Epidemiology and Prevention of HPV and Cervical Cancer: Global Trends and the Current Status in China

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1. Epidemiology & Disease Burden

Human Papilloma Virus (HPV) infection and its related cancers are prevalent globally, posing a significant challenge to public health. HPV is primarily transmitted through sexual contact or direct mucocutaneous contact, capable of infecting various anatomical sites including the genitals, anus, and the head and neck region.

1.1 Infection Rate & Disease Burden

Epidemiological studies indicate a global HPV prevalence of approximately 11.7% among women, with significant regional disparities [1]. In contrast, the prevalence among the general female population in China is 17.7%, markedly higher than the global average level, highlighting the severity of the HPV burden in China [2]. Substantial heterogeneity exists across different regions of China (Figure 1). Hainan Province reports the highest overall prevalence at 25.11%, followed by Heilongjiang Province at 24.28%. The lowest prevalence is observed in the Xinjiang Uygur Autonomous Region at only 8.02% [2].

HPV infection is a pathogenic factor for various malignancies. In 2022, there were 1.468 million new cases of HPV-related malignancies globally, with China accounting for 238,000 cases (16.2%). Global deaths totaled 742,000, with 106,000 occurring in China (14.3%) [3]. Consequently, China bears one of the heaviest burdens of HPV-related diseases worldwide. Rough estimates suggest the total annual economic burden caused by HPV-related diseases in China is approximately 18.03 billion RMB, with the first-year cost for a single case of HPV-related malignancy ranging from 58,000 to 80,000 RMB [4].

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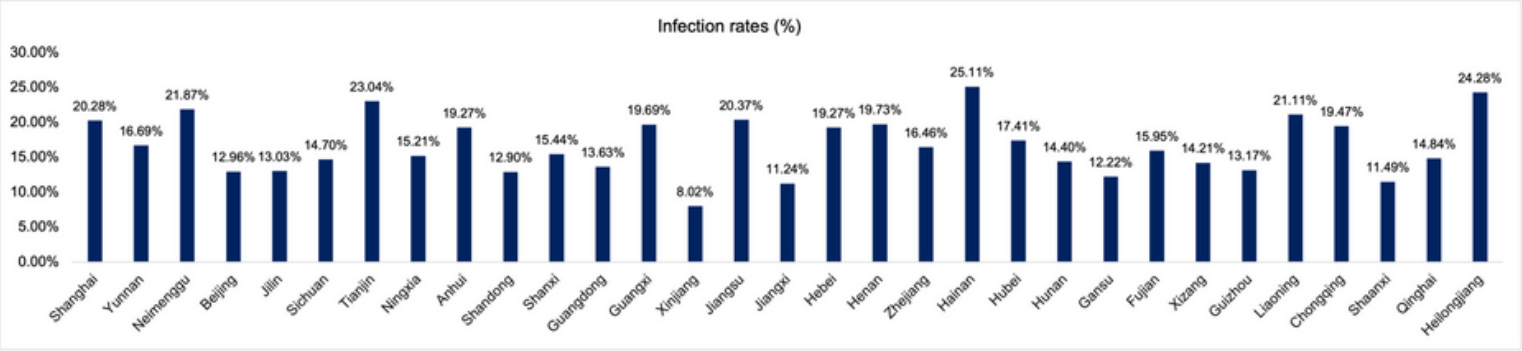

Figure 1: HPV Prevalence across Provinces and Municipalities in China

1.2 Incidence & Mortality

As one of the primary cancers associated with HPV infection, cervical cancer ranks as the fourth leading cause of cancer incidence and mortality among women globally. It is estimated that in 2022, there were 662,044 new cases of cervical cancer (age-standardized incidence rate: 14.12/100,000) and 348,709 deaths (age-standardized mortality rate: 7.08/100,000) worldwide. In China, there were 150,700 new cases and 55,700 deaths in 2022, accounting for 23% and 16% of the global totals, respectively [5].

1.3 Prevalence of HPV Genotypes

To date, over 200 HPV genotypes have been identified. Based on their oncogenic risk, they are classified into high-risk HPV (HR-HPV) and low-risk HPV (LR-HPV). Persistent infection with HR-HPV is a key trigger for various malignancies, causing anal, penile, cervical, vulvar, vaginal, and head and neck squamous cell carcinomas in both men and women; it has become a major pathogen for infection-related malignancies. LR-HPV infections generally cause benign conditions such as condyloma acuminatum (genital warts) and recurrent respiratory papillomatosis.

