Current status of human papillomavirus vaccination in India's cervical cancer prevention efforts

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Efforts are being made to scale up human papillomavirus (HPV) vaccination for adolescent girls in India. Bivalent and quadrivalent HPV vaccines were licensed in the country in 2008, and a nonavalent vaccine was licensed in 2018. Demonstration projects initiated in Andhra Pradesh and Gujarat in 2009 introduced HPV vaccination in public health services in India. Following a few deaths in these projects, although subsequently deemed unrelated to vaccination, HPV vaccination in research projects was suspended. This suspension by default resulted in some participants in a trial evaluating two versus three doses receiving only one dose. Since 2016, the successful introduction of HPV vaccination in immunisation programmes in Punjab and Sikkim (with high coverage and safety), government-sponsored opportunistic vaccination in Delhi, prospects of a single dose providing protection, and future availability of an affordable Indian vaccine shows promise for future widespread implementation and evaluation of HPV vaccination in India.

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Introduction

Almost all cervical cancers are caused by persistent infection with one of 13 high-risk types of human papillomavirus (HPV), with HPV types 16 and 18 accounting for 73% of cervical cancers globally.[1–3] Cervical cancer is a major public health problem in India, predominantly affecting women of lower socioeconomic status.[4] Cervical cancer accounted for an estimated 96 922 new cases and 60 078 deaths in India in 2018, which is close to one-fifth of the global burden of this cancer.[5] Cervical cancer is the second most common cancer in women aged 15–44 years in India, with more than three-quarters of cases diagnosed at a locally advanced clinical stage with poor prospects of survival. HPV types 16 and 18 account for 80–85% of cervical cancers in the country.[6–8] Currently, effective and safe vaccines are available to prevent HPV 16 and HPV 18 infection in HPV-naive women in the form of bivalent and quadrivalent vaccines.[9] The nonavalent vaccine, in addition to protecting against HPV 16 and 18, also protects against high-risk HPV types 31, 33, 45, 52, and 58.[10]

Poor awareness exists about cervical cancer and its prevention among women in India.[11–13] During 2012–14, cervical cancer incidence in India varied from five to 30 new cases per 100 000 women per year, with the highest prevalences generally reported in rural areas and in northeast India.[14] Although cervical cancer incidence is now declining in the country, falling at a rate of 1–2% per year, in absolute terms it is still a cancer with a high burden in India that disproportionately affects women of poor socioeconomic status and thus remains an issue of considerable inequity.[14–16] Furthermore, population projections suggest that the falling prevalence of cervical cancer will not be sufficient to avoid substantial increases in the numbers of women affected during the coming decades. The cumulative risk of developing cervical cancer for Indian women was 1·59% in 2018, and one in 63 Indian women will develop cervical cancer in their lifetime.[5] Cervical cancer is a major women's health issue and the burden of cervical cancer in India can potentially be substantially reduced by a judicious combination of HPV vaccination and affordable, organised, and accessible screening programmes. Nevertheless, much misinformation, ambiguity, controversy, and confusion surround the safety, duration of immunity, validity of endpoints chosen in trials, effectiveness, and cost-effectiveness of HPV vaccines, and moral and cultural issues also exist. Moreover, against the backdrop of declining cervical cancer incidence, the need to introduce HPV vaccination as a public health intervention as part of the national immunisation programme has been questioned by some respected health-care professionals.[17–19]

Persistent global misinformation on the safety and effectiveness of vaccines in general has resulted in ambivalence and hesitancy on the introduction of HPV vaccination on the part of government authorities. In this Policy Review, we review the various initiatives in public health and scientific research settings in India that aim to catalyse the introduction and scale-up of HPV vaccination as one of the major interventions for cervical cancer prevention and potential elimination in India. The HPV vaccines are not licensed for boys in India and our discussions are restricted to the efforts of scaling up the vaccination of adolescent girls, who are the primary targets for the prophylactic vaccine.

