PERSPECTIVE

Prevalence of HPV Infection among Men: A Systematic Review of the Literature

Eileen F. Dunne,[1] Carrie M. Nielson,[3] Katherine M. Stone,[2] Lauri E. Markowitz,[1] and Anna R. Giuliano[4]

[1]Division of STD Prevention, US Centers for Disease Control and Prevention, and [2]Consultant practice, Atlanta, Georgia; [3]Arizona Cancer Center, University of Arizona, Tucson; [4]Department of Interdisciplinary Oncology, H. Lee Moffitt Cancer Center and Research Institute, Tampa, Florida

Background. Human papillomavirus (HPV) infection is estimated to be the most common sexually transmitted infection; an estimated 6.2 million persons are newly infected every year in the United States. There are limited data on HPV infection in heterosexual men.

Methods. We conducted a systematic review of the literature by searching MEDLINE using the terms "human papillomavirus," "HPV," "male," "seroprevalence," and "serology" to retrieve articles published from 1 January 1990 to 1 February 2006. We included studies that had data on population characteristics and that evaluated male genital anatomic sites or specimens for HPV DNA or included assessments of seropositivity to HPV type 6, 11, 16, or 18 in men. We excluded studies that had been conducted only in children or immunocompromised persons (HIV infected, transplant recipients, or elderly).

Results. We included a total of 40 publications on HPV DNA detection and risk factors for HPV in men; 27 evaluated multiple anatomic sites or specimens, 10 evaluated a single site or specimen, and 3 evaluated risk factors or optimal anatomic sites/specimens for HPV detection. Twelve studies assessed site- or specimen-specifi HPV DNA detection. HPV prevalence in men was 1.3%–72.9% in studies in which multiple anatomic sites or specimens were evaluated; 15 (56%) of these studies reported ⩾20% HPV prevalence. HPV prevalence varied on the basis of sampling, processing methods, and the anatomic site(s) or specimen(s) sampled. We included 15 publications reporting HPV seroprevalence. Rates of seropositivity depended on the population, HPV type, and methods used. In 9 studies that evaluated both men and women, all but 1 demonstrated that HPV seroprevalence was lower in men than in women.

Conclusion. HPV infection is highly prevalent in sexually active men and can be detected by use of a variety of specimens and methods. There have been few natural-history studies and no transmission studies of HPV in men. The information that we have reviewed may be useful for future natural-history studies and for modeling the potential impact of a prophylactic HPV vaccine.

Human papillomaviruses (HPVs) are members of the Papillomaviridae family of DNA viruses. More than 100 types have been identified ~40 types infect the anogenital region. Anogenital HPV types have been further classifie into low-risk types (e.g., 6 and 11), which are associated with anogenital warts and mild dysplasia, and high-risk types (e.g., 16, 18, 31, and 45), which are associated with high-grade dysplasia and anogenital cancers, such as cervical and anal carcinoma. Anogenital HPV infections are the most common sexually transmitted infection; an estimated 6.2 million persons are newly infected every year in the United States [1, 2]. Most infections are asymptomatic or subclinical and become undetectable over time.

Most research has focused on HPV infection in women because of the association between HPV infection and cervical cancer; however, information on HPV infection and serologic responses to infection in men is informative for evaluations of the potential impact of prophylactic HPV vaccines [3, 4]. We review studies of asymptomatic anogenital HPV infections in men and the seroprevalence of HPV types 6, 11, 16, and 18.

Received 12 April 2006; accepted 23 May 2006; electronically published 12 September 2006.

Financial support: Centers for Disease Control and Prevention (cooperative agreement AAMC MM-0579-03/03); Merck (support to A.R.G.).

Potential conflicts of interest; A.R.G. receives support from Merck for the Phase III Quadrivalent HPV Vaccine Trial among Men (Tampa, Florida, site), is a member of the Merck Young Women's Advisory Board, and is on the speaker's bureau for Merck (research support from Merck is <5% of her total research funding for HPV). K.M.S. is a consultant to Merck and GlaxoSmithKline and is on the speaker's bureau for GlaxoSmithKline. All other authors: no conflicts reported.

Reprints or correspondence: Dr. Eileen F. Dunne, 1600 Clifton Rd., MS E-02, Atlanta, GA 30333 (dde9@cdc.gov).

The Journal of Infectious Diseases 2006; 194:1044–57

0022-1899/2006/19408-0005$15.00

METHODS

We conducted a systematic review of the literature by searching MEDLINE for articles published in English from 1 January 1990 through 1 February 2006. We also included references from the retrieved publications. We excluded studies conducted only in children <12 years old or immunosuppressed persons (HIV infected, transplant recipients, or elderly) and studies that included <20 men. When possible, we included results only for asymptomatic men.

To retrieve publications reporting HPV DNA prevalence, we used the search terms "HPV," "human papillomavirus," and "male." We included studies that used polymerase chain reaction or hybrid capture to detect HPV DNA from genital anatomic sites or specimens. We excluded publications that evaluated only prostate, anal, or testicular samples.

To retrieve publications reporting HPV seropositivity, we used the same search terms but also included "serology" and "seroprevalence." We included studies that evaluated IgG antibodies to HPV-6, -11, -16, and -18 virus-like particles (VLPs) or to L1 or L2 peptides.

RESULTS

HPV DNA detection studies. Our search identifie 148 eligible studies; review of these studies resulted in the inclusion of 43 publications. Three studies had information reported in another publication and were excluded, resulting in a total of 40 studies [5–44]. Two studies had information on risk factors only [43, 44], and 1 study had information on anatomic sites and samples [42].

Study populations included a variety of age and racial/ethnic groups in diverse geographic locations. Twenty-seven studies evaluated multiple anatomic sites and specimens (table 1) [6–9, 11–13, 16, 19, 22, 23, 25–28, 30–41], and 10 studies evaluated single sites or specimens (table 2) [5, 10, 14, 15, 17, 18, 20, 21, 24, 29]. Twelve studies evaluated multiple sites or specimens and reported the results for each site or specimen separately (table 3) [11, 12, 22, 23, 25, 30–33, 35, 36, 42]. Four longitudinal studies evaluated the incidence and/or persistence of HPV (table 4) [19, 31, 34, 41].

HPV prevalence in men was 1.3%–72.9% in studies in which multiple anatomic sites or specimens were evaluated; 15 (56%) of these studies reported an overall HPV prevalence ⩾20% (table 1). HPV prevalence varied both within and among populations (figu e 1).

Sampling methods. Sampling methods varied among studies. Most sampling methods involved rubbing or rotating a swab or brush, either dry or moist, on the genital epithelium. One study that evaluated 3 different sampling techniques (10 men for each method) found that using a saline-wetted sterile Dacron swab after having rubbed the sampling site with a small piece of emery paper was superior for specimen adequacy to using the swab alone or using a saline-wetted sterile cytobrush [32]. One study found that self-collection yielded a greater proportion of adequate specimens than physician-collected specimens [36].

