

## Human Papillomavirus

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States. The relationship of cervical cancer and sexual behavior was suspected for more than 100 years and was established by epidemiologic studies in the 1960s. In the early 1980s, cervical cancer cells were demonstrated to contain HPV DNA. Epidemiologic studies showing a consistent association between HPV and cervical cancer were published in the 1990s. The first vaccine to prevent infection with four types of HPV was licensed in 2006.

## Human Papillomavirus

Human papillomaviruses are small, double-stranded DNA viruses that infect the epithelium. More than 100 HPV types have been identified; they are differentiated by the genetic sequence of the outer capsid protein L1. Most HPV types infect the cutaneous epithelium and cause common skin warts. About 40 types infect the mucosal epithelium; these are categorized according to their epidemiologic association with cervical cancer. Infection with low-risk, or nononcogenic types, such as types 6 and 11, can cause benign or low-grade cervical cell abnormalities, genital warts and laryngeal papillomas. High-risk, or oncogenic, HPV types act as carcinogens in the development of cervical cancer and other anogenital cancers. High-risk types (currently including types 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 68, 69, 73, 82) can cause low-grade cervical cell abnormalities, high-grade cervical cell abnormalities that are precursors to cancer, and anogenital cancers. High-risk HPV types are detected in 99% of cervical cancers. Type 16 is the cause of approximately 50% of cervical cancers worldwide, and types 16 and 18 together account for about 70% of cervical cancers. Infection with a high-risk HPV type is considered necessary for the development of cervical cancer, but by itself it is not sufficient to cause cancer because the vast majority of women with HPV infection do not develop cancer.

In addition to cervical cancer, HPV infection is also associated with anogenital cancers less common than cervical cancer, such as cancer of the vulva, vagina, penis and anus. The association of genital types of HPV with non-genital cancers is less well established, but studies support a role for these HPV types in a subset of oral cavity and pharyngeal cancers.

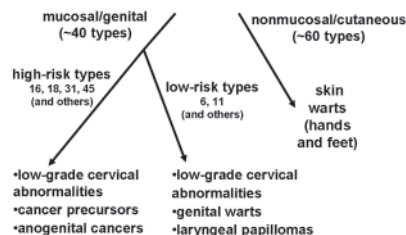
## Pathogenesis

HPV infection occurs at the basal epithelium. Although the incidence of infection is high, most infections resolve spontaneously. A small proportion of infected persons become persistently infected; persistent infection is the most

### Human Papillomavirus (HPV)

- Small DNA virus
- More than 100 types identified based on the genetic sequence of the outer capsid protein L1
- 40 types infect the mucosal epithelium

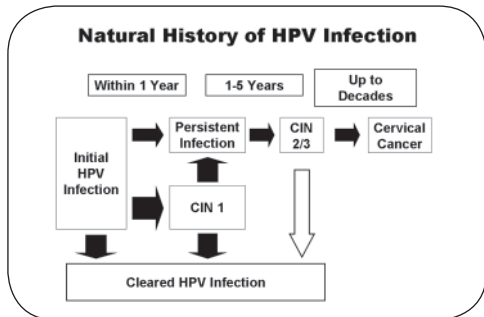
### Human Papillomavirus Types and Disease Association



### HPV-Associated Disease

Type	Women	Men
16/18	70% of cervical cancers 70% of anal/genital cancers	70% of anal cancers Transmission to women
6/11	90% of genital warts 90% of RRP lesions	90% of genital warts 90% of RRP lesions Transmission to women

# Human Papillomavirus



## HPV Clinical Features

- Most HPV infections are asymptomatic and result in no clinical disease
- Clinical manifestations of HPV infection include:
  - anogenital warts
  - recurrent respiratory papillomatosis
  - cervical cancer precursors (cervical intraepithelial neoplasia)
  - Cancer (cervical, anal, vaginal, vulvar, penile, and some head and neck cancer)

important risk factor for the development of cervical cancer precursor lesions. The most common clinically significant manifestation of persistent genital HPV infection is cervical intraepithelial neoplasia, or CIN. Within a few years of infection, low-grade CIN—called CIN 1—may develop, which may spontaneously resolve and the infection clear.

