



**International Journal of Biology, Pharmacy
and Allied Sciences (IJBPAS)**

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

A COMPREHENSIVE REVIEW ARTICLE ON EXPANDING HPV VACCINATION HORIZONS IN INDIA: EVIDENCE FOR ONE-DOSE SCHEDULES AND MALE INCLUSION

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Received 29th Sept. 2025; Revised 18th Oct. 2025; Accepted 22nd March 2026; Available online 1st Sept. 2026

<https://doi.org/10.31032/IJBPAS/2026/15.9.10462>

ABSTRACT

In India, cervical cancer continues to affect many women, though it is largely preventable through HPV vaccines. Recent Indian studies suggest that a single dose may be enough for lasting protection, which is especially useful where access to healthcare is limited. There is rising focus on vaccinating boys, which provides protection against HPV-associated cancers in males while also decreasing community-level infection. The evidence reviewed here points to the potential of these interventions to fast-track India's efforts in meeting cervical cancer elimination targets.

Keywords: Human papillomavirus; Single-dose HPV vaccination; Male HPV vaccination; Cervical cancer prevention; Gender-neutral immunization; Cost-effectiveness; India; Cervavac
INTRODUCTION

Given the global cervical cancer burden, 123,000 of new diagnosis and 77,000 deaths India bears nearly 20%, with reports around per year [1]. The types 16 and 18 are the

high-risk HPV strains which show a persistent infection hold account for nearly 70% of these cases [1, 5]. Protection against HPV16/18 persists for at least 5 years after a single dose [17]. Despite the proven role of HPV vaccination, two- or three dose schedules remain the global standard. Evidence is increasingly showing that a one-dose regimen could achieve adequate and sustained defence against infection [1-3]. At the same time, shifted interest in vaccinating boys enhances its potential to boost herd immunity and reduce the wider impact of HPV associated cancers in both genders. So, while still making cervical cancer elimination as the primary goal, we need to make sure to follow gender neutral vaccination and simple one dose regimen which helps in redefining the strategy on india. One-dose HPV vaccination could prevent a majority of cervical cancers in India, making it highly cost-effective [11]. The review highlights the India's shifting HPV vaccination policies, focusing on research that validates one-dose protection and the public health benefits of male vaccination.

THE CRITICAL ROLE OF HPV VACCINATION IN CANCER PREVENTION:

A single dose of HPV vaccine can help cut down cervical cancer incidence and reduce overall costs in India, though gaps in vaccination coverage remain a concern [36,

37]. In South Asia, uptake is low at about 8%, but improving knowledge and awareness can increase acceptance. Even with lower antibody responses, a single dose still provides effective protection compared with multiple doses [38, 39]. HPV vaccines are widely regarded as safe, protective, and economically beneficial. Offering a single dose to 10-year-old girls in India proves more cost-effective than giving two doses [40, 41]. The recently tested quadrivalent vaccine has shown excellent safety and immune response in both girls and boys aged 9–14, and both one- and two-dose regimens work well if given before exposure [42, 43]. India's indigenous vaccine highlights progress, yet barriers like limited awareness and access continue. Long-term results reveal about 95% protection up to 10 years, supporting inclusion in the UIP [44, 45]. Widespread adolescent vaccination could prevent up to 90% of cervical cancer cases. Persistent hurdles include limited epidemiological clarity, mixed parental attitudes, and gaps in monitoring. Vaccine efficacy remains highest when given between ages 9 and 14 [46-48]. A single dose has shown strong protection against HPV-16 in Indian girls, yet overall uptake in South Asia is still poor, with awareness continuing to be the strongest predictor of acceptance [49, 50].

EVIDENCE FOR ONE DOSE HPV VACCINATION IN INDIA:

Indian research, in collaboration with IARC, provides robust data validating the effectiveness of single-dose HPV vaccination. Basu *et al.* [1, 18] reported long-term outcomes showing that protection against HPV-16/18 infection persisted for at least a decade, with efficacy from a single dose approximating that of multidose regimens. Longitudinal immunogenicity analysis also confirmed durable antibody levels after one dose [2], and further observational work showed reduced new HPV infections [5]. Economic and modeling analyses further emphasize the potential of this approach, showing that single-dose programs could be both impactful in reducing cervical cancer and financially

practical for India [3, 4, 16]. Studies indicate that a one-dose HPV vaccination plan offers nearly 50% savings compared to multi-dose regimens while still delivering strong protection levels.

For resource-constrained settings such as India, this cost-effectiveness could make large-scale vaccination programs more feasible. Yet, it remains important to track recipients long-term to confirm durability and address potential risks of waning immunity. Single-dose schedules provide comparable long-term protection as two- or three-dose regimens [12, 15, 19, 20]. Single-dose vaccination effectively reduces cervical precancerous lesions (CIN2+) [30].