Sites of detection. The prevalence of HPV varied on the basis of sampling, processing methods and the anatomic site(s) or specimen(s) sampled. Twelve studies compared HPV detection in individual anatomic sites or specimens (table 3). Most studies evaluated the glans, corona, prepuce, or shaft of the penis. Although no 2 studies included all the same sites, 8 sampled the corona and/or glans, and the reported HPV prevalence was 6.5%–50% [11, 22, 23, 30–33, 36]. Three studies evaluated the penile shaft, and the reported HPV prevalence was 5.6%–51.5% [11, 32, 36]. Four studies sampled the prepuce, and the reported HPV prevalence was 24.0%–50.0% [23, 32, 33, 36]. HPV prevalence was 7.1%–46.2% in 5 studies that evaluated the scrotum [11, 23, 32, 36, 42]. Seven studies evaluated the distal 1–3 cm of the urethra, and the reported HPV prevalence was 8.7%–50% [12, 22, 23, 31, 33, 35, 42]. The few studies that evaluated the perianal area, anus, or rectum found an HPV prevalence of 0%–32.8% [11, 23, 30, 31]. Semen was evaluated in 2 studies that compared multiple anatomic sites and specimens [25, 35] and in 7 studies that evaluated semen as a single specimen [5, 15, 17, 20, 21, 24, 29]; HPV was detected in 2.2%–41.3% of men evaluated and in up to 82.9% of specimens. Most studies that evaluated urine reported an HPV prevalence of <7% [11, 12, 22, 25, 32, 35]. Seven studies reported sample adequacy by the evaluation of β-globin [11, 12, 22, 32, 35, 36, 42]. Samples collected from the prepuce, shaft, glans, corona, and scrotum were the most likely to have adequate DNA; 70%–98.5% were β-globin positive.

HPV DNA types. The most common anogenital HPV types detected in men varied by study but were similar to the types commonly detected in women. Type 16 was consistently among the most common; however, other types were also reported (types 6, 11, 18, 31, 33, 42, 52, 53, 54, 59, and 84) [7, 9, 27, 39, 41]. One study found that undetermined types may be found more frequently in men than in women [39]. Multiple types were commonly found in men; 51.1% of men with HPV in one study had multiple HPV types detected [41].

Risk factors for HPV DNA detection. Ten studies evaluated the risk factors associated with HPV infection in men in a cross-sectional analysis [6, 9, 13, 22, 26, 27, 30, 41, 43, 44]; of these, 5 reported factors statistically significantl associated with infection. Few studies included multivariate analyses to evaluate factors independently associated with HPV infection [27, 43]. Two studies included multivariate analysis to evaluate the factors independently associated with the acquisition or persistence of HPV infection [19, 41].

Measures of sexual behavior were associated with HPV in-

Table 1. Human papillomavirus (HPV) DNA detection in asymptomatic men, determined using multiple genital sites and specimens.

Reference	Population (location)	No.	Age, years	Anatomic site or specimen	Method	DNA testing	HPV types detected	Men with HPV infection, %			
								Total	HR types	LR types	Other types
Hernandez et al. 2006 [36]	University students (HI)	136	18–63	Glans, corona, shaft, prepuce, scrotum	Physician-collected: emery paper (600A grit, Wetordry Tri-M-ite; 3M) to swab area, followed by prewetted sterile Dacron swab, both put in Digene STM; self-collected: obtained 24 h after clinic visit using the same procedure	PCR	6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51–56, 58–62, 64, 66–73, 81–84, CP6108, IS39	42.8–41.3	UNK	UNK	ND
Bleeker et al. 2005[a,b] [39]	Partners of women with CIN (The Netherlands)	181	22–57	Glans, corona, frenulum, prepuce	Cervex brush (Rovers Medical Devices) for penile scraping starting at the top of the penis[c]	PCR	6, 11, 16, 18, 26, 31, 33–35, 39, 40, 42–45, 51–59, 61, 66, 68, 70–73, 81, 82, 82/MM4, 82/1529, 83, 84, cand89	72.9	58.6	27.1	11.6
Kjaer et al. 2005 [19]	Military conscripts (Denmark)	374	19–22	Glans, corona	Prewetted cotton-tipped swabs put in PBS[c]	PCR	6, 11, 16, 18, 26, 31, 33–35, 39, 40, 42–45, 51–59, 61, 66, 68, 70, 72, 73, 81–84, 89	33.8	UNK	UNK	UNK
Lajous et al. 2005 [41]	Military conscripts (Mexico)	1030	16–40	Corona, shaft, upper third of the scrotum, shaft, urethral meatus, urethra	Cytobrush for scrotum, shaft, and corona; cotton swab for urethra meatus; Accelon Multi biosampler swab (Medscand) for urethra[c]	PCR	6, 11, 16, 18, 31, 33, 35, 39, 40, 42, 45, 51–59, 66, 68, 73, 82–84	44.6	34.8	23.9	UNK
Nicolau et al. 2005 [23]	Partners of women with HPV (Brazil)	50	19–53	Glans, urethra, internal and external prepuce, scrotum, anus	Anogenital region sprayed with saline, specimens obtained using a vigorous motion with conical brush from Digene kit, distal to proximal, right to left	hc2 HR and LR	6, 11, 16, 18, 31, 33, 35, 39, 42–45, 51, 52, 56, 58, 59, 68	70	UNK	UNK	UNK
Takahashi et al. 2005 [38]	STD clinic attendees (Japan)	204	18–35	Glans, corona, inner surface of prepuce	Self-collected by extensively wiping area with a wet cotton swab	hc2 HR and LR	6, 11, 16, 18, 31, 33, 35, 39, 42–45, 51, 52, 56, 58, 59, 68	5.9	5.9	0	UNK
Rosenblatt et al. 2004 [40]	Partners of women with and without CIN (Brazil)	90	UNK	Shaft, dorsal and prebalanic area, prepuce, urethral meatus	Brushing[c]	HC HR, LR	6, 11, 16, 18, 31, 33, 35, 39, 42–45, 52, 56, 58, 59, 68	UNK	35.6	15.6	UNK
Shin et al. 2004[a] [26]	Male students (South Korea)	381	UNK	Glans, corona, scrotum, prepuce, urethra	Prewetted cytobrush (Sang-A Medical) on penis, bottom to top, starting at the middle third of the scrotum; the corona, glans, and tip were also brushed with a moistened Dacron swab inserted 1 cm, all specimens in PBS[c]	PCR	6, 11, 16, 18, 30, 31, 33, 34, 35, 39, 40, 42–45, 51–59, 66, 68, 73	8.7	4.2	2.6	1.8