Persistent HPV infection, however, may progress directly to high-grade CIN, called CIN2 or CIN3. High-grade abnormalities are at risk of progression to cancer and so are considered cancer precursors. A small proportion of high-grade abnormalities spontaneously regress. If left undetected and untreated, years or decades later CIN2 or 3 can progress to cervical cancer.

Infection with one type of HPV does not prevent infection with another type. Of persons infected with mucosal HPV, 5% to 30% are infected with multiple types of the virus.

## Clinical Features

Most HPV infections are asymptomatic and result in no clinical disease. Clinical manifestations of HPV infection include anogenital warts, recurrent respiratory papillomatosis, cervical cancer precursors (cervical intraepithelial neoplasia), and cancers, including cervical, anal, vaginal, vulvar, penile, and some head and neck cancer.

## Laboratory Diagnosis

HPV has not been isolated in culture. Infection is identified by detection of HPV DNA from clinical samples. Assays for HPV detection differ considerably in their sensitivity and type specificity, and detection is also affected by the anatomic region sampled as well as the method of specimen collection.

Currently, only the Digene Hybrid Capture<sup>®</sup>2 (hc2) High-Risk HPV DNA Test is approved by the Food and Drug Administration for clinical use. The hc2 uses liquid nucleic acid hybridization and detects 13 high-risk types (HPV 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, 59, 68). Results are reported as positive or negative and are not type-specific. The hc2 test is approved for triage of women with equivocal Papanicolaou (Pap) test results (ASC-US, atypical cells of undetermined significance) and in combination with the Pap test for cervical cancer screening in women over age 30. The test is not clinically indicated nor approved for use in men.

Epidemiologic and basic research studies of HPV generally use nucleic acid amplification methods that generate type-specific results. The PCR assays used most commonly in epidemiologic studies target genetically conserved regions in the L1 gene.

The most frequently used HPV serologic assays are VLP-based enzyme immunoassays. However, laboratory reagents used for these assays are not standardized and there are no standards for setting a threshold for a positive result.

## Medical Management

There is no specific treatment for HPV infection. Medical management depends on treatment of the specific clinical manifestation of the infection (such as genital warts or abnormal cervical cell cytology).

## Epidemiology

### Occurrence

HPV infection occurs throughout the world.

### Reservoir

Viruses in the papillomavirus family affect other species (notably rabbits and cows). However, humans are the only natural reservoir of HPV.

### Transmission

HPV is transmitted by direct contact, usually sexual, with an infected person. Transmission occurs most frequently with sexual intercourse but can occur following nonpenetrative sexual activity.

Studies of newly acquired HPV infection demonstrate that infection occurs soon after onset of sexual activity. In a prospective study of college women, the cumulative incidence of infection was 40% by 24 months after first sexual intercourse. HPV 16 accounted for 10.4% of infections.

Genital HPV infection also may be transmitted by nonsexual routes, but this appears to be uncommon. Nonsexual routes of genital HPV transmission include transmission from a woman to a newborn infant at the time of birth.

### Temporal Pattern

There is no known seasonal variation in HPV infection.

### Communicability

HPV is presumably communicable during the acute infection and during persistent infection. This issue is difficult to study because of the inability to culture the virus. Communicability can be presumed to be high because of the large number of new infections estimated to occur each year.

### HPV Epidemiology

• Reservoir	Human
• Transmission	Direct contact, usually sexual
• Temporal pattern	None
• Communicability	Presumed to be high

## HPV Disease Burden in the United States

- Anogenital HPV is the most common sexually transmitted infection in the US
  - Estimated 20 million currently infected
  - 6.2 million new infections/year
- Common among adolescents and young adults
- More than 80% of sexually active women will have been infected by age 50
- Infection also common in men

## Cervical Cancer Disease Burden in the United States

- The American Cancer Society estimates that in 2006
  - 9,700 new cervical cancer cases
  - 3,700 cervical cancer deaths
- Almost 100% of these cervical cancer cases will be caused by one of the 40 HPV types that infect the mucosa

## Risk Factors

Risk factors for HPV infection are related to sexual behavior, including the number of sex partners, lifetime history of sex partners, and the partners' sexual history. Most studies suggest that young age (less than 25 years) is a risk factor for infection. Results of epidemiologic studies are less consistent for other risk factors, including young age at sexual initiation, inconsistent condom use, number of pregnancies, genetic factors, smoking, lack of circumcision of male partner, and oral contraceptive use.