Risk Classification	Associated Genotypes	Diseases
High-Risk (HR-HPV)	HPV-16, HPV-18, HPV-31, HPV-33, HPV-45, HPV-52, HPV-58, etc.	**Cancers:** Cervical cancer, head and neck squamous cell carcinoma, anal cancer, vulvar cancer, penile cancer, vaginal cancer, etc. **Precancerous Lesions:** Persistent infection can lead to site-specific precancerous lesions.
Low-Risk (LR-HPV)	HPV-6, HPV-11	Anogenital warts, respiratory papillomatosis, focal epithelial hyperplasia
	HPV-3, HPV-10, HPV-28	Flat warts
	HPV-2, HPV-7, HPV-40	Common warts

Table 1: HPV Genotypes and Associated Diseases

HPV-16 and HPV-18 are recognized globally as the two most carcinogenic types [6], accounting for approximately 71% of cervical cancer cases worldwide. However, in China, in addition to type 16 and type 18, the prevalence of HPV-52 and HPV-58 is notably high. A study involving nearly 2.73 million participants revealed that HPV-52 is the most common carcinogenic type among Chinese women, followed by HPV-58 and HPV-16 [2].

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2. Role of Vaginal Microbiota and HPV in Cervical Cancer

In 1995, a monograph published by the International Agency for Research on Cancer (IARC) stated that there is sufficient evidence that infection with high-risk HPV (HR-HPV) is the primary cause of cervical cancer and its precursors [7]. HPV infection is not only the principal pathogenic factor for cervical cancer but is also closely associated with the development of anal, vaginal, penile, and vulvar cancers, as well as head and neck malignancies such as oral and oropharyngeal cancers.

Most HPV infections are transient and are cleared spontaneously by the immune system without causing clinical symptoms. However, persistent HR-HPV infection may induce cervical intraepithelial neoplasia (CIN), which, if left untreated, can progress to cervical cancer [8]. Studies show that nearly 99% of cervical cancer cases are associated with HR-HPV infection. Currently, fifteen types of HR-HPV have been confirmed to be related to the development of cervical cancer; HPV-16 and HPV-18 account for approximately 75% of cases, while HPV-31, 33, 45, 52, and 58 collectively account for the remaining 15% to 20% [6].

The vaginal microbiota plays a crucial regulatory role in the progression from acquisition to persistent infection. A healthy microenvironment is dominated by the Lactobacillus genus.

These probiotics inhibit pathogens by producing lactic acid to maintain a low pH acidic environment, generating hydrogen peroxide, and exerting competitive exclusion, serving as the first line of defense against pathogenic factors. Furthermore, normal local vaginal immunity is dominated by Th1 cells, maintaining the body's normal immune function [9]. The microbiome and the local immune system together constitute a natural barrier for female reproductive health.

When vaginal dysbiosis occurs, the proportion of Lactobacillus decreases while anaerobic bacteria levels rise, a condition closely linked to HPV acquisition and persistence. This imbalance damages the mucosal barrier; for instance, Gardnerella can secrete sialidase to degrade vaginal mucus. More importantly, dysbiosis disrupts local immune equilibrium, leading to a Th1/Th2 shift toward Th2 dominance and resulting in immunosuppression, characterized by decreased Interleukin-2 (IL-2), increased IL-10, and a reduced IL-2/IL-10 ratio [9]. Immunosuppression increases susceptibility to HPV infection, thereby promoting the progression of cervical lesions. Following persistent HPV infection, cervical precancerous lesions (CIN) can evolve into invasive cervical cancer.

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3. Prevention & Vaccination

Globally, the proportion of women aged 30-49 who have been screened at least once in their lifetime is 36%, far below the World Health Organization (WHO) target of 70%. In high-income countries, this proportion reaches 84% [5]. Since the launch of the "Two-Cancer Screening" (cervical and breast cancer) program in China, cervical cancer screening coverage has expanded annually. Between 2018 and 2019, the national screening coverage was only 43.4% for women aged 35-44 and 36.8% for those aged 35-64.

Coverage has since continued to expand, significantly improving overall screening levels. Latest estimates ***(Figure 2)*** indicate that in 2023-2024, coverage reached 57.9% for women aged 35-44 and 51.5% for those aged 35-64. However, screening rates remain relatively low in rural areas and among women with lower socioeconomic status, at only 48.2% [10]. Key factors affecting coverage include low education levels, unemployment, limited household income, low health insurance coverage, and a lack of awareness regarding regular medical check-ups.