Weaver et al. 2004 [32]	University students (WA)	318	18–25	Glans, prepuce, shaft, scrotum	Emery paper (600A grit Wetordry Tri-M-ite), followed by prewetted swab	PCR	6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51–59, 66, 68, 73, 82–84	35.0	UNK	UNK	UNK
Baldwin et al. 2003[a] [7]	STD clinic attendees (AZ)	443	18–70	Glans, corona, urethra	Urethra: prewetted Dacron tipped urethra swab inserted 1 cm in the urethra and rotated; second cervical-sized prewetted swab swept around the corona and penis, put in Digene STM[c]	PCR	6, 11, 16, 18, 26, 31, 33–35, 39, 42, 45, 51, 59, 66, 68, 73, 82–84	28.2	12.0	14.8	5.9
Fife et al. 2003 [11]	STD clinic attendees (IN)	20	18–50	Glans, corona, shaft, inguinal skin, scrotum, perineum, perianal, urine	Dry swab specimens were put in Digene STM	PCR	6, 11	10	UNK	10	UNK
Takahashi et al. 2003 [28]	University students (Japan)	75	18–35	Glans, corona, inner prepuce	Self-collected using a cotton swab, put in Digene swab specimen buffer[c]	hc2 HR and LR	6, 11, 16, 18, 31, 33, 35, 39, 42–45, 51, 52, 56, 58, 59, 68	1.3	1.3	0	UNK
Van der Snoek et al. 2003 [30]	MSM: STD clinic attendees, HIV positive or negative (The Netherlands)	258	19–76	Corona, anus	Dry swab	PCR	6, 11, 16, 18, 31, 33–35, 39, 40, 42–45, 51–54, 56, 58, 59, 66, 68, 70, 74	15.8	UNK	UNK	1.0
Franceschi et al. 2002[a,b,c] [13]	Husbands of women enrolled in case-control studies of cervical carcinoma (Thailand, Philippines, Brazil, Columbia, Spain)	1143	19–82	Glans, corona, urethra	Prewetted cotton-tipped swabs from urethra and another from the glans and corona, put in PBS[c]	PCR	6, 11, 16, 18, 31, 33	16.0	UNK	0.5	9.9
Bleeker et al. 2002 [8]	Partners of women with CIN (The Netherlands)	119	23–58	Glans, corona, frenulum, prepuce	Cervex brush (Rovers Medical Devices), put in 5 mL of PBS[c]	PCR	16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 66, 68	59	55.4	3.4	UNK
Rintala et al. 2002[e] [25]	Vasectomy patients (Finland)	27	33–49	Semen, urine, vas deferens	Postvasectomy semen, pre-/post-ejaculation urine, vas deferens	PCR	6, 11, 16, 18, 31, 33, 35, 45, 51, 52, 54, 56, 58	44.4	29.6	22.2	UNK
Svare et al. 2002[a,b] [27]	STD clinic attendees (Denmark)	216	>18	Glans, corona, shaft, scrotum, perianus	Prewetted cotton-tipped swabs: 1 over the glans/corona and 1 over the shaft, scrotum, perianus, all put in PBS[c]	PCR	27 types	44.9	UNK	UNK	24.7
Lazcano-Ponce et al. 2001[a] [22]	Sexually active college students and industry workers (Mexico)	120	14–55	Corona, urethra, urine	Accelon biosampler swab (Medscand) inserted 2 cm into urethra and rotated; second swab along circumference of the corona, both put in PBS[d]	PCR	6, 11, 16, 18, 31, 33, 35, 39, 40, 42–45, 51, 52, 56, 58, 59, 66, 68	42.7	19.8	17.7	5.2
Wikstrom et al. 2000[b] [34]	STD clinic attendees (Sweden)	235	18–54	Glans, corona, inner prepuce	Cytobrush rotated, put in PBS[c]	PCR	6, 11, 16, 18, 31, 33, 35, sequenced nontypeable HPV DNA	20.4	UNK	UNK	UNK
Castellsagué et al. 1997[a,b] [9]	Population (Spain, Colombia)	816	Median, 45	Glans, corona, urethra, penis	Swabbing with wet thin cotton-tipped swabs[c]	PCR	25 types	15.3	9.7	2.9	4.4

Baken et al. 1995[a,e] [6]	Heterosexual partners of STD clinic attendees (WA)	48	>17	Penis	Dacron swabs put in ViraPap transport medium[c]	PCR	6, 11, 16, 18, 31, 33, 35	63	~18	~12	~18
Astori et al. 1995 [35]	Asymptomatic partners of women with HPV (Italy)	70	UNK	Urethra, urine, semen	First-void urine, urethra swabs using prewetted swab (Kima-Italy), inserted 1 cm, rotated, and put in 3 mL of PBS; self-collected semen	PCR	UNK	UNK	UNK	UNK	UNK
Hippelainen et al. 1994[b,e] [37]	Male partners of women with CIN (Finland)	77	17–74	Peniscopically normal area adjacent to lesion, HPV negative by ISH	Biopsy sample fixed in 10% formalin and embedded in paraffin	PCR	6, 11, 16, 18, 31, 33, 42	9.1	UNK	UNK	UNK
Van Doornum et al. 1994 [31]	Heterosexual STD clinic attendees, The Netherlands	85	UNK	Corona, urethra, anus, rectum	Sterile cotton-tipped swab or wooden spatula	PCR	6, 11, 16, 18, 33	28.2	UNK	UNK	UNK
Forslund et al. 1993[a] [12]	Military conscripts and adolescent clinic attendees (Sweden)	145	UNK	Urine, urethra	First-void urine, Accelon (Medscand) prewetted brush, rotated in urethra	PCR	6, 11, 16, 18, 31, 33, other types	7.5	UNK	UNK	UNK
Hippelainen et al. 1993 [16]	Voluntary conscripts (Finland)	168	UNK	Glans, prepuce, sulcus, urethra, urethral meatus	Sterile brush inserted 2 cm in the urethral meatus; rotation and gentle scraping on other sites; put in 70% ethanol[c]	PCR	1, 6, 11, 16, 18, 31, 33	7.1	UNK	UNK	UNK
Wikstrom et al. 1991 [33]	STD clinic attendees, men with no history of genital warts (Sweden)	135	17–58	Corona, prepuce, urethral meatus	Cytobrush (Medscand) for corona and prepuce, sterile cotton-tipped swab inserted 1 cm in the urethra and rotated, put in PBS	PCR	6, 16	50	13	43	ND

NOTE. CIN, cervical intraepithelial neoplasia; HC, hybrid capture; HR, high risk; ISH, in situ DNA hybridization; LR, low risk; MSM, men who have sex with men; ND, not done; PCR, polymerase chain reaction, STD, sexually transmitted disease; STM, specimen transport medium; UNK, unknown/not reported.

[a] Reports from valid test only (β-globin or another measure).
[b] HPV seroprevalence was calculated using information in the article.
[c] Samples and specimens were pooled into 1 specimen.
[d] Penile samples were pooled into 1 specimen, and urine was evaluated separately.
[e] Symptomatic and asymptomatic men were included.

Table 2. Human papillomavirus (HPV) DNA detection in asymptomatic men, determined using single genital sites and specimens.

Reference	Population (location)	No.	Age, years	Anatomic site or specimen	Method	DNA testing	HPV types detected	Men with HPV, %			
								Total	HR types	LR types	Other types
Aynaud et al. 2002 [5]	Partners of women with HPV (France)	46	19–42	Semen	Self-collected	PCR	6, 11, 16, 18, 33, 42	2.2	UNK	2.2	UNK
Olatunbosun et al. 2001[a] [24]	Sperm donors (Canada)	85	20–41	Semen	Self-collected, sperm cells evaluated	PCR	UNK	31.7	UNK	UNK	UNK
Tanaka et al. 2000 [29]	Infertility clinic attendees (Japan)	99	UNK	Semen	Self-collected	PCR	16	4.0	25–70	UNK	UNK
Lai et al. 1997 [21]	Fertility clinic attendees (Taiwan)	24	UNK	Semen	Self-collected, sperm cells evaluated	PCR	16, 18	25.0	25.0	UNK	UNK
Kyo et al. 1994[b] [20]	Infertility clinic attendees (Japan)	53	UNK	Semen	Self-collected	PCR	16, 18	22.6	22.6	UNK	UNK
Geddy et al. 1993[c] [14]	STD clinic attendees (UK)	73	UNK	Urine	First-void urine	PCR	UNK	0	UNK	UNK	UNK
Della Torre et al. 1992[b] [10]	Partners of women with HPV (Italy)	64	UNK	Urethra	Small brush inserted to 1 cm and rotated, placed in 0.9% NaCl solution	PCR	6, 11, 16, 18	21.9	9.4	12.5	UNK
Inoue et al. 1992 [17]	Partners of women with HPV (Japan)	23	UNK	Semen	Self-collected	PCR	16, 18	17.4	17.4	UNK	UNK
Green et al. 1991 [15]	Infertility clinic attendees, no warts (UK)	104	UNK	Semen	Self-collected	PCR	6, 11, 16	41.3	33.6	22.1	UNK
Kataoka et al. 1991[b] [18]	Army conscripts, normal or acetowhite epithelium (Sweden)	66	18–23	Urethra	Brush with thin plastic shaft (Urobrush; Medscand) inserted 2–3 cm and rotated, put in lytic buffer	PCR	6, 11, 16, 18, 33	17.1	UNK	UNK	UNK

NOTE. HR, high risk; LR, low risk; PCR, polymerase chain reaction; STD, sexually transmitted disease; UNK, unknown/not reported.