## Disease Burden in the United States

Anogenital HPV infection is believed to be the most common sexually transmitted infection in the United States. An estimated 20 million persons are currently infected, and an estimated 6.2 million new HPV infections occur annually. HPV infection is common among adolescents and young adults. Prevalence among adolescent girls is as high as 64%. Up to 75% of new infections occur among persons 15–24 years of age. Modeling estimates suggest that more than 80% of sexually active women will have been infected by age 50.

HPV infection is also common in men. Among heterosexual men in clinic-based studies, prevalence of genital HPV infection is often greater than 20%. Prevalence is highly dependent on the anatomic sites sampled and method of specimen collection.

The two most common types of cervical cancer worldwide, squamous cell carcinoma followed by adenocarcinoma, are both caused by HPV. The American Cancer Society estimates that in 2006 about 9,700 new cases of cervical cancer will be diagnosed in the United States. Approximately 3,700 women will die as a result of cervical cancer. HPV is believed to be responsible for nearly all of these cases of cervical cancer. HPV types 16 and 18 are associated with 70% of these cancers.

In addition to cervical cancer, HPV is believed to be responsible for 90% of anal cancers, 40% of vulvar, vaginal, or penile cancers, and 12% of oral and pharyngeal cancers.

Population-based estimates, primarily from clinics treating persons with sexually transmitted infections, indicate that about 1% of the sexually active adolescent and adult population in the United States have clinically apparent genital warts. More than 90% of cases of anogenital warts are associated with the low-risk HPV types 6 and 11.

About 4 billion dollars are spent annually on management of sequelae of HPV infections, primarily for the management of abnormal cervical cytology and treatment of cervical neoplasia. This exceeds the economic burden of any other sexually transmitted infection except human immunodeficiency virus.

## Prevention

### HPV Infection

HPV transmission can be reduced but not eliminated with the use of physical barriers such as condoms. Recent studies demonstrated a significant reduction in HPV infection among young women after initiation of sexual activity when their partners used condoms consistently and correctly. Abstaining from sexual activity (i.e., refraining from any genital contact with another individual) is the surest way to prevent genital HPV infection. For those who choose to be sexually active, a monogamous relationship with an uninfected partner is the strategy most likely to prevent future genital HPV infections.

### Cervical Cancer Screening

Most cases and deaths from cervical cancer can be prevented through detection of precancerous changes within the cervix by cervical cytology using the Pap test. Currently available Pap test screening can be done by a conventional Pap or a liquid-based cytology. CDC does not issue recommendations for cervical cancer screening, but various professional groups have published recommendations. The American College of Obstetricians and Gynecologists (ACOG), the American Cancer Society (ACS), and the U.S. Preventive Services Task Force (USPSTF) guidelines recommend that all women should have a Pap test for cervical cancer screening within 3 years of beginning sexual activity or by age 21, whichever occurs first. While the USPSTF recommends a conventional Pap test at least every 3 years regardless of age, ACS and ACOG recommend annual or biennial screening of women younger than age 30, depending on use of conventional or liquid-based cytology. According to these national organizations, women over age 30 with three normal consecutive Pap tests should be screened every 2 to 3 years.

The use of HPV vaccine does not eliminate the need for continued Pap test screening, since 30% of cervical cancers are caused by HPV types not included in the vaccine.