HPV vaccination demonstration projects in Andhra Pradesh and Gujarat to examine operational feasibility

Bivalent and quadrivalent HPV vaccines were licensed for prescription use by Indian authorities in 2008 (figure 1). The first large-scale introduction of HPV vaccination in the public health setting in India was in demonstration projects in 2009 that aimed to establish how best to deliver the vaccine. These projects were implemented by

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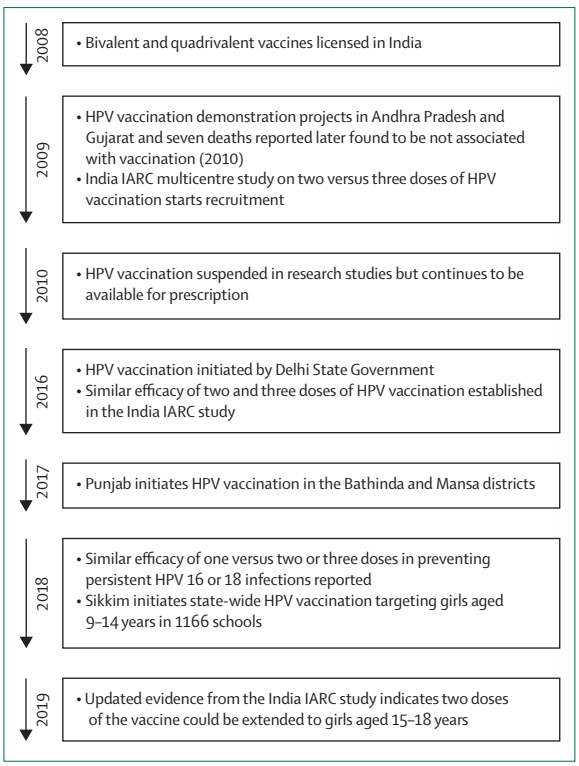

Figure 1: **History of HPV vaccine studies and implementation in India**
HPV=human papillomavirus. IARC=International Agency for Research on Cancer.

the state governments of Andhra Pradesh and Gujarat in collaboration with the Indian Council of Medical Research (ICMR) and the Programme for Appropriate Technology in Health (PATH), a US-based not-for-profit non-governmental organisation, in 2009 (figure 1). These post-licensure demonstration programmes were designed to address the operational feasibility and acceptability of school-based versus community-based vaccination through the existing public health services, and to generate data about the feasibility, coverage, acceptability, and implementation costs to inform government and policy makers on whether and how to integrate HPV vaccination into routine public health services.

Short-term safety analysis of the vaccine recipients in the demonstration projects implemented in Khammam district in Andhra Pradesh and Vadodara district in Gujarat was tracked through the routine vaccine safety monitoring system used for all licensed vaccines in India (during which all adverse events following immunisation including physiological reactions, errors in vaccine handling or administration, and any coincidental disease temporally associated with vaccination are to be reported by the health professionals administering the vaccines or monitoring the programme). The quadrivalent vaccine (human recombinant papillomavirus vaccine against types 6, 11, 16, and 18 [Gardasil, Merck, Branchburg, NJ, USA]) was used in Khammam district and the bivalent vaccine (human recombinant papillomavirus vaccine against types 16 and 18 [Cervarix, GlaxoSmithKline, Rixensert, Belgium]) was used in Vadodara district using a three-dose schedule (Gardasil at 0, 2, and 6 months and Cervarix at 0, 1, and 6 months). Given that the vaccine was already licensed for use in India, these projects were not designed to address efficacy or effectiveness, but rather aimed to address operational feasibility and acceptability. The projects were implemented after approvals from the Institutional Ethics Committee for Human Research of Baroda Medical College (Vadodara, India), Mehdi Nawaj Jung Institute of Oncology and Regional Cancer Center (Hyderabad, India), and the Western Institutional Review Board, by the Drugs Controller General of India and the Health Ministry's Screening Committee, and were overseen by multidisciplinary and multistakeholder project advisory groups. In addition to individual consent, community consent was approved by the ICMR before the start of the demonstration projects.