[a] HPV seroprevalence was calculated from information in the article.

[b] Symptomatic and asymptomatic men were included.

[c] Reports from valid test only (β-globin or another measure).

Table 3. Human papillomavirus (HPV) DNA detection, by anogenital site or specimen.

Reference, anatomic site or specimen (no.)	Adequate samples,[a] no. (%)	HPV-positive samples,[b] no. (%)
Aguilar et al.[a] 2006 [42]		
Urethra (298)	298 (100)	62 (20.8)
Urethral meatus (522)	512 (98.1)	62 (12.1)
Penis and scrotum (820)	591 (72.1)	274 (46.4)
Hernandez et al. 2006 [36]		
Physician collected		
Shaft (136)	129 (94.8)	66 (51.2)
Scrotum (136)	119 (87.5)	49 (41.2)
Prepuce (22)	21 (95.4)	7 (33.3)
Glans/corona (136)	116 (85.3)	37 (31.9)
Self-collected		
Shaft (136)	134 (98.5)	69 (51.5)
Scrotum (136)	130 (95.6)	60 (46.2)
Glans/corona (136)	133 (97.8)	44 (33.1)
Prepuce (22)	21 (95.4)	6 (28.6)
Nicolau et al. 2005 [23]		
Internal prepuce (50)	UNK	22 (44.0)
Urethra (50)	UNK	15 (30.0)
Glans (50)	UNK	12 (24.0)
External prepuce (50)	UNK	12 (24.0)
Scrotum (50)	UNK	6 (12.0)
Anus (50)	UNK	4 (8.0)
Weaver et al. 2004 [32]		
Urine (314)	313 (99.7)	18 (5.8)
Prepuce (58)	57 (98.3)	16 (28.1)
Shaft (317)	311 (98.1)	77 (24.8)
Glans (317)	309 (97.5)	51 (6.5)
Scrotum (317)	298 (94.0)	53 (17.8)
Fife et al. 2003 [11]		
Urine (20)	19 (95.0)	1 (5.3)
Shaft (20)	18 (90.0)	1 (5.6)
Glans (20)	14 (70.0)	2 (14.3)
Scrotum (20)	14 (70.0)	1 (7.1)
Inguinal area (20)	12 (60.0)	1 (8.3)
Perianal (20)	11 (55.0)	0
Perineum (20)	9 (45.0)	0
Van der Snoek et al. 2003 [30]		
Anus (241)	UNK	79 (32.8)
Corona (241)	UNK	38 (15.8)
Rintala et al. 2002 [25]		
Semen (18)	UNK	5 (27.8)
Pre-ejaculatory urine (18)	UNK	4 (22.2)
Vas deferens (27)	UNK	5 (18.5)
Postejaculatory urine (18)	UNK	3 (16.7)
Lazcano-Ponce et al. 2001[c] [22]		
Urethra and corona (120)	114 (95.0)	41 (42.7)
Urine (120)	29 (24.2)	2 (6.9)

(continued)

Table 3. ***(Continued.)***

Reference, anatomic site or specimen (no.)	Adequate samples,[a] no. (%)	HPV-positive samples,[b] no. (%)
Astori et al. 1995 [35]		
Semen (70)	70 (100)	58 (82.9)
Urine (70)	55 (78.6)	18 (32.7)
Urethra (70)	9 (12.9)	4 (44.4)
Van Doornum et al. 1994 [31]		
Urethra (85)	UNK	16 (18.8)
Corona (85)	UNK	6 (7.1)
Rectum (85)	UNK	4 (4.7)
Anus (85)	UNK	1 (1.2)
Forslund et al. 1993 [12]		
Urethra (143)	143 (100)	12 (8.7)
Urine (143)	138 (96.5)	5 (3.6)
Wikstrom et al. 1991[d] [33]		
Corona and prepuce (135)	UNK	(50)
Urethra (135)	UNK	(50)

NOTE. UNK, unknown.

[a] Determined by β-globin detection.

[b] Percentage of adequate samples at the site (β-globin positive).

[c] Authors excluded virgins ($n = 18$) when calculating prevalence, so the denominator was 96.

[d] Based on a bar chart.

fection in men. Five cross-sectional studies found risk factors related to sexual behavior, including young age at firs sexual intercourse [9]; a greater number of regular, lifetime, and recent sex partners [13, 27, 44]; and a greater number of sex partners before and during marriage [9, 44]. In addition, female sex partners' lifetime number of sex partners [44] and a high frequency of sexual intercourse [43] were associated with HPV detection. However, only 2 of these studies included a multivariate analysis that adjusted for confounding [27, 43]. Longitudinal studies found that anal intercourse with men [41] and having had $\geqslant$3 sex partners [19] were independently associated with HPV acquisition.

The effect of condom use was evaluated in 5 cross-sectional analyses [13, 30, 41, 43, 44], 1 of which found, after controlling for confounding factors, a significan reduction in the risk of HPV infection in men who used condoms consistently [43]. Consistent condom use during the preceding 3 months was associated with a decreased risk of both any and high-risk HPV infection; condom use during the last occurrence of anal sex was associated in the same study with a decreased risk of low-risk HPV infection [43]. Another study demonstrated that condom use significantl reduced the risk of HPV in circumcised men but not in uncircumcised men [44]. One longitudinal study found that consistent or occasional condom use was independently associated with a reduced risk of acquiring HPV [19].

The effect of circumcision was evaluated in 5 cross-sectional studies [26, 27, 41, 43, 44], 3 of which found, after adjusting for confounding factors, that circumcision was associated with a statistically significan lower risk of HPV infection [27, 41, 43]. The statistically significan reduction in risk ranged from 20% to 48%. One longitudinal study found that self-reported circumcision was independently associated with a reduced risk of HPV persistence [19].

Two cross-sectional studies evaluated factors associated with the detection of high-risk versus low-risk HPV types [27, 43]; only 1 adjusted for confounding factors [43]. Factors associated with high-risk HPV types were young age [27], a higher lifetime number of sex partners [27], and higher frequency of sexual intercourse [43]. High-risk HPV types were less likely to be detected in circumcised men or in those who had used condoms consistently during the preceding 3 months [43]. Factors associated with the detection of low-risk HPV types were young age [27], a history of genital warts [27], the presence of genital warts [43], and the number of sex partners during the preceding year [27]. Low-risk HPV types were less likely to be detected in circumcised men and in those who had used condoms during their last occurrence of anal sex [43]. Two longitudinal studies found that the detection of >1 HPV type at baseline was independently associated with HPV persistence [19, 41].

Natural-history studies. Only 4 studies prospectively evaluated HPV infection in men [19, 31, 34, 41] (table 4). The duration of follow-up varied among studies. Of men who tested negative for HPV at baseline, between 13.8% and 22.7% acquired HPV (i.e., tested positive during follow-up). Indepen-

Table 4. Longitudinal studies of human papillomavirus (HPV) DNA in men.

			Acquisition of HPV infection			Persistent HPV infection		
Reference (no. of men in study)	Duration of follow-up, mean (range)	Incidence/1000 man-months	Acquisition,[a] %	Factors associated with acquisition	AOR (95% CI)	Persistent infection, %	Factors associated with persistence	AOR (95% CI)
Lajous et al. 2005[c] [41] (336)	1 year (NA)	17.9	21.4	High SES	0.3 (0.1–0.6)	11[b]	Median baseline infection (>1)	1.8 (1.24–2.90)
				Anal intercourse with men	5.3 (1.2–24.2)		Circumcision (self-reported)	0.1 (0–0.87)
Kjaer et al. 2005 [19] (250)	6.6 mos (5.4–7.8 mos)	NA	13.8	⩾3 sex partners	17.2 (4.6–64.7)	57.5[c]	Multiple HPV types at baseline	4.2 (1.3–12.7)
				Always/occasional condom use	0.2 (0.1–0.8)			
Wikstrom et al. 2000 [34] (88)	3.5 mos (0.5–16 mos)	NA	22.7	NA	NA	50.0[c]	NA	NA
Van Doornum et al. 1994 [31] (48)	498 days (NA)	42.1	NA	NA	NA	6[b]	NA	NA

NOTE. AOR, adjusted odds ratio; CI confidence interval; NA, not available; SES, socioeconomic status.