#### Cervical Cancer Screening

- Cervical cancer screening – no change
  - 30% of cervical cancers caused by HPV types not prevented by the quadrivalent HPV vaccine
  - Vaccinated females could subsequently be infected with non-vaccine HPV types
  - Sexually active females could have been infected prior to vaccination
- Providers should educate women about the importance of cervical cancer screening

## Human Papillomavirus Vaccine

- HPV L1 major capsid protein of the virus is antigen used for immunization
- L1 protein expressed in yeast cells using recombinant technology
- L1 proteins self-assemble into virus-like particles (VLP)
- Noninfectious and nononcogenic

## Human Papillomavirus Vaccine

### Characteristics

The currently licensed vaccine is a quadrivalent HPV vaccine (Gardasil, Merck). The vaccine antigen is the L1 major capsid protein of HPV, produced by using recombinant DNA technology. The L1 protein is expressed in *Saccharomyces cerevisiae* (yeast) cells, and the protein self-assembles into noninfectious, nononcogenic virus-like-particles (VLP). Each 0.5-mL dose contains 20 µg HPV 6 L1 protein, 40 µg HPV 11 L1 protein, 40 µg HPV 16 L1 protein, and 20 µg HPV 18 L1 protein. The VLPs are adsorbed on 225 µg alum adjuvant. The vaccine also includes sodium chloride, L-histidine, polysorbate 80, sodium borate, and water for injection. The quadrivalent HPV vaccine contains no thimerosal or antibiotics. The vaccine is supplied in single-dose vials and syringes.

### Immunogenicity and Vaccine Efficacy

The immunogenicity of the quadrivalent HPV vaccine has been measured by detection of IgG antibody to the HPV L1 by a type-specific immunoassay developed by the manufacturer. In all studies conducted to date, more than 99.5% of participants developed an antibody response to all four HPV types in the vaccine 1 month after completing the three-dose series. At that time interval, antibody titers against HPV types 6, 11, 16, and 18 were higher than those that developed after natural HPV infection.

There is no known serologic correlative of immunity and no known minimal titer determined to be protective. The high efficacy found in the clinical trials to date has precluded identification of a minimum protective antibody titer. Further follow-up of vaccinated cohorts may allow determination of serologic correlates of immunity in the future.

HPV vaccine has been found to have high efficacy for prevention of HPV vaccine type-related persistent infection, vaccine type-related CIN, CIN2/3, and external genital lesions in women 16–26 years of age. Clinical efficacy against cervical disease was determined in two double-blind, placebo-controlled trials, using various endpoints. Vaccine efficacy was 100% for prevention of HPV 16 or 18-related CIN 2/3 or adenocarcinoma in-situ (AIS). Efficacy against any CIN due to HPV 6, 11, 16, or 18 was 95%. Efficacy against HPV 6, 11, 16 or 18-related genital warts was 99%.

Although high efficacy among females without evidence of infection with vaccine HPV types was demonstrated in clinical trials, there was no evidence of efficacy against disease caused by vaccine types with which participants were infected at the time of vaccination. Participants infected

### HPV Vaccine Efficacy\*

Endpoint	Efficacy
HPV 16/18-related CIN2/3 or AIS	100
HPV 6/11/16/18 related CIN	95
HPV 6/11/16/18 related genital warts	99

\*Among 16-26 year old females. CIN – cervical intraepithelial neoplasia; AIS – adenocarcinoma in situ

with one or more vaccine HPV types prior to vaccination were protected against disease caused by the other vaccine types. However, prior infection with one HPV type did not diminish efficacy of the vaccine against other vaccine HPV types.

There is no evidence that the vaccine protects against disease due to non-vaccine HPV types or provides a therapeutic effect against cervical disease or genital warts present at the time of vaccination.

A subset of participants in the phase II HPV vaccine study has been followed for 60 months post-dose 1 with no evidence of waning protection. Study populations will continue to be followed for any evidence of waning immunity.

HPV vaccine has been shown to be immunogenic and safe in males. However, no clinical efficacy data are available for males. These studies are in progress.

## Vaccination Schedule and Use

As of January 2007, ACIP recommendations for use of HPV vaccine have not been published. Recommendations included here are provisional until published in the *Morbidity and Mortality Weekly Report*.

Quadrivalent HPV vaccine is licensed by the Food and Drug Administration for use among females 9–26 years of age. The recommended age for routine vaccination in the United States is 11–12 years. The vaccine can be given as young as 9 years of age at the discretion of the clinician. The vaccine should be given at the same visit as other vaccines recommended for persons of this age (e.g., Tdap, meningococcal conjugate, hepatitis B).