Following the completion of vaccine administration in the demonstration projects, some activists and media outlets alleged that five deaths in Khammam district, Telangana, and two deaths in Vadodara district, Gujarat, among vaccinated girls were caused by the vaccine, sparking controversy about its safety. Following this episode, the Government of India suspended HPV vaccination in all clinical trials and demonstration projects, while paradoxically both vaccines continued to be approved for use in clinical settings.[20] The conduct of the demonstration project and the causes of death were scrutinised by an Inquiry Committee appointed by the Government of India, which found that none of the deaths were related to vaccination, but the reputation of the vaccines had already been damaged. The five deaths in Andhra Pradesh were determined to be due to poisoning (n=2), drowning (n=1), malaria (n=1), and pyrexia of unknown origin (n=1); fever started 96 days after the third dose of the vaccine in the last case. In Gujarat, one girl died due to malaria and another due to a snake bite.[21]

The combination of press reporting and misinformation surrounding the deaths in the two demonstration projects and the muted defence against this news have proved to be an impediment to introducing and integrating HPV vaccination into the universal immunisation programme in India during the past 8 years. Although the National Technical Advisory Group on Immunisation has advised its inclusion in the universal immunisation programme, and professional societies such as Federation of Obstetric & Gynaecological Societies of India (FOGSI) and the Indian Academy of Paediatrics recommend its use, substantial resistance to HPV vaccination remains.

The multicentre Indian study to evaluate protection by fewer than three doses of HPV vaccination

A multicentre cluster randomised trial (NCT00923702) was initiated in India in 2009 to evaluate whether two doses

of the quadrivalent HPV vaccine (Gardasil) administered over a 6-month period for girls aged 10–18 years could be as effective as three doses in preventing persistent HPV infection and cervical neoplasia (figure 1). The study design has been described in detail elsewhere.[22] The aim of the study was to recruit 20 000 unmarried girls aged 10–18 years and randomly allocate half to receive two doses of quadrivalent HPV vaccine on days 1 and 180 and the other half to receive three doses on days 1, 60, and 180. Recruitment and vaccination of the eligible girls were initiated in September, 2009, and continued satisfactorily until April, 2010, with more than 95% of the invited girls participating in the study. However, in April, 2010, the Indian authorities suspended further vaccination of participants in all HPV vaccination trials in India, following the deaths in the HPV vaccination demonstration projects in Andhra Pradesh and Gujarat states.

Suspension of vaccination in the trial meant that only those receiving their first dose within the first 2 months of the trial were vaccinated as intended by randomisation. By the time of suspension, 17729 of the target 20 000 participants were recruited, but many participants could not complete their allocated vaccine schedules and received incomplete doses, which by default resulted in participants receiving one of four (rather than the two intended) different dosing schedules. Thus, this study ended up as an observational cohort study that had four different groups: girls vaccinated on days 1, 60, and 180 or later (the three-dose group [n=4348]); girls vaccinated on days 1 and 180 or later (the two-dose group [n=4979]); girls vaccinated on days 1 and 60 by default (the two-dose default group [n=3452]); and girls who had only one dose by default (the single-dose default group [n=4950]). The girls in the single-dose default group consisted of participants allocated two doses on day 1 and 180 who could not receive the second dose, and participants allocated three doses who did not receive the second and third doses; none of the single-dose group had refused further doses after receiving the first dose. Despite the suspension of vaccination, 17 064 (96%) of 17729 recruited study participants are still being followed up yearly to monitor and evaluate safety and to determine the effectiveness of the different dose schedules in inducing immunogenicity and in preventing HPV infection and cervical neoplasia. In 2012–14, a group of age-matched and residence-matched unvaccinated women were recruited on the basis of a post-hoc decision following the suspension of vaccination, as a default control group to facilitate the assessment of vaccine effectiveness.