[a] Men with no HPV at the baseline visit who had HPV detected at a follow-up visit.

[b] Percentage of the total no. of men in the study who had persistent infection.

[c] Percentage of HPV-positive men in the study whose type-specific infection persisted.

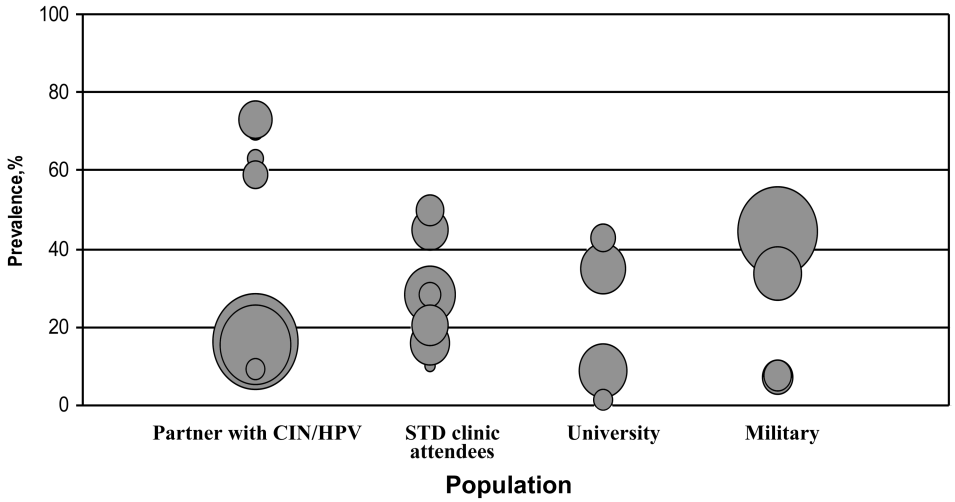

Figure 1. Human papillomavirus (HPV) prevalence in men of various populations. Each circle represents a study, the size of the circle indicates the no. of men tested, and the center of the circle is the point estimate of prevalence. CIN, cervical intraepithelial neoplasia; STD, sexually transmitted disease.

dent predictors of HPV acquisition were anal sex with other men (adjusted odds ratio [AOR], 5.34 [95% confidenc interval {CI}, 1.18–24.2]) [41] and having had ⩾3 sex partners since the last clinic visit (AOR, 17.2 [95% CI, 4.6–64.7]) [19]. Factors independently associated with a reduced risk of HPV acquisition were consistent or occasional condom use (AOR, 0.2 [95% CI, 0.1–0.8]) [19] and high socioeconomic status (AOR, 0.28 [95% CI, 0.12–0.64]) [41].

The definitio of persistence varied by study; persistence occurred in 6%–11% of men in the study or in 50%–57.5% of men with HPV infection at the baseline visit. Factors associated with persistence included multiple HPV types detected at the baseline visit and circumcision [19, 41].

Transmission studies. Few studies have evaluated HPV infection in both men and their female sex partners; all of these studies published to date have evaluated cross-sectional concordance [6, 23, 37, 39]. A recent cross-sectional study of heterosexual couples found that 37% of partners were infected with the same HPV type. Notable finding were that overall viral loads were much lower in penile-scrape specimens than in cervical-scrape specimens. Higher loads of HPV-16 were associated with having a partner who was also positive for HPV-16 [39]. Another study that assessed HPV by DNA detection or peniscopy found that 76% of male sex partners of women with HPV were HPV DNA positive; that study did not evaluate type-specifi concordance [23]. A study of 50 couples found that HPV type–specifi concordance between sex partners was more common than predicted by chance ($P = .01$) [6]. Another study found that only 22.7% of couples had the same HPV type in genital specimens [37].

To our knowledge, there have been no longitudinal transmission studies; however, recent modeling efforts seeking to match transmission characteristics to available incidence and prevalence data estimated the median probability per sex act of HPV transmission to be ~40% (range, 5%–100%) [45].

HPV seroprevalence studies. We identifie 42 studies of HPV seroprevalence; 14 met our inclusion criteria (table 5) [46–59]. Eleven publications evaluated HPV-16 seroprevalence [46, 49–55, 57–59]; 5 evaluated HPV-6 seroprevalence [47, 49, 51, 55, 56]; 4 evaluated HPV-11 seroprevalence [48, 51, 55, 56]; and 1 evaluated HPV-18 seroprevalence [59]. One study used a combined assay for HPV-6 and -11 seroprevalence [51]. Nine studies compared HPV seroprevalence in men and women [46–48, 51–53, 57–59].

HPV-16 seropositivity differed by study population; most studies in sexually transmitted disease (STD) clinics reported a higher rate of seropositivity than studies in other populations. The range of reported seropositivity in male STD clinic attendees was between 18.7% [58] and 48% [49] in the United States. The seropositivity to HPV-16 in males in the general population was 7.9% in the United States [57]. HPV-16 seropositivity was similar in male STD clinic attendees in Denmark, Greenland, and Jamaica [52, 53]; however, a lower seroprevalence was noted in China, and a higher seroprevalence was noted in Sweden [54, 55]. Eight of 9 studies that compared seroprevalence in men and women reported a higher seroprevalence in women than in men [46, 48, 51–53, 57–59].

Comparisons of studies of HPV-6, -11, and -18 seropositivity were more difficult because most studies of HPV-6 and -11 were conducted in STD clinic attendees, and the study of HPV-18 was conducted in clinics or community centers. HPV-6 or -11 seroprevalence ranged from 26.4% [51] to 41% [49] in one

Table 5. Human papillomavirus (HPV) seroprevalence in men.

Reference	Study population (location)	No.	Age, range, years	HPV types	Prevalence, %
Kreimer et al. 2004 [59]	Community centers and clinics (MD)	340	18–72	16	14.1
				18	18.8
Thompson et al. 2004 [58]	Heterosexual STD clinic attendees (US)	786	⩾14	16	18.7
Stone et al. 2002 [57]	General population (US)	3110	12–59	16	7.9
Carter et al. 2001 [46]	Control subjects from general population (WA)[a]	797	NA	16	12.6–15.6
Slavinsky et al. 2001 [51]	STD clinic attendees (LA)	583	NA	6, 11	26.4
				16	32.8
Hisada et al. 2000 [50]	HMO members (CA)	63	NA	16	30
Strickler et al. 1999 [52]	Blood donors (US)	140	17–72	16	3
	Blood donors (Jamaica)	141	17–80	16	19
	STD clinic attendees (Jamaica)	404	15–70	16	29
Hagensee et al. 1997 [49]	HIV-negative MSM attending a clinic for HIV testing (WA)	101	16–50	6	41
				16	48
Svare et al. 1997 [53]	Men attending STD clinics (Denmark)	219	18–56	16	19
	(Greenland)	88	18–58	16	26
Wikstrom et al. 1997 [56]	STD clinic attendees (Sweden)	198	18–58	6	10
				11	27
Eisemann et al. 1996 [48]	Fertility clinic attendees (Germany)	124	17–73	11	3.2
	Blood donors (Germany)[b]	66	22–65	11	16.7
	Hospitalized patients (Germany)[b]	39	22–60	11	5.3
Wideroff et al. 1996 [54]	Community members (China)	60	NA	16	0
Carter et al. 1995 [47]	HMO members with no history of genital warts (WA)	137	NA	6	26
Wikstrom et al. 1992 [55]	STD clinic attendees (Sweden)	116	18–58	6	L1, 27; L2, 68
				11	L1, 25
				16	L1, 52

NOTE. HMO, health maintenance organization; MSM, men who have sex with men; NA, not available; STD, sexually transmitted disease.

