi:10.1371/journal.pone.0027937
  33. Maucort-Boulch D, Plummer M, Castle PE, Demuth F, Safaeian M, Wheeler CM, Schiffman M (2010) Predictors of human papillomavirus persistence among women with equivocal or mildly abnormal cytology. *Int J Cancer* 126(3):684–691. doi:10.1002/ijc.24752
  34. Koshiol J, Schroeder J, Jamieson DJ, Marshall SW, Duerr A, Heilig CM, Shah KV, Klein RS, Cu-Uvin S, Schuman P, Celentano D, Smith JS (2006) Smoking and time to clearance of human papillomavirus infection in HIV-seropositive and HIV-seronegative women. *Am J Epidemiol* 164(2):176–183. doi:10.1093/aje/kwj165
  35. Ho GY, Bierman R, Beardsley L, Chang CJ, Burk RD (1998) Natural history of cervicovaginal papillomavirus infection in young women. *N Engl J Med* 338(7):423–428. doi:10.1056/nejm199802123380703
  36. Louvanto K, Rintala MA, Syrjanen KJ, Grenman SE, Syrjanen SM (2010) Genotype-specific persistence of genital human papillomavirus (HPV) infections in women followed for 6 years in the Finnish Family HPV Study. *J Infect Dis* 202(3):436–444. doi:10.1086/653826
  37. Nielsen A, Kjaer SK, Munk C, Osler M, Iftner T (2010) Persistence of high-risk human papillomavirus infection in a population-based cohort of Danish women. *J Med Virol* 82(4):616–623. doi:10.1002/jmv.21750
  38. Phanuphak N, Teeratakulpisarn N, Pankam T, Kerr SJ, Barisri J, Deesua A, Rodbamrung P, Hongchookiat P, Chomchey N, Phanuphak P, Sohn AH, Ananworanich J, Palefsky JM (2013) Anal human papillomavirus infection among Thai men who have sex with men with and without HIV infection: prevalence, incidence, and persistence. *J Acquir Immune Defic Syndr* 63(4):472–479. doi:10.1097/QAI.0b013e3182918a5a
  39. Giuliano AR, Sedjo RL, Roe DJ, Harri R, Baldwi S, Papenfuss MR, Abrahamsen M, Inserra P (2002) Clearance of oncogenic human papillomavirus (HPV) infection: effect of smoking (United States). *Cancer Causes Control: CCC* 13(9):839–846
  40. Schabath MB, Villa LL, Lazcano-Ponce E, Salmeron J, Quiterio M, Giuliano AR (2012) Smoking and human papillomavirus (HPV) infection in the HPV in Men (HIM) study. *Cancer Epidemiol*

- Biomark Prev: Publ Am Assoc Cancer Res Cosponsored Am Soc Prev Oncol 21(1):102–110. doi:10.1158/1055-9965.epi-11-0591
41. Kliucinskas M, Nadisauskiene RJ, Minkauskiene M (2006) Prevalence and risk factors of HPV infection among high-risk rural and urban Lithuanian women. *Gynecol Obstet Investig* 62(3):173–180. doi:10.1159/000093572
  42. Kataja V, Syrjanen S, Yliskoski M, Hippelinen M, Vayrynen M, Saarikoski S, Mantyjärvi R, Jokela V, Salonen JT, Syrjanen K (1993) Risk factors associated with cervical human papillomavirus infections: a case-control study. *Am J Epidemiol* 138(9):735–745
  43. Hoang HT, Ishizaki A, Nguyen CH, Tran VT, Matsushita K, Saikawa K, Hosaka N, Pham HV, Bi X, Ta VT, Van Pham T, Ichimura H (2013) Infection with high-risk HPV types among female sex workers in northern Vietnam. *J Med Virol* 85(2):288–294. doi:10.1002/jmv.23456
  44. Nielsen A, Munk C, Jorgensen H, Winther J, van den Brule A, Kjaer S (2013) Multiple-type human papillomavirus infection in younger uncircumcised men. *Int J STD AIDS*. doi:10.1177/0956462412472294
  45. Remschmidt C, Kaufmann AM, Hagemann I, Vartazarova E, Wichmann O, Delere Y (2013) Risk factors for cervical human papillomavirus infection and high-grade intraepithelial lesion in women aged 20 to 31 years in Germany. *Int J Gynecol Cancer: Off J Int Gynecol Cancer Soc* 23(3):519–526. doi:10.1097/IGC.0b013e318285a4b2