Ongoing follow-up of this study indicated that immunogenicity following two doses of HPV vaccination was non-inferior to that following three doses, and one-dose recipients showed a robust and sustained immune response against HPV 16 and 18, albeit inferior to that seen after two or three doses, and the antibody levels were stable over a 4-year period (figure 2).[22–25] The frequencies of cumulative incident and persistent

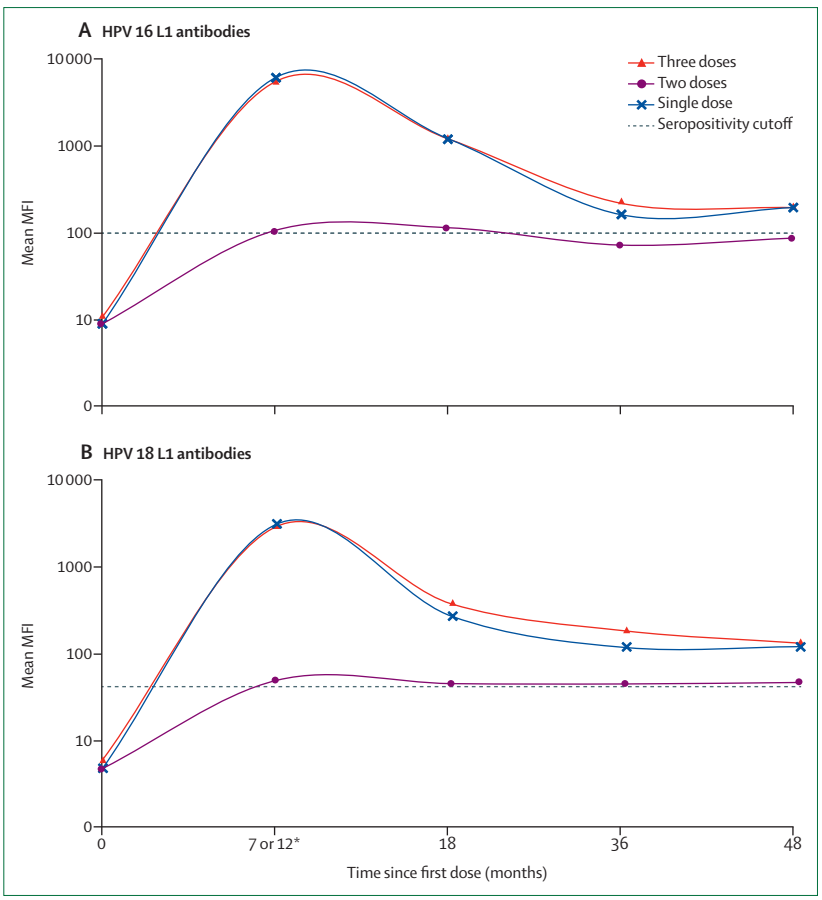

Figure 2: **Immunogenicity following fewer than three doses of quadrivalent HPV vaccination in an observational study in India[23]**
Mean MFI values for HPV 16 and 18 L1 antibodies at different times in girls who completed the vaccination schedule per protocol (vaccination on days 1, 60, and 180 [three-dose group] or days 1 and 180 [two-dose group]), and individuals who received only a single dose of vaccination by default. HPV=human papillomavirus. MFI=median fluorescent intensity. *7 months for the three-dose and two-dose groups; 12 months for the single-dose group. Reproduced from Sankaranarayanan et al,[23] by permission of HPV World.

HPV 16 and 18 infections up to 7 years of follow-up from vaccination were similar and uniformly low in all four vaccinated study groups and the frequency of HPV 16 and 18 infections was substantially higher in the unvaccinated age-matched control women than in vaccine recipients (table 1).[24] This study also showed that two doses in girls aged 15–18 years are as effective as three doses in inducing immunogenicity and in protecting against targeted HPV infections over a 7-year follow-up period.[25,26] No serious adverse events associated with HPV vaccination have been reported and the vaccine was safe and well tolerated.[22] Follow-up is continuing to establish the effect of fewer than three doses on the incidence of cervical intraepithelial neoplasia.