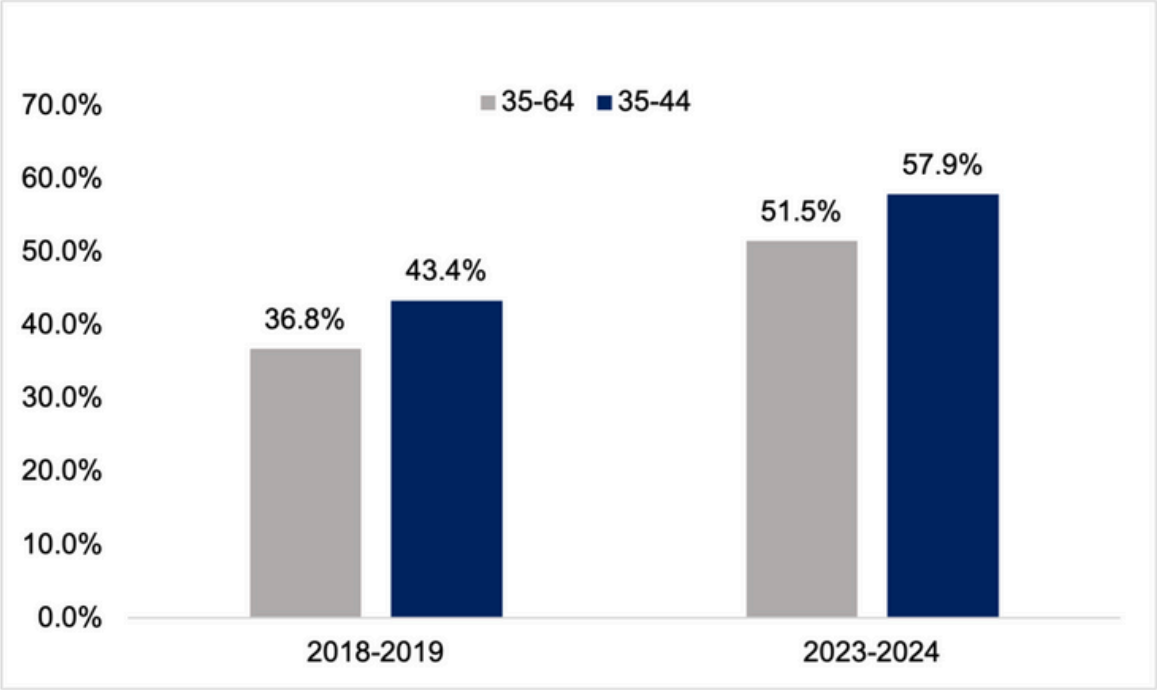

Figure 2: Cervical Cancer Screening Coverage Across Age Groups

Substantial evidence demonstrates that HPV vaccines reduce the risk of HPV infection, cervical precancerous lesions, and cervical cancer. With the gradual introduction of HPV vaccines in many countries, global full-course HPV vaccination coverage increased from 13% in 2019 to 20% in 2023 [11]. China is currently actively promoting HPV vaccination; however, the vaccine has not yet been included in the National Immunization Program (NIP), and challenges remain in promoting vaccination in some economically underdeveloped areas. In China, the first-dose vaccination rate for women aged 9 to 45 increased from 0.01% to 10.15%, while the full three-dose rate increased from 0% to 6.21% ***(Figure 3)*** [12].

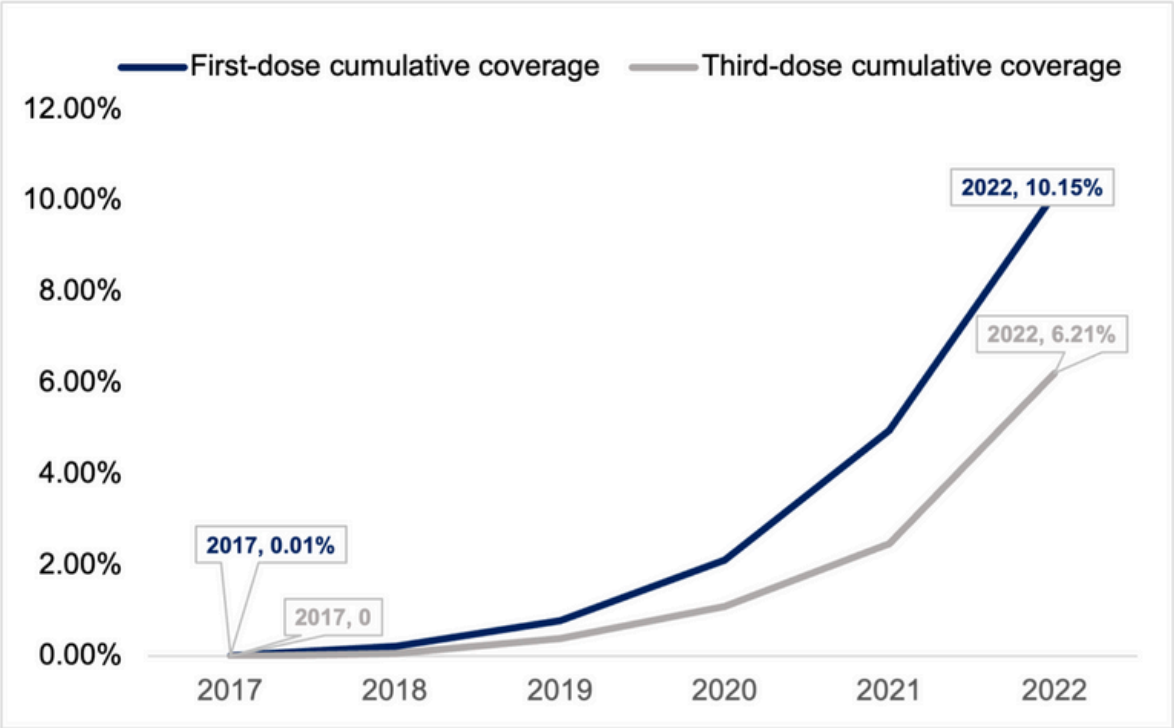

Figure 3: HPV Vaccination Rates Among Ages 9-45 (2017-2022)

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