  46. Brassard P, Jiang Y, Severini A, Goleski V, Santos M, Chatwood S, Lys C, Johnson G, Wong T, Kotaska A, Kandola K, Morrison H, Mao Y (2012) Factors associated with human papillomavirus infection among women in the Northwest Territories. *Can J Public Health* 103(4):e282–e287
  47. Bumbuliene Z, Alisauskas J (2012) Sexual behavior and high-risk human papillomavirus in 15- to 22-year-old Lithuanian women. *Acta Obstet Gynecol Scand* 91(4):511–513. doi:10.1111/j.1600-0412.2011.01334.x
  48. Monsonego J, Zerat L, Syrjanen K, Zerat JC, Smith JS, Halfon P (2012) Prevalence of type-specific human papillomavirus infection among women in France: implications for screening, vaccination, and a future generation of multivalent HPV vaccines. *Vaccine* 30(35):5215–5221. doi:10.1016/j.vaccine.2012.06.013
  49. Pista A, de Oliveira CF, Cunha MJ, Paixao MT, Real O (2012) Risk factors for human papillomavirus infection among women in Portugal: the CLEOPATRE Portugal Study. *Int J Gynaecol Obstet: Off Organ Int Fed Gynaecol Obstet* 118(2):112–116. doi:10.1016/j.ijgo.2012.03.028
  50. Roset Bahmanyar E, Paavonen J, Naud P, Salmeron J, Chow SN, Apter D, Kitchener H, Castellsague X, Teixeira JC, Skinner SR, Jaisamrarn U, Limson GA, Garland SM, Szarewski A, Romanowski B, Aoki F, Schwarz TF, Poppe WA, De Carvalho NS, Harper DM, Bosch FX, Raillard A, Descamps D, Struyf E, Lehtinen M, Dubin G (2012) Prevalence and risk factors for cervical HPV infection and abnormalities in young adult women at enrolment in the multinational PATRICIA trial. *Gynecol Oncol* 127(3):440–450. doi:10.1016/j.ygyno.2012.08.033
  51. Roura E, Iftner T, Vidart JA, Kjaer SK, Bosch FX, Munoz N, Palacios S, Rodriguez MS, Morillo C, Serradell L, Torcel-Pagnon L, Cortes J, Castellsague X (2012) Predictors of human papillomavirus infection in women undergoing routine cervical cancer screening in Spain: the CLEOPATRE study. *BMC Infect Dis* 12:145. doi:10.1186/1471-2334-12-145
  52. Yetimallar H, Kasap B, Cukurova K, Yildiz A, Keklik A, Soylu F (2012) Cofactors in human papillomavirus infection and cervical carcinogenesis. *Arch Gynecol Obstet* 285(3):805–810. doi:10.1007/s00404-011-2034-3
  53. Badano I, Pedrozo RW, Ruiz Diaz LS, Galuppo JA, Picconi MA, Campos RH, Liotta DJ (2011) Human papillomavirus (HPV) detection and Papanicolaou cytology in low-resource women in Posadas city, Misiones, Argentina. *Rev Argent Microbiol* 43(4):263–267. doi:10.1590/s0325-75412011000400005
  54. Bell MC, Schmidt-Grimminger D, Jacobsen C, Chauhan SC, Maher DM, Buchwald DS (2011) Risk factors for HPV infection among American Indian and White women in the Northern Plains. *Gynecol Oncol* 121(3):532–536. doi:10.1016/j.ygyno.2011.02.032
  55. Ferrera A, Tabora N, Flores Y, Zelaya A, Massuger L, Melchers WJ (2011) Assessment of HPV infection among female university students in Honduras via Roche linear array. *Int J Gynaecol Obstet: Off Organ Int Fed Gynaecol Obstet* 113(2):96–99. doi:10.1016/j.ijgo.2010.11.016
  56. Garland SM, Brotherton JM, Condon JR, McIntyre PB, Stevens MP, Smith DW, Tabrizi SN (2011) Human papillomavirus prevalence among indigenous and non-indigenous Australian women prior to a national HPV vaccination program. *BMC Med* 9:104. doi:10.1186/1741-7015-9-104
  57. Kasap B, Yetimallar H, Keklik A, Yildiz A, Cukurova K, Soylu F (2011) Prevalence and risk factors for human papillomavirus DNA in cervical cytology. *Eur J Obstet Gynecol Reprod Biol* 159(1):168–171. doi:10.1016/j.ejogrb.2011.06.021