Table 1: Comparision between one dose and multi dose schedule [12, 26, 30, 31, 43]

PARAMETER	ONE DOSE SCHEDULE	MULTI-DOSE SCHEDULE
Efficacy against HPV 16/18 infecion	Comparable protection sustained for 10 years or more	High protection but requires 2-3 doses for full effect
Antibody response	Stable and durable after one dose	Higher initial antibody levels but similar long term protection
Cost effectiveness	40-50% cheaper and easier to implement	More expensive due to multiple doses and logistics
Feasibility in low resource settings	Simplified logistics and better compliance	Difficult due to repeated visits and higher cost
Protection duration	Proven protection up to 10 years	Long term protection established but depends on full schedule
Public acceptance	Increasing awareness and acceptance	Acceptable but compliance drops due to multiple visits

Rationale for one-dose HPV vaccination in India

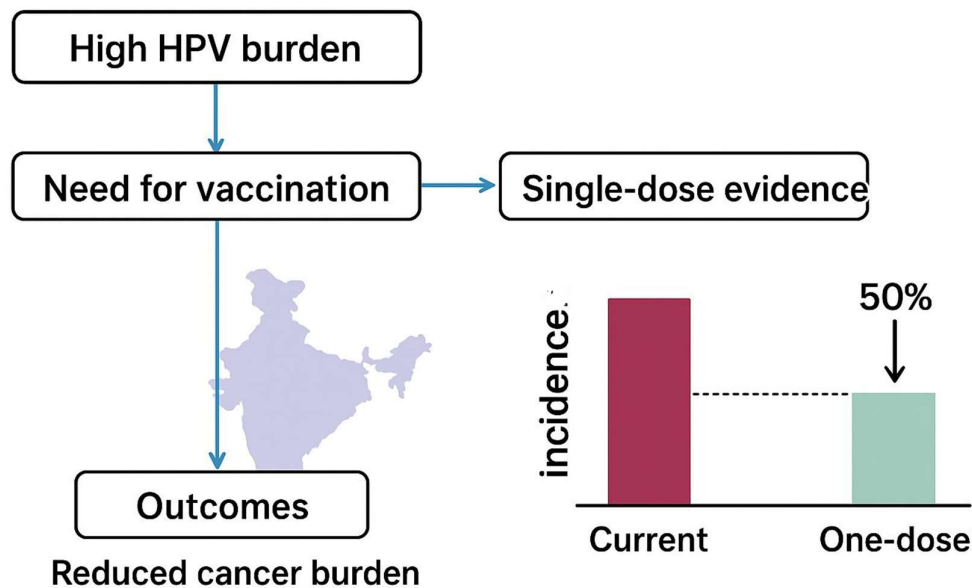


Figure 1: Rationale for one-dose HPV vaccination in India [1, 3, 11]

MALE HPV VACCINATION: RATIONALE AND EVIDENCE

HPV vaccination is primarily targeted at cervical cancer prevention, yet males remain at risk for several HPV-associated malignancies, including anal, penile, and oropharyngeal cancers. A systematic review by Ferrandiz-Pulido *et al.* [6] reported substantial evidence that vaccination is highly effective in protecting males against persistent HPV infection. Trials of India's home grown vaccine, Cervavac, demonstrated robust immune responses and a favourable safety profile among 9–14-year-old boys and girls, performing on par with Gardasil [7]. Vaccinating boys

provides them direct protection and enhances herd immunity by lowering overall viral spread. Antibody responses in males after one dose support the inclusion of boys in vaccination programs [13]. Expanding HPV vaccination to males reframes the program as a universal health intervention rather than a women-only measure. Alongside reducing stigma, it provides crucial protection against male cancers like oropharyngeal, anal, and penile cancers, which are increasingly recognized as a growing burden in India. Gender-neutral HPV vaccination can reduce HPV transmission and protect both sexes effectively [14, 29].

India Burden Map

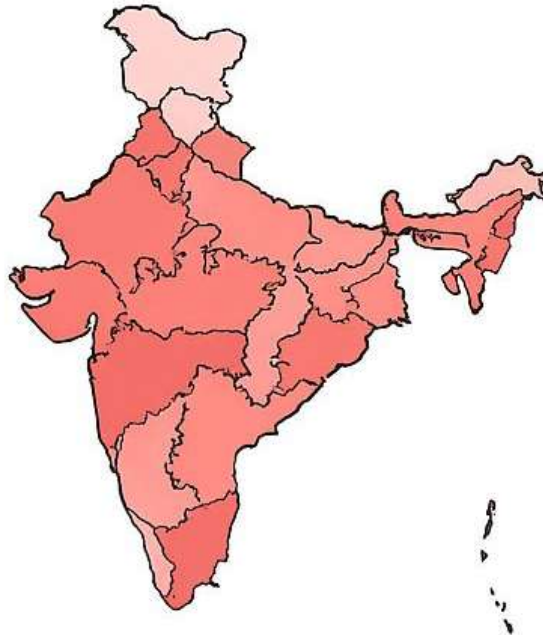


Figure 2: Indian burden map [27, 37, 47]