[a] Control subjects from a case-control study of anal and penile cancer.

[b] Age ranges were reported for female and male subjects combined.

study. The estimate of HPV-18 seroprevalence in one study was 18.8% [59].

Risk factors for HPV seropositivity. Six studies reported factors associated with HPV seropositivity [49, 51–53, 57, 58], and all included multivariate analyses to identify factors independently associated with HPV seropositivity. All studies evaluated HPV-16 seropositivity as an outcome; one also evaluated HPV-6 and -11 seropositivity [51], and another evaluated HPV-6 seropositivity [49].

Age was evaluated in 6 studies [49, 51–53, 57, 58]. In 3 studies, age (generally, being >20 years old) was associated with an increased likelihood of detection of HPV-16 antibodies [51, 52, 58]. No association was observed between age and HPV-6 and -11 seropositivity in the 2 studies that evaluated age as a risk factor [49, 51].

Sexual behavior was evaluated in 6 studies [49, 51–53, 57, 58] and was found to be independently associated with HPV seropositivity, including the lifetime [53] and recent [49, 51, 52, 58] number of sex partners. Having had >1 occasional sex partner within the preceding year was associated with an increased risk of HPV seropositivity in 1 study [58]. Younger age (<18 years) at firs sexual intercourse was evaluated in 2 studies [53, 57] and was a significan risk factor in 1 study [53]. One study found an increased risk of HPV-16 seropositivity in men who had had sex with a man [57].

Three studies, 2 of which included multivariate analyses, evaluated condom use and HPV seropositivity [51, 52, 58]. One study found that HPV-16 seropositivity was more likely to occur with less-frequent condom use during the preceding year (never vs. more than one-half the time) [52]. One study examined consistent condom use in a bivariate analysis and found no significan association between condom use and the detection of HPV-16 or -6 and -11 antibodies [51].

DISCUSSION

HPV infection is common in sexually active men and can be detected by use of a variety of specimens and methods. HPV in asymptomatic men is frequently associated with various measures of sexual activity. Few studies are available that have determined the frequency of acquisition and the duration of infection in men.

Our review demonstrates a wide range of HPV DNA prevalence among men, depending on the study population and the type and number of anatomic sites evaluated. Most studies in men found prevalences as high as those reported in studies in women. Our review identifie HPV prevalence in men as high as 72.9% and usually ⩾20%; HPV prevalence in women in one systematic review was 14%–90% [60].

The best anatomic sites for sampling in men—taking into consideration convenience of sampling, adequacy of the sample, and detection of HPV DNA—appear to be the glans, corona, prepuce, and shaft of the penis. It is possible that combined samples from these sites may be optimal. Sampling from these sites appears to have several advantages: samples are consistently adequate, and sample collection is simple and painless. Scrotum samples are often adequate, but, in most studies, they were less likely to yield HPV DNA. The prepuce, when present, is possibly the best single site for HPV DNA detection.

Specimens that are less useful include urine, semen, and urethral swabs. The source of infection in these specimens is unclear, but it could be the urethra, seminal fluid sperm, or vas deferens. Semen and urethral specimens often have adequate β-globin and HPV DNA but are difficul and sometimes uncomfortable to collect. β-globin and HPV DNA detection is often poor from urine specimens, although these specimens could be the easiest to obtain.

The sites on the penis that consistently yield HPV—the glans, corona, prepuce, and most of the shaft—are covered when a condom is properly used. However, it is clear that other areas, such as the scrotum and inguinal area, may also harbor HPV; despite consistent and correct condom use, these areas would not be protected or covered by a condom. Although it was less common than at other sites, 7.1%–46.2% of men had HPV detected on the scrotum or inguinal area.

Factors associated with HPV infection and seropositivity in men varied across studies; however, the most consistent find ings were associations with sexual behavior. The potential value of circumcision in preventing HPV infection is unclear. Most cross-sectional studies and 1 longitudinal study demonstrated a lower risk of HPV infection associated with circumcision. One study demonstrated significan differences between circumcised and uncircumcised men that could have resulted in confounding [44]; not all studies take into consideration characteristics of the population such as sexual behaviors and cultural differences when evaluating this characteristic. An ongoing randomized controlled clinical trial measuring the effect of circumcision on the prevention of HPV will address some questions regarding the value of circumcision for the prevention of HPV.

Serologic testing for IgG antibodies to HPV may be a better measurement of cumulative exposure; antibodies may indicate past infection in persons who have no history or current signs of HPV disease. Previous evaluations of serologic testing in women demonstrated that serologic testing likely underestimates the cumulative incidence of HPV infection [61]. We found that HPV seroprevalence varied depending on the population evaluated. The detection of HPV antibodies may be more common in persons with disease such as anogenital warts, but not all men with these clinical finding have antibodies to HPV infection, and many never develop an immune response. The higher HPV seroprevalence in men with a history of anogenital warts, compared with men who have warts at the time of sampling, is attributed to the time it takes to develop an immune response to HPV [55, 56].

A higher seroprevalence of HPV types 6, 11, 16, and 18 has been found in women than in men. Possible explanations may be related to the sites of infection in men, compared with those in women; the vigor of the serologic response to genital infection; or other host genetic and immunologic factors.

Our evaluation of HPV DNA prevalence has several limitations. First, the methods for examining HPV DNA varied among studies, including methods of sampling, HPV DNA detection, analysis, and the reporting of results. Second, not all studies evaluated the adequacy of the sample, which might influenc HPV DNA detection. HPV DNA is detectable in the absence of adequate β-globin, but the significanc of this findin is unclear [62].

Our evaluation of serologic studies also has several limitations. Methods varied among studies, including methods to determine cutoffs for positivity, the quantitation of antibodies to VLPs, and the reporting of results. Cross-reactivity has been observed between HPV types 6 and 11; among types 16, 31, 33, and 58; and among types 18, 39, 45, and 59 [63]. In addition to cross-reactivity, which limits the specificit of findings there is no standard method to establish ELISA absorbance cutoff values for positivity. A common method for establishing a cutoff value is to calculate the mean absorbance value and add 2 or 3 SDs; however, it is not clear whether the mean should be determined from all subjects [53, 64], control subjects [54], virgin women [47, 49], or children [51]. Karem et al. [65] recommended the use of multiple control groups (children and adults) to obtain cutoff values applicable to the general population. In addition, few publications reported the sensitivity and specificit of their tests; when results were reported, they varied considerably. In one study, 93% sensitivity and 98.5% specificit was reported for an HPV-16 assay [57]; by contrast, another study demonstrated 50.6% sensitivity and 90% specificit [46].

Many questions exist regarding the clinical utility of testing men for HPV infection; there is no current indication for testing men. At present, there is a Food and Drug Administration (FDA)–approved HPV test that is indicated for women in the setting of the screening and management of cervical cancer [66, 67]. Screening for HPV infection is not recommended for men

for many reasons: infection is very common, no FDA-approved test is available, and findin HPV infection does not indicate an increased risk of disease or cancer in men or their sex partners. In addition, no therapy has been identifie that eradicates infection. The evaluation and treatment of male sex partners of women with clinical or subclinical infection (genital warts or abnormal Pap smear results) is also not known to have a benefi [68, 69].