  58. Montalvo MT, Lobato I, Villanueva H, Borquez C, Navarrete D, Abarca J, Calaf GM (2011) Prevalence of human papillomavirus in university young women. *Oncol Lett* 2(4):701–706. doi:10.3892/ol.2011.290
  59. Shikova E, Todorova I, Ganchev G, Kouseva-Dragneva V, Kalascheva-Zaimova P (2011) Prevalence of human papillomavirus infection among female sex workers in Bulgaria. *Int J STD AIDS* 22(5):278–280. doi:10.1258/ijsa.2009.009362
  60. Cercato MC, Mariani L, Vocaturro A, Carrone A, Terrenato I, Morano G, Benevolo M, Rollo F, Germelli C, Paolini F, Venuti A (2010) Predictors of human papilloma virus (HPV) infection in Italian women. *J Med Virol* 82(11):1921–1927. doi:10.1002/jmv.21887
  61. Iftner T, Eberle S, Iftner A, Holz B, Banik N, Quint W, Straube AN (2010) Prevalence of low-risk and high-risk types of human papillomavirus and other risk factors for HPV infection in Germany within different age groups in women up to 30 years of age: an epidemiological observational study. *J Med Virol* 82(11):1928–1939. doi:10.1002/jmv.21910
  62. Ripabelli G, Grasso GM, Del Riccio I, Tamburro M, Sammarco ML (2010) Prevalence and genotype identification of human papillomavirus in women undergoing voluntary cervical cancer screening in Molise, central Italy. *Cancer Epidemiol* 34(2):162–167. doi:10.1016/j.canep.2009.12.010
  63. Chan PK, Ho WC, Wong MC, Chang AR, Chor JS, Yu MY (2009) Epidemiologic risk profile of infection with different groups of human papillomaviruses. *J Med Virol* 81(9):1635–1644. doi:10.1002/jmv.21575
  64. Nielson CM, Harris RB, Flores R, Abrahamsen M, Papenfuss MR, Dunne EF, Markowitz LE, Giuliano AR (2009) Multiple-type human papillomavirus infection in male anogenital sites: prevalence and associated factors. *Cancer Epidemiol Biomark Prev Publ Am Assoc Cancer Res Cosponsored Am Soc Prev Oncol* 18(4):1077–1083. doi:10.1158/1055-9965.epi-08-0447
  65. Silva KC, Rosa ML, Moyses N, Afonso LA, Oliveira LH, Cavalcanti SM (2009) Risk factors associated with human papillomavirus infection in two populations from Rio de Janeiro, Brazil. *Mem Inst Oswaldo Cruz* 104(6):885–891
  66. Valles X, Murga GB, Hernandez G, Sabido M, Chuy A, Lloveras B, Alameda F, de San JS, Bosch FX, Pedroza I, Castellsague X, Casabona J (2009) High prevalence of human papillomavirus infection in the female population of Guatemala. *Int J Cancer* 125(5):1161–1167. doi:10.1002/ijc.24444
  67. Gonzalez C, Canals J, Ortiz M, Munoz L, Torres M, Garcia-Saiz A, Del Amo J (2008) Prevalence and determinants of high-risk human papillomavirus (HPV) infection and cervical cytological



- abnormalities in imprisoned women. *Epidemiol Infect* 136(2):215–221. doi:10.1017/s0950268807008382
68. Lindau ST, Drum ML, Gaumer E, Surawska H, Jordan JA (2008) Prevalence of high-risk human papillomavirus among older women. *Obstet Gynecol* 112(5):979–989. doi:10.1097/AOG.0b013e31818b0df2
  69. Nielson CM, Harris RB, Dunne EF, Abrahamsen M, Papenfuss MR, Flores R, Markowitz LE, Giuliano AR (2007) Risk factors for anogenital human papillomavirus infection in men. *J Infect Dis* 196(8):1137–1145. doi:10.1086/521632
  70. del Amo J, Gonzalez C, Losana J, Clavo P, Munoz L, Ballesteros J, Garcia-Saiz A, Belza MJ, Ortiz M, Menendez B, del Romero J, Bolumar F (2005) Influence of age and geographical origin in the prevalence of high risk human papillomavirus in migrant female sex workers in Spain. *Sex Transm Infect* 81(1):79–84. doi:10.1136/sti.2003.008060