Introduction of HPV vaccination in Punjab

A stakeholders' meeting organised by ICMR was held in August, 2016, and was attended by experts and senior officials from the Department of Health and Family Welfare, Punjab, regarding the ongoing controversies

	Three doses (n=1056)	Two doses (n=1055)	One dose (n=1643)	Unvaccinated women (n=1242)
HPV 16 or 18	1 (0·1% [0·0–0·5])	1 (0·1% [0·0–0·5])	1 (0·1% [0·0–0·3])	28 (2·3% [1·5–3·2])
HPV 6 or 11	1 (0·1% [0·0–0·5])	0 (0·0% [0·0–0·0])	1 (0·1% [0·0–0·3])	2 (0·2% [0·0–0·6])
HPV 16, 18, 6, or 11	2 (0·2% [0·0–0·7])	1 (0·1% [0·0–0·5])	2 (0·1% [0·0–0·4])	30 (2·4% [1·6–3·4])

Data are n (% [95% CI]) and were provided by PB (unpublished). HPV=human papillomavirus.

Table 1: **Frequencies of persistent infection with vaccine-targeted HPV types following quadrivalent HPV vaccination and in unvaccinated women in an observational study in India**

For more on the **Punjab Edusat Society** see http://www.ssapunjab.org/edusat/

	Punjab	Sikkim
Total girls targeted	9922	25 284
Total girls vaccinated	9672 (98%)	24 446 (97%)
Vaccine vials wasted	<1%	<1%
Adverse events	28*	119†
Syncope	0	1
Headache	2	48
Dizziness	5	31
Nausea	0	25
Vomiting	5	0
Fainting	16	0
Injection site pain	0	8
Other	0	6

Data were obtained from the immunisation programme databases (not in the public domain) for Punjab and Sikkim. HPV=human papillomavirus. *Reported in 28 girls following vaccination. †Reported in 118 girls following vaccination.

Table 2: **Frequency of coverage for two doses of the quadrivalent HPV vaccine and adverse events following immunisation in the Punjab and Sikkim vaccination programmes**

surrounding the value, need, efficacy, and safety of HPV vaccination in India. The experts agreed on the need for the introduction of HPV vaccination in India.[27] Following this meeting, the Punjab state health department constituted a technical expert group, which endorsed Punjab's plan to include two-dose HPV vaccination with the quadrivalent vaccine as part of the routine immunisation programme in the state, targeting girls in class 6 (approximate age 11–12 years) in schools. The technical expert group further recommended preparation of operational guidelines and conduct of a cost-effectiveness analysis. A subsequent cost-effectiveness analysis reported HPV vaccination to be very cost-effective for Punjab.[28] The study estimated that discounted incremental cost per quality-adjusted life-year for HPV vaccination was 73 Indian rupees (INR), resulting in a 64% reduction in the lifetime risk of cervical cancer with three to four cases prevented for every 1000 girls immunised. Subsequently, the Government of Punjab decided to introduce HPV vaccination into the state in a phased manner, beginning with the Bathinda and Mansa districts which had high annual incidences of cervical cancer (17·5 cases per 100 000 women in Bathinda and 17·3 cases per 100 000 women in Mansa).[29]

Operational guidelines for the implementation of vaccination through the health facilities for class 6 girls studying in government and government-aided schools (not private schools) were developed with technical input from the ICMR,[30] WHO, UNICEF, and the US Centers for Disease Control and Prevention. All necessary training targeting officials, school principals and teachers, district immunisation officers, medical officers, cold-chain handlers, auxiliary nurse midwives, and accredited social health activist workers was provided by Department of Health and Family Welfare Punjab in collaboration with WHO. Detailed training was provided to vaccinators and medical officers on recognition, management, and reporting of adverse events following immunisation.