At the beginning of a vaccination program, there will be females older than 12 years of age who did not have the opportunity to receive vaccine at age 11–12 years. Catch-up vaccination is recommended for females 13 through 26 years of age who have not been previously vaccinated or who have not completed the full series. Ideally, vaccine should be administered before potential exposure to HPV through sexual contact; however, females who may have already been exposed to HPV should be vaccinated. Sexually active females who have not been infected with any of the HPV vaccine types will receive full benefit from vaccination. Vaccination will provide less benefit to females if they have already been infected with one or more of the four HPV vaccine types. However, it is not possible for a clinician to assess the extent to which sexually active females would

### HPV Vaccine Efficacy

- High efficacy among females without evidence of infection with vaccine HPV types
- No evidence of efficacy against disease caused by vaccine types with which participants were infected at the time of vaccination
- Prior infection with one HPV type did not diminish efficacy of the vaccine against other vaccine HPV types

### Routine HPV Vaccination Recommendations\*

- ACIP recommends routine vaccination of females 11-12 years of age \*
- The vaccination series can be started as young as 9 years of age at the clinician's discretion
- Catch-up vaccination recommended for females 13 through 26 years of age

\*Provisional ACIP recommendations, June 2006

## HPV Vaccination Schedule

- Routine schedule is 0, 2, 6 months
- Minimum intervals
  - 4 weeks between doses 1 and 2
  - 12 weeks between doses 2 and 3
- Do not restart the series if the schedule is interrupted
- Administer at same visit as other age-appropriate vaccines (e.g., Tdap, MCV)

benefit from vaccination, and the risk of HPV infection may continue as long as persons are sexually active. Pap testing or screening for HPV DNA or HPV antibody is not recommended prior to vaccination at any age.

HPV vaccine is administered in a three-dose series administered by intramuscular injection. The second and third doses should be administered 2 and 6 months after the first dose. The minimum interval between the first and second doses is 4 weeks. The minimum interval between the second and third dose of vaccine is 12 weeks. Doses administered at an interval shorter than the minimum interval should not be counted as valid and should be repeated.

If the HPV vaccine schedule is interrupted, the vaccine series does not need to be restarted. If the series is interrupted after the first dose, the second dose should be given as soon as possible, and the second and third doses should be separated by an interval of at least 12 weeks. If only the third dose is delayed, it should be administered as soon as possible.

Although no data are available yet on administration of quadrivalent HPV vaccine with vaccines other than hepatitis B vaccine, the vaccine contains only HPV capsid protein and has no components that have been found to adversely affect safety or efficacy of other vaccinations. The vaccine can be administered at the same visit as other age-appropriate vaccines, such as Tdap and quadrivalent meningococcal conjugate (MCV4) vaccines. Administering all indicated vaccines at a single visit increases the likelihood that adolescents and young adults will receive each of the vaccines on schedule. Each vaccine should be administered using a separate syringe at a different anatomic site.

HPV vaccine is not approved for use among females younger than 9 years or older than 26 years of age. Use of the vaccine in females younger than 9 years or older than 26 years is not recommended. Studies with females older than 26 years of age are ongoing. There are no current studies among children younger than 9 years of age.

Quadrivalent HPV vaccine is not licensed for use among males, and off-label use among males is not recommended. While data on immunogenicity and safety are available for 9–15-year-old males, there are no data on efficacy in males at any age. Efficacy studies among males are under way.

Females who have an equivocal or abnormal Pap test could be infected with any of more than 40 high-risk or low-risk genital HPV types. It is unlikely that such females would be infected with all four HPV vaccine types, and they may not

## Quadrivalent HPV Vaccine

- HPV vaccine is not licensed for use among males
  - Efficacy data are not available
  - Off-label use not recommended
- Efficacy studies in males in progress

be infected with any HPV vaccine type. Women younger than 27 years with a previously abnormal Pap test may be vaccinated. Women should be advised that data do not indicate the vaccine will have any therapeutic effect on existing HPV infection or cervical lesions.