  71. Beby-Defaux A, Bourgoin A, Ragot S, Battandier D, Lemasson JM, Renaud O, Bouguermouh S, Vienne Md Mde L, Agius G (2004) Human papillomavirus infection of the cervix uteri in women attending a Health Examination Center of the French social security. *J Med Virol* 73(2):262–268. doi:10.1002/jmv.20085
  72. Shin HR, Franceschi S, Vaccarella S, Roh JW, Ju YH, Oh JK, Kong HJ, Rha SH, Jung SI, Kim JI, Jung KY, van Doorn LJ, Quint W (2004) Prevalence and determinants of genital infection with papillomavirus, in female and male university students in Busan, South Korea. *J Infect Dis* 190(3):468–476. doi:10.1086/421279
  73. Chan PK, Chang AR, Cheung JL, Chan DP, Xu LY, Tang NL, Cheng AF (2002) Determinants of cervical human papillomavirus infection: differences between high- and low-oncogenic risk types. *J Infect Dis* 185(1):28–35. doi:10.1086/338010
  74. Lazcano-Ponce E, Herrero R, Munoz N, Hernandez-Avila M, Salmeron J, Leyva A, Meijer CJ, Walboomers JM (2001) High prevalence of human papillomavirus infection in Mexican males: comparative study of penile-urethral swabs and urine samples. *Sex Transm Dis* 28(5):277–280
  75. Nyari T, Cseh I, Woodward M, Szollosi J, Bak M, Deak J (2001) Screening for human papillomavirus infection in asymptomatic women in Hungary. *Hum Reprod (Oxford, England)* 16(10):2235–2237
  76. Sellors JW, Mahony JB, Kaczorowski J, Lytwyn A, Bangura H, Chong S, Lorincz A, Dalby DM, Janjusevic V, Keller JL (2000) Prevalence and predictors of human papillomavirus infection in women in Ontario, Canada. Survey of HPV in Ontario Women (SHOW) Group. *CMAJ: Can Med Assoc J* 163(5):503–508
  77. Marrazzo JM, Koutsky LA, Stine KL, Kuypers JM, Grubert TA, Galloway DA, Kiviat NB, Handsfield HH (1998) Genital human papillomavirus infection in women who have sex with women. *J Infect Dis* 178(6):1604–1609
  78. Burk RD, Ho GY, Beardsley L, Lempa M, Peters M, Bierman R (1996) Sexual behavior and partner characteristics are the predominant risk factors for genital human papillomavirus infection in young women. *J Infect Dis* 174(4):679–689
  79. Davidson M, Schnitzer PG, Bulkow LR, Parkinson AJ, Schloss ML, Fitzgerald MA, Knight JA, Murphy CM, Kiviat NB, Toomey KE et al (1994) The prevalence of cervical infection with human papillomaviruses and cervical dysplasia in Alaska Native women. *J Infect Dis* 169(4):792–800
  80. Palefsky JM, Shiboski S, Moss A (1994) Risk factors for anal human papillomavirus infection and anal cytologic abnormalities in HIV-positive and HIV-negative homosexual men. *J Acquir Immune Defic Syndr* 7(6):599–606
  81. Bauer HM, Hildesheim A, Schiffman MH, Glass AG, Rush BB, Scott DR, Cadell DM, Kurman RJ, Manos MM (1993) Determinants of genital human papillomavirus infection in low-risk women in Portland, Oregon. *Sex Transm Dis* 20(5):274–278
  82. Ley C, Bauer HM, Reingold A, Schiffman MH, Chambers JC, Tashiro CJ, Manos MM (1991) Determinants of genital human papillomavirus infection in young women. *J Natl Cancer Inst* 83(14):997–1003
  83. Rohan T, Mann V, McLaughlin J, Harnish DG, Yu H, Smith D, Davis R, Shier RM, Rawls W (1991) PCR-detected genital papillomavirus infection: prevalence and association with risk factors for cervical cancer. *Int J Cancer* 49(6):856–860
  84. Feldman JG, Chirgwin K, Dehovitz JA, Minkoff H (1997) The association of smoking and risk of condyloma acuminatum in women. *Obstet Gynecol* 89(3):346–350. doi:10.1016/s0029-7844(97)00011-2