Education of the parents of class 6 girls about the benefits of the vaccine was done through the Punjab Edusat Society that has been established and functioning since 2008, providing quality education to government educational institutions. Through this network, pre-recorded messages about HPV vaccination from medical professionals were delivered during parent–teacher meetings to create awareness among parents and teachers. An information dashboard was established by the WHO National Polio Surveillance Project, which was updated every hour to report coverage and adverse events following immunisation, if any, to all stakeholders and senior government officials.

Administration of the vaccine was initiated in the second half of November, 2016, through a facility-based approach at community health centres, and sub-district and district hospitals. After vaccination, all the vaccinated girls were given a refreshment pack and were observed for 30 min. Each vaccination team was provided with an adverse events following immunisation management kit containing all essential medicines and equipment. A mechanism was established to trace and vaccinate willing girls who were missed during vaccination days, by actively reaching them at home and bringing them to the health centre for vaccination.

Vaccination coverage was excellent, with 9672 (98%) of 9922 targeted participants in government and government-aided schools completing the prescribed two doses (table 2), indicating high acceptability and compliance with the intervention. The programme was run with high efficiency as indicated by less than 1% of vaccine being wasted. Minor adverse events were documented in 28 girls (16 cases of fainting, five of dizziness, five of vomiting, and two of headache; table 2), all of which subsided quickly.

The second phase of the programme in the Bathinda and Mansa districts aimed to cover a new cohort of 16 106 class 6 girls studying in government, government-aided, and private schools for the first dose. The second phase was completed in November, 2017, where 15 140 (94%) of the 16 106 eligible girls received the first dose of vaccine and 14 988 (99%) of the individuals who had the first dose received the second dose.

Introduction of HPV vaccination in Sikkim

The state of Sikkim has a comprehensive cervical cancer policy involving targeted primary prevention with HPV vaccination of girls aged 9–14 years followed by vaccination of girls aged 9 years in routine immunisation thereafter, screening of women aged 30 years and older using visual inspection with acetic acid, early diagnosis of women with invasive cervical cancer, and referral of suspicious lesions to empanelled hospitals outside Sikkim for treatment (since Sikkim does not have any cancer treatment facilities).

Sikkim introduced HPV vaccination using a two-dose schedule, with a minimum gap of 6 months between doses (day 1 and day 180) targeting 25 284 girls aged 9–14 years in 1166 schools (table 2). During a 2-week period in August, 2018, 24 446 (97%) girls received the first dose at school (for school-going girls) or in a health centre (for individuals not attending school; figure 1). The second dose was administered between April 23 and May 4, 2019. WHO, UNICEF, Jhpiego, and a state advisory committee provided technical support for the programme. Of the 24 459 vaccine vials used, only 13 (<1%) were wasted. 119 minor adverse events were reported in 118 girls (48 cases of headache, 31 of dizziness, 25 of nausea, eight of injection site pain, one case of syncope, and six cases of other symptoms; table 2). One severe adverse event was reported in the form of syncope. These adverse events were temporary and resolved quickly.

Opportunistic HPV vaccination in Delhi

As reported by the programme coordinators, in November, 2016,[30] the Government of Delhi National Capital Territory launched an opportunistic HPV vaccination programme targeting girls aged 12–13 years. By December, 2018, 4741 girls were vaccinated; of these individuals, 3263 girls received the second dose; and 8108 bivalent vaccine vials were used. No severe adverse events following vaccination were observed in this ongoing opportunistic programme.

Cost-effectiveness of HPV vaccination in India

Only a few studies have estimated the cost-effectiveness of HPV vaccination in India,[28,31] an assessment that has been recommended by the National Technical Advisory group on Immunisation in India.[29] The study in Punjab[32] found that the cost of vaccinating 11-year-old girls in that state is around 135 million INR (US$2·1 million); however, the net cost, taking into consideration the cervical cancer treatment costs in Punjab, is around 38 million INR ($0·6 million). These findings might be generalisable to other Indian states, implying that HPV vaccination is not only highly cost-effective but also fiscally sustainable for India.