Females who have a positive HPV DNA test (Hybrid Capture 2®) done in conjunction with a Pap test could be infected with any of 13 high-risk types. This assay does not identify specific HPV types, and testing for specific HPV types is not done routinely in clinical practice. Women younger than 27 years with a positive HPV DNA test may be vaccinated. HPV DNA testing is not a prerequisite for vaccination. Women should be advised that the vaccine will not have a therapeutic effect on existing HPV infection or cervical lesions.

A history of genital warts or clinically evident genital warts indicate infection with HPV, most often type 6 or 11. However, these females may be infected with HPV types other than the vaccine types, and therefore they may receive HPV vaccine if they are in the recommended age group. Women with a history of genital warts should be advised that data do not indicate the vaccine will have any therapeutic effect on existing HPV infection or genital warts.

Because quadrivalent HPV vaccine is a subunit vaccine, it can be administered to females who are immunosuppressed because of disease or medications. However, the immune response and vaccine efficacy might be less than that in persons who are immunocompetent. Women who are breastfeeding may receive HPV vaccine.

## Adverse Reactions Following Vaccination

The most common adverse reactions reported during clinical trials of HPV vaccine were local reactions at the site of injection. These were most commonly pain (84%), swelling (25%), and erythema (25%). The majority of injection-site adverse experiences reported by recipients of quadrivalent HPV vaccine were mild to moderate in intensity. Fever was reported within 15 days of vaccination by 10% of vaccine recipients and 9% of placebo recipients. No serious adverse reactions have been reported.

A variety of systemic adverse reactions were reported by vaccine recipients, including nausea, dizziness, myalgia and malaise. However, these symptoms occurred with equal frequency among both vaccine and placebo recipients.

### HPV Vaccine Special Situations\*

- Vaccine can be administered
  - Equivocal or abnormal Pap test
  - Positive HPV DNA test
  - Genital warts
  - Immunosuppression
  - Breastfeeding

### HPV Vaccine Adverse Reactions

- Local reactions (pain, swelling) 84%
- Fever 10%\*
- No serious adverse reactions reported

\*similar to reports in placebo recipients (9%)

## HPV Vaccine Contraindications and Precautions

- **Contraindication**
  - Severe allergic reaction to a vaccine component or following a prior dose
- **Precaution**
  - Moderate or severe acute illnesses (defer until symptoms improve)

## Vaccination During Pregnancy Provisional Recommendation

- Initiation of the vaccine series should be delayed until after completion of pregnancy
- If a woman is found to be pregnant after initiating the vaccination series, remaining doses should be delayed until after the pregnancy
- If a vaccine dose has been administered during pregnancy, there is no indication for intervention
- Women vaccinated during pregnancy should be reported to Merck registry (800.986.8999)

## HPV Vaccine Storage and Handling

- Store at 36°–46°F (2°–8°C)
- Protect from light
- Administer immediately after removing from refrigeration
- Do not expose to freezing temperature

## Contraindications and Precautions to Vaccination

A severe allergic reaction (acute respiratory distress or collapse) to a vaccine component or following a prior dose of HPV vaccine is a contraindication to receipt of HPV vaccine. A moderate or severe acute illness is a precaution to vaccination, and vaccination should be deferred until symptoms of the acute illness improve. A minor acute illness (e.g., diarrhea or mild upper respiratory tract infection, with or without fever) is not a reason to defer vaccination.

HPV vaccine is not recommended for use during pregnancy. The vaccine has not been associated with adverse outcomes of pregnancy or with adverse effects on the developing fetus. However, data on vaccination during pregnancy are limited. Until further information is available, initiation of the vaccine series should be delayed until after completion of the pregnancy. If a woman is found to be pregnant after initiating the vaccination series, the remainder of the three-dose regimen should be delayed until after completion of the pregnancy. If a vaccine dose has been administered during pregnancy, no intervention is indicated. A vaccine in pregnancy registry has been established; patients and healthcare providers are urged to report any exposure to quadrivalent HPV vaccine during pregnancy by calling (800) 986-8999.

## Vaccine Storage and Handling

HPV vaccine should be stored continuously at 35°–46°F (2°–8°C) and should be protected from light. The vaccine should be removed from refrigeration immediately before administration. The vaccine must not be exposed to freezing temperature. Vaccine exposed to freezing temperature should never be administered.

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