The present review of HPV infection and seroprevalence in men will be useful for the design of natural-history studies and the measurement of transmission. Future research will inform models designed to estimate the impact of various prevention strategies, including prophylactic HPV vaccines.

References

1. Cates W Jr, American Social Health Association. Estimates of the incidence and prevalence of sexually transmitted diseases in the United States. Panel. Sex Transm Dis **1999**; 26(Suppl 1):S2–7.
2. Weinstock H, Berman S, Cates W Jr. Sexually transmitted diseases among American youth: incidence and prevalence estimates, 2000. Perspect Sex Reprod Health **2004**; 36:6–10.
3. Villa LL, Costa RL, Petta CA, et al. Prophylactic quadrivalent human papillomavirus (types 6, 11, 16, and 18) L1 virus-like particle vaccine in young women: a randomised double-blind placebo-controlled multicentre phase II efficac trial. Lancet Oncol **2005**; 6:271–8.
4. Harper DM, Franco EL, Wheeler C, et al. Efficac of a bivalent L1 virus-like particle vaccine in prevention of infection with human papillomavirus types 16 and 18 in young women: a randomised controlled trial. GlaxoSmithKline HPV Vaccine Study Group. Lancet **2004**; 364: 1757–65.
5. Aynaud O, Poveda JD, Huynh B, Guillemotonia A, Barrasso R. Frequency of herpes simplex virus, cytomegalovirus and human papillomavirus DNA in semen. Int J STD AIDS **2002**; 13:547–50.
6. Baken LA, Koutsky LA, Kuypers J, et al. Genital human papillomavirus infection among male and female sex partners: prevalence and typespecifi concordance. J Infect Dis **1995**; 171:429–32.
7. Baldwin SB, Wallace DR, Papenfuss MR, et al. Human papillomavirus infection in men attending a sexually transmitted disease clinic. J Infect Dis **2003**; 187:1064–70.
8. Bleeker MC, Hogewoning CJ, Van Den Brule AJ, et al. Penile lesions and human papillomavirus in male sexual partners of women with cervical intraepithelial neoplasia. J Am Acad Dermatol **2002**; 47:351–7.
9. Castellsagué X, Ghaffari A, Daniel RW, Bosch FX, Muñoz N, Shah KV. Prevalence of penile human papillomavirus DNA in husbands of women with and without cervical neoplasia: a study in Spain and Colombia. J Infect Dis **1997**; 176:353–61.
10. Della Torre G, Donghi R, de Campos Lima PO, et al. Human papillomavirus genomes in male urethral cells. Am J Pathol **1992**; 141:1181–6.
11. Fife KH, Coplan PM, Jansen KU, et al. Poor sensitivity of polymerase chain reaction assays of genital skin swabs and urine to detect HPV 6 and 11 DNA in men. Sex Transm Dis **2003**; 30:246–8.
12. Forslund O, Hansson BG, Rymark P, Bjerre B. Human papillomavirus DNA in urine samples compared with that in simultaneously collected urethra and cervix samples. J Clin Microbiol **1993**; 31:1975–9.
13. Franceschi S, Castellsague X, Dal Maso L, et al. Prevalence and determinants of human papillomavirus genital infection in men. Br J Cancer **2002**; 86:705–11.
14. Geddy PM, Wells M, Lacey CJ. Lack of detection of human papillomavirus DNA in male urine samples. Genitourin Med **1993**; 69:276–9.
15. Green J, Monteiro E, Bolton VN, Sanders P, Gibson PE. Detection of human papillomavirus DNA by PCR in semen from patients with and without penile warts. Genitourin Med **1991**; 67:207–10.
16. Hippelainen M, Syrjanen S, Hippelainen M, et al. Prevalence and risk factors of genital human papillomavirus (HPV) infections in healthy males: a study on Finnish conscripts. Sex Transm Dis **1993**; 20:321–8.
17. Inoue M, Nakazawa A, Fujita M, Tanizawa O. Human papillomavirus (HPV) type 16 in semen of partners of women with HPV infection. Lancet **1992**; 339:1114–5.
18. Kataoka A, Claesson U, Hansson BG, Eriksson M, Lindh E. Human papillomavirus infection of the male diagnosed by Southern-blot hybridization and polymerase chain reaction: comparison between urethra samples and penile biopsy samples. J Med Virol **1991**; 33:159–64.
19. Kjaer SK, Munk C, Winther JF, Jorgensen HO, Meijer CJ, van den Brule AJ. Acquisition and persistence of human papillomavirus infection in younger men: a prospective follow-up study among Danish soldiers. Cancer Epidemiol Biomarkers Prev **2005**; 14:1528–33.
20. Kyo S, Inoue M, Koyama M, et al. Detection of high-risk human papillomavirus in the cervix and semen of sex partners. J Infect Dis **1994**; 170:682–5.
21. Lai YM, Lee JF, Huang HY, et al. The effect of human papillomavirus infection on sperm cell motility. Fertil Steril **1997**; 67:1152–5.
22. Lazcano-Ponce E, Herrero R, Munoz N, et al. High prevalence of human papillomavirus infection in Mexican males: comparative study of penile-urethral swabs and urine samples. Sex Transm Dis **2001**; 28: 277–80.
23. Nicolau SM, Camargo CG, Stavale JN, et al. Human papillomavirus DNA detection in male sexual partners of women with genital human papillomavirus infection. Urology **2005**; 65:251–5.
24. Olatunbosun O, Deneer H, Pierson R. Human papillomavirus DNA detection in sperm using polymerase chain reaction. Obstet Gynecol **2001**; 97:357–60.
25. Rintala MAM, Pöllanen PP, Nikkanen VP, Grénman SE, Syrjänen SM. Human papillomavirus DNA is found in the vas deferens. J Infect Dis **2002**; 185:1664–7.
26. Shin H-R, Franceschi S, Vaccarella S, et al. Prevalence and determinants of genital infection with papillomavirus, in female and male university students in Busan, South Korea. J Infect Dis **2004**; 190:468–76.
27. Svare EI, Kjaer SK, Worm AM, Osterlind A, Meijer CJ, van den Brule AJ. 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 **2002**; 78:215–8.
28. Takahashi S, Shimizu T, Takeyama K, et al. Detection of human papillomavirus DNA on the external genitalia of healthy men and male patients with urethritis. Sex Transm Dis **2003**; 30:629–33.
29. Tanaka H, Karube A, Kodama H, Fukuda J, Tanaka T. Mass screening for human papillomavirus type 16 infection in infertile couples. J Reprod Med **2000**; 45:907–11.
30. van der Snoek EM, Niesters HG, Mulder PG, van Doornum GJ, Osterhaus AD, van der Meijden WI. Human papillomavirus infection in men who have sex with men participating in a Dutch gay-cohort study. Sex Transm Dis **2003**; 30:639–44.
31. Van Doornum GJ, Prins M, Juffermans LH, et al. Regional distribution and incidence of human papillomavirus infections among heterosexual men and women with multiple sexual partners: a prospective study. Genitourin Med **1994**; 70:240–6.
32. Weaver BA, Feng Q, Holmes KK, et al. Evaluation of genital sites and sampling techniques for detection of human papillomavirus DNA in men. J Infect Dis **2004**; 189:677–85.
33. Wikstrom A, Lidbrink P, Johansson B, von Krogh G. Penile human papillomavirus carriage among men attending Swedish STD clinics. Int J STD AIDS **1991**; 2:105–9.
34. Wikstrom A, Popescu C, Forslund O. Asymptomatic penile HPV infection: a prospective study. Int J STD AIDS **2000**; 11:80–4.
35. Astori G, Pipan C, Muffato G, Botta GA. Detection of HPV-DNA in semen, urine and urethral samples by dot blot and PCR. New Microbiol **1995**; 18:143–9.
36. Hernandez BY, McDuffi K, Goodman MT, et al. Comparison of phy-