POSITIONING INDIA WITHIN THE GLOBAL HPV ELIMINATION EFFORT:

The Kenyan KEN SHE study provided compelling evidence that a single HPV vaccine dose can offer substantial protection for adolescent girls, bolstering the argument for streamlined vaccine regimens in low- and middle-income regions [8]. In South Asia, however, progress has been uneven, with ongoing obstacles such as reluctance toward vaccination, gender-related inequalities, and gaps in health infrastructure [9]. Initial trials of Cervavac in Indian adults confirmed its favourable safety profile [10], which supports its integration into large-scale programs. With

its cost-effective local production, strong one-dose data, and the potential for vaccinating boys, India has a chance to spearhead global initiatives aimed at eliminating cervical cancer. HPV vaccine uptake in India is hindered by cultural perceptions linking it to sexual activity, low awareness in rural communities, and limited school-based delivery. Digital health tools, engagement of ASHA workers, and targeted social media campaigns can help address misinformation and improve coverage [21, 22]. Cultural beliefs and misinformation can affect vaccine acceptance in rural India [24, 34]. Cervavac offers an affordable indigenous option and strengthens India's role in global health [28, 33].

Immune Response Diagram (One-dose vs Multiple-dose)

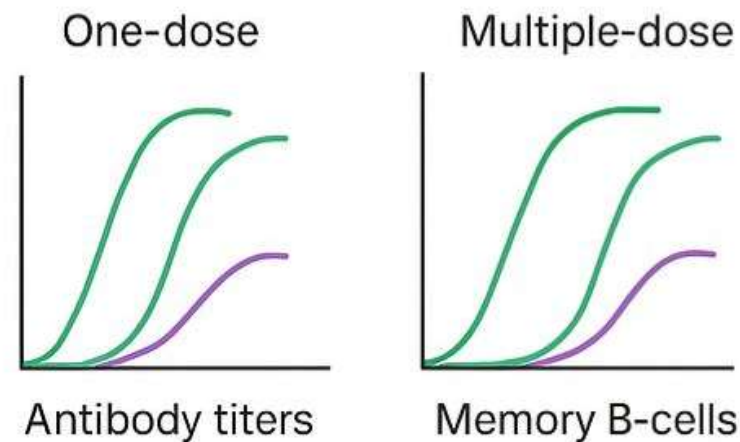


Figure 3: Diagram of immune response between one dose and multiple dose [2, 5, 16, 17]

POLICY IMPLICATIONS AND FUTURE DIRECTIONS:

India's commitment to the WHO target of cervical cancer elimination by 2030 underscores the urgency of adopting innovative vaccination strategies. A single-dose schedule could significantly improve uptake and adherence, especially among rural and marginalized groups [3, 4]. Integrating boys into routine programs could normalize HPV vaccination as a shared responsibility while reducing inequities [6, 7]. Future studies should emphasize long-term follow-up of one-dose recipients, evaluate Cervavac's effectiveness in real-world settings, and design practical frameworks for including boys in the national program. Integrating HPV vaccination into the Universal Immunization Programme (UIP) with

school-based initiatives can promote equitable access. Coupling vaccination with cervical cancer screening programs establishes a comprehensive prevention framework, maximizing public health benefits. Integrating HPV vaccination into the Universal Immunization Programme ensures equitable access [23]. New quadrivalent vaccines show strong immunogenicity and favourable safety profiles in Indian populations [25, 26]. School-based delivery increases coverage and helps overcome rural access barriers. Adolescents' misconceptions linking HPV to sexual activity can hinder uptake [31, 32].

CONCLUSION:

Research findings clearly indicate that a single-dose HPV vaccine is a practical and affordable choice for India's healthcare setting. Extending vaccination to boys

provides added protection against male cancers while strengthening herd immunity at the population level. In low-resource settings, completing multi-dose vaccination schedules is often difficult, making simplified regimens highly valuable. With proper nationwide implementation, India could achieve the WHO's 2030 cervical cancer elimination goals and act as a benchmark for other developing countries aiming for equitable, gender-neutral immunization. Key challenges include awareness, infrastructure, and school-based delivery gaps in India [27, 35]. India's homegrown HPV vaccine, Cervavac, is cheaper and helps the country take a leading role in health collaborations with other developing nations. In the future, it's important to improve systems that track how well the vaccine works, especially in people who receive only one dose and in boys, to make sure it provides long-lasting protection.

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