  85. Simen-Kapeu A, La Ruche G, Kataja V, Yliskoski M, Bergeron C, Horo A, Syrjanen K, Saarikoski S, Lehtinen M, Dabis F, Sasco AJ (2009) Tobacco smoking and chewing as risk factors for multiple human papillomavirus infections and cervical squamous intraepithelial lesions in two countries (Cote d'Ivoire and Finland) with different tobacco exposure. *Cancer Causes Control: CCC* 20(2):163–170. doi:10.1007/s10552-008-9230-x
  86. Wörden J, Schnatz PF, Mandavilli S, Allen G, Murphy JL, Greene JF, Egan JF, Sorosky JI (2008) Prevalence of the human papillomavirus in an inner-city indigent population with previously normal Pap tests. *Journal Lower Genit Tract Dis* 12(4):287–292. doi:10.1097/LGT.0b013e31817e307b
  87. Hajjaj AA, Senok AC, Al-Mahmeed AE, Issa AA, Arzese AR, Botta GA (2006) Human papillomavirus infection among women attending health facilities in the Kingdom of Bahrain. *Saudi Med J* 27(4):487–491
  88. O'Keefe EJ, Gardner A, Currie MJ, Garland S, Tabrizi S, Bowden FJ (2006) Prevalence of genital human papillomavirus DNA in a sample of senior school-aged women in the Australian Capital Territory. *Sex Health* 3(2):91–94
  89. de Sanjose S, Almirall R, Lloveras B, Font R, Diaz M, Munoz N, Catala I, Meijer CJ, Snijders PJ, Herrero R, Bosch FX (2003) Cervical human papillomavirus infection in the female population in Barcelona, Spain. *Sex Transm Dis* 30(10):788–793. doi:10.1097/01.olq.0000080177.82204.e0
  90. Franceschi S, Castellsague X, Dal Maso L, Smith JS, Plummer M, Ngelangel C, Chichareon S, Eluf-Neto J, Shah KV, Snijders PJ, Meijer CJ, Bosch FX, Munoz N (2002) Prevalence and determinants of human papillomavirus genital infection in men. *Br J Cancer* 86(5):705–711. doi:10.1038/sj.bjc.6600194
  91. Svare EI, Kjaer SK, Worm AM, Osterlind A, Meijer CJ, van den Brule AJ (2002) Risk factors for genital HPV DNA in men resemble those found in women: a study of male attendees at a Danish STD clinic. *Sex Transm Infect* 78(3):215–218
  92. Muckerman DR (1994) Subclinical human papillomavirus infection in a high-risk population. *J Am Osteopath Assoc* 94(7):545–550, 555-547
  93. Hildesheim A, Gravitt P, Schiffman MH, Kurman RJ, Barnes W, Jones S, Tchabo JG, Brinton LA, Copeland C, Epp J et al (1993) Determinants of genital human papillomavirus infection in low-income women in Washington, D.C. *Sex Transm Dis* 20(5):279–285
  94. Wheeler CM, Parmenter CA, Hunt WC, Becker TM, Greer CE, Hildesheim A, Manos MM (1993) Determinants of genital human papillomavirus infection among cytologically normal women attending the University of New Mexico student health center. *Sex Transm Dis* 20(5):286–289
  95. Kemp EA, Hakenewerth AM, Laurent SL, Gravitt PE, Stoerker J (1992) Human papillomavirus prevalence in pregnancy. *Obstet Gynecol* 79(5 ( Pt 1)):649–656
  96. Meekin GE, Sparrow MJ, Fenwicke RJ, Tobias M (1992) Prevalence of genital human papillomavirus infection in Wellington women. *Genitourin Med* 68(4):228–232

97. Melbye M, Palefsky J, Gonzales J, Ryder LP, Nielsen H, Bergmann O, Pindborg J, Biggar RJ (1990) Immune status as a determinant of human papillomavirus detection and its association with anal epithelial abnormalities. *Int J Cancer* 46(2):203–206
98. Moscicki AB, Palefsky J, Gonzales J, Schoolnik GK (1990) Human papillomavirus infection in sexually active adolescent females: prevalence and risk factors. *Pediatr Res* 28(5):507–513. doi:10.1203/00006450-199011000-00018
99. Sherman JF, Mount SL, Evans MF, Skelly J, Simmons-Arnold L, Eltabbakh GH (2008) Smoking increases the risk of high-grade vaginal intraepithelial neoplasia in women with oncogenic human papillomavirus. *Gynecol Oncol* 110(3):396–401. doi:10.1016/j.ygyno.2008.05.015