sician- and self-collected genital specimens for detection of human papillomavirus in men. J Clin Microbiol **2006**; 44:513–17.
37. Hippelainen MI, Yliskoski M, Syrjanen S, et al. Low concordance of genital human papillomavirus (HPV) lesions and viral types in HPV-infected women and their male sexual partners. Sex Transm Dis **1994**; 21:76–82.
38. Takahashi S, Takeyama K, Miyamoto S, et al. Incidence of sexually transmitted infections in asymptomatic healthy young Japanese men. J Infect Chemother **2005**; 21:76–82.
39. Bleeker MCG, Hogewoning CJA, Berkhof J, et al. Concordance of specifi human papillomavirus types in sex partners is more prevalent than would be expected by chance and is associated with increased viral loads. Clin Infect Dis **2005**; 41:612–20.
40. Rosenblatt C, Lucon AM, Pereyra EA, Pinotti JA, Arap S, Ruiz CA. HPV prevalence among partners of women with cervical intraepithelial neoplasia. Int J Gynaecol Obstet **2004**; 84:156–61.
41. Lajous M, Mueller N, Cruz-Valdez A, Aguilar LV, Franceschi S, Hernandez-Avila M. Determinants of prevalence, acquisition, and persistence of human papillomavirus in healthy Mexican military men. Cancer Epidemiol Biomarkers Prev **2005**; 14:1710–6.
42. Aguilar LV, Lazcano-Ponce E, Vaccarella S, et al. Human papillomavirus in men: comparison of different genital sites. Sex Transm Infect **2006**; 82:31–3.
43. Baldwin SB, Wallace DR, Papenfuss MR, Abrahamsen M, Vaught LC, Giuliano AR. Condom use and other factors affecting penile human papillomavirus detection in men attending a sexually transmitted disease clinic. Sex Transm Dis **2004**; 31:601–7.
44. Castellsague X, Bosch FX, Munoz N, et al. Male circumcision, penile human papillomavirus infection, and cervical cancer in female partners. N Engl J Med **2002**; 346:1105–12.
45. Burchell AN, Richardson H, Mahmud SM, et al. Modeling the sexual transmissibility of human papillomavirus infection using stochastic computer simulation and empirical data from a cohort study of young women in Montreal, Canada. Am J Epidemiol **2006**; 163:534–43.
46. Carter JJ, Madeline MM, Shera K, et al. Human papillomavirus 16 and 18 L1 serology compared across anogenital cancer sites. Cancer Res **2001**; 61:1934–40.
47. Carter JJ, Wipf GC, Hagensee ME, et al. Use of human papillomavirus type 6 capsids to detect antibodies in people with genital warts. J Infect Dis **1995**; 172:11–8.
48. Eisemann C, Fisher SG, Gross G, Muller M, Gissmann L. Antibodies to human papillomavirus type 11 virus-like particles in sera of patients with genital warts and in control groups. J Gen Virol **1996**; 77:1799–803.
49. Hagensee ME, Kiviat N, Critchlow CW, et al. Seroprevalence of human papillomavirus types 6 and 16 capsid antibodies in homosexual men. J Infect Dis **1997**; 176:625–31.
50. Hisada M, Rabkin CS, Strickler HD, Wright WE, Christianson RE, van den Berg BJ. Human papillomavirus antibody and risk of prostate cancer. JAMA **2000**; 283:340–1.
51. Slavinsky J III, Kissinger P, Burger L, Boley A, DiCarlo RP, Hagensee ME. Seroepidemiology of low and high oncogenic risk types of human papillomavirus in a predominantly male cohort of STD clinic patients. Int J STD AIDS **2001**; 12:516–23.
52. Strickler HD, Kirk GD, Figueroa JP, et al. HPV 16 antibody prevalence in Jamaica and the United States reflect differences in cervical cancer rates. Int J Cancer **1999**; 80:339–44.
53. Svare EI, Kjaer SK, Nonnenmacher B, et al. Seroreactivity to human papillomavirus type 16 virus-like particles is lower in high-risk men than in high-risk women. J Infect Dis **1997**; 176:876–83.
54. Wideroff L, Schiffman M, Hubbert N, et al. Serum antibodies to HPV 16 virus-like particles are not associated with penile cancer in Chinese males. Viral Immunol **1996**; 9:23–5.
55. Wikstrom A, Eklund C, Von Krogh G, Lidbrink P, Dillner J. Levels of immunoglobulin G antibodies against define epitopes of the L1 and L2 capsid proteins of human papillomavirus type 6 are elevated in men with a history of condylomata acuminata. J Clin Microbiol **1992**; 30:1795–800.
56. Wikstrom A, Eklund C, von Krogh G, Lidbrink P, Dillner J. Antibodies against human papillomavirus type 6 capsids are elevated in men with previous condylomas. APMIS **1997**; 105:884–8.
57. Stone KM, Karem KL, Sternberg MR, et al. Seroprevalence of human papillomavirus type 16 infection in the United States. J Infect Dis **2002**; 186:1396–402.
58. Thompson DL, Douglas JM Jr, Foster M, et al. Seroepidemiology of infection with human papillomavirus 16, in men and women attending sexually transmitted disease clinics in the United States. J Infect Dis **2004**; 190:1563–74.
59. Kreimer AR, Alberg AJ, Viscidi R, Gillison ML. Gender differences in sexual biomarkers and behaviors associated with human papillomavirus-16, -18, and -33 seroprevalence. Sex Transm Dis **2004**; 31:247–56.
60. Revzina NV, Diclemente RJ. Prevalence and incidence of human papillomavirus infection in women in the USA: a systematic review. Int J STD AIDS **2005**; 16:528–37.
61. Carter JJ, Koutsky LA, Hughes JP, et al. Comparison of human papillomavirus types 16, 18, and 6 capsid antibody responses following incident infection. J Infect Dis **2000**; 181:1911-9.
62. Kruger Kjaer S, Munk C, Winther JF, et al. Acquisition and persistence of human papillomavirus infection in younger men: a prospective follow-up study among Danish soldiers. Cancer Epidemiol Biomarkers Prev **2005**; 14:1528–33.
63. Coursaget P. Serology for human papillomavirus. Salud Publica Mex **2003**; 45(Suppl 3):S361–6.
64. Hamsikova E, Ludvikova V, Smahel M, Sapp M, Vonka V. Prevalence of antibodies to human papillomaviruses in the general population of the Czech Republic. Int J Cancer **1998**; 77:689–94.
65. Karem KL, Poon AC, Bierl C, Nisenbaum R, Unger E. Optimization of a human papillomavirus-specifi enzyme-linked immunosorbent assay. Clin Diagn Lab Immunol **2002**; 9:577–82.
66. Wright TC, Shiffman M, Solomon D, et al. Interim guidance for the use of human papillomavirus DNA testing as an adjunct to cervical cytology for screening. Obstet Gynecol **2004**; 103:304–9.
67. Saslow D, Runowicz CD, Solomon D, et al. American Cancer Society guideline for the early detection of cervical neoplasia and cancer. CA Cancer J Clin **2002**; 52:342–62.
68. Krebs HB, Helmkamp BF. Does the treatment of genital condylomata in men decrease the treatment failure rate of cervical dysplasia in the female sexual partner? Obstet Gynecol **1990**; 76:660–3.
69. Krebs HB, Helmkamp BF. Treatment failure of genital condylomata acuminata in women: role of the male sexual partner. Am J Obstet Gynecol **1991**; 165:337–40.