100. Munk C, Svare EI, Poll P, Bock JE, Kjaer SK (1997) History of genital warts in 10,838 women 20 to 29 years of age from the general population. Risk factors and association with Papanicolaou smear history. *Sexually transmitted diseases* 24(10):567–572
101. Brisson J, Roy M, Fortier M, Bouchard C, Meisels A (1988) Condyloma and intraepithelial neoplasia of the uterine cervix: a case-control study. *Am J Epidemiol* 128(2):337–342
102. Hansen BT, Hagerup-Jenssen M, Kjaer SK, Munk C, Tryggvadottir L, Sparen P, Liaw KL, Nygard M (2010) Association between smoking and genital warts: longitudinal analysis. *Sex Transm Infect* 86(4):258–262. doi:10.1136/sti.2009.038273
103. Massad LS, Xie X, Darragh T, Minkoff H, Levine AM, Watts DH, Wright RL, D'Souza G, Colie C, Strickler HD (2011) Genital warts and vulvar intraepithelial neoplasia: natural history and effects of treatment and human immunodeficiency virus infection. *Obstet Gynecol* 118(4):831–839. doi:10.1097/AOG.0b013e31821a0f4d
104. Massad LS, Silverberg MJ, Springer G, Minkoff H, Hessel N, Palefsky JM, Strickler HD, Levine AM, Sacks HS, Moxley M, Heather Watts D (2004) Effect of antiretroviral therapy on the incidence of genital warts and vulvar neoplasia among women with the human immunodeficiency virus. *Am J Obstet Gynecol* 190(5):1241–1248. doi:10.1016/j.ajog.2003.12.037
105. Luu HN, Amirian ES, Beasley RP, Piller L, Chan W, Scheurer ME (2012) Association between smoking and size of anal warts in HIV-infected women. *Int J STD AIDS* 23(11):792–798. doi:10.1258/ijsa.2012.011420
106. Habel LA, Van Den Eeden SK, Sherman KJ, McKnight B, Stergachis A, Daling JR (1998) Risk factors for incident and recurrent condylomata acuminata among women. *Popul-Based Stud Sex Transm Dis* 25(6):285–292
107. Sopori M (2002) Effects of cigarette smoke on the immune system. *Nat Rev Immunol* 2(5):372–377. doi:10.1038/nri803
108. Peters EJ, Morice R, Benner SE, Lippman S, Lukeman J, Lee JS, Ro JY, Hong WK (1993) Squamous metaplasia of the bronchial mucosa and its relationship to smoking. *Chest* 103(5):1429–1432
109. Sekhon HS, Wright JL, Churg A (1994) Cigarette smoke causes rapid cell proliferation in small airways and associated pulmonary arteries. *Am J Physiol* 267(5 Pt 1):L557–L563
110. Feng Z, Hu W, Hu Y, Tang MS (2006) Acrolein is a major cigarette-related lung cancer agent: Preferential binding at p53 mutational hotspots and inhibition of DNA repair. *Proc Natl Acad Sci U S A* 103(42):15404–15409. doi:10.1073/pnas.0607031103
111. Phillips DH, Hewer A, Scholefield JH, Skinner P (2004) Smoking-related DNA adducts in anal epithelium. *Mutat Res* 560(2):167–172. doi:10.1016/j.mrgentox.2004.02.014
112. Herrero R, Brinton LA, Reeves WC, Brenes MM, Tenorio F, de Britton RC, Gaitan E, Garcia M, Rawls WE (1989) Invasive cervical cancer and smoking in Latin America. *J Natl Cancer Inst* 81(3):205–211
113. Wiley DJ, Elashoff D, Masongsong EV, Harper DM, Gyls KH, Silverberg MJ, Cook RL, Johnson-Hill LM (2009) Smoking enhances risk for new external genital warts in men. *Int J Environ Res Public Health* 6(3):1215–1234. doi:10.3390/ijerph6031215
114. Kjaer SK, Tran TN, Sparen P, Tryggvadottir L, Munk C, Dasbach E, Liaw KL, Nygard J, Nygard M (2007) The burden of genital warts: a study of nearly 70,000 women from the general female population in the 4 Nordic countries. *J Infect Dis* 196(10):1447–1454. doi:10.1086/522863
115. Daling JR, Sherman KJ, Weiss NS (1986) Risk factors for condyloma acuminatum in women. *Sex Transm Dis* 13(1):16–18