Discussion

Against the backdrop of various adverse situations, the state-wide introduction of HPV vaccination in Sikkim, vaccination in two districts of Punjab, and opportunistic vaccination in Delhi are encouraging signs of government engagement in delivering HPV vaccines to individuals seeking vaccination voluntarily in India. Logistics for documentation of long-term safety and effectiveness have been put in place within the state immunisation programmes, given that safety concerns have been a major impediment to the scale-up of HPV vaccination in the country. Factors responsible for the successful introduction of HPV vaccination in Delhi, Punjab, and Sikkim include strong political commitment by the governments in these states, ably supported by strong state technical advisory groups that included experts from national and international organisations, agencies, and professional bodies; locally relevant awareness initiatives targeting parents, girls, teachers, and officials; allocation of adequate resources for vaccine purchase and roll-out from state funds; ensuring vaccine preparedness by efficient audit and reinforcement of immunisation programme infrastructure; efficient organisation of transportation services for the vaccines and the participants; good intersectoral coordination; an overall positive attitude of parents and the wider community towards HPV vaccination; good support from printed and electronic media; and committed immunisation staff. These observations are consistent with the experience in 46 low-income countries working to implement prophylactic HPV vaccination, as analysed by the London School of Hygiene & Tropical Medicine and PATH.[32] Professional societies such as FOGSI[33] and the Indian Academy of Pediatrics,[34] among others, strongly endorse the safety of the vaccine, but to what extent HPV vaccination is prescribed in the private sector remains unclear. A growing interest exists in introducing this vaccine in state immunisation programmes in India despite the previous and ongoing—but declining—adverse publicity that has delayed the scale-up efforts. The positive experience and the safety data from Punjab and Sikkim states are anticipated to encourage the future widespread introduction of HPV vaccination in immunisation programmes in other states.

The declining incidence of cervical cancer, and rates as low as seven to nine cases per 100 000 women per year in locations such as Kerala and in Mumbai,[14] are often cited as an argument against the cost-effectiveness of HPV vaccination, and in favour of a focus on screening alone as a control strategy.[19] However, the decreasing prevalence of cervical cancer also presents an opportunity to potentially eliminate the disease with a judicious combination of vaccination and screening. Moreover, the current trends of decreasing incidence are not a guarantee that future increases will not occur, especially in view of the evolving trends in sociocultural norms governing sexual behaviour, especially in young people in emerging economies. For example, cervical cancer incidence in China declined substantially before 2000, but substantially increased thereafter, especially among

young women during the past two decades—a trend that has been attributed mainly to lifestyle changes such as changing sexual behaviours.[35,36] The annual incidence of cervical cancer has increased by 9·8% in urban areas and 15·5% in rural areas of China.[36] Modelling studies have shown that early HPV vaccination in populations before social transitions in sexual behaviour can substantially mitigate the increased risk of HPV infection attributable to transition.[37,38] Even if rates continue to decline, the number of annual cases of cervical cancer in India is likely to increase as the population ages. Therefore, the public health impact of introducing timely HPV vaccination in India might be substantial given the window of opportunity.

Recognising the fact that cervical cancer as a public health problem can be eliminated through intensified HPV vaccination, screening, and treatment of detected lesions, in May 2018, WHO called for global action in reaching this goal.[39] Evidence from Scotland has shown that vaccination of girls aged 12–13 years with the bivalent HPV vaccine has resulted in a substantial reduction in preinvasive cervical disease, with apparent herd protection in girls who had not been vaccinated.[40] Studies from Denmark and Sweden have also reported more than a 70% decline in prevalence of cervical intraepithelial neoplasia grade 2 or worse lesions following vaccination of young girls with the quadrivalent HPV vaccine.[41] Australia, one of the first countries to introduce HPV vaccination (in 2006) and subsequently change its cervical cancer screening programme in the post-vaccination era (in 2017; by targeting women aged 25–70 years with HPV testing every 5 years[42]), is likely to reduce annual cervical cancer incidence to fewer than six cases per 100 000 women by 2020 and fewer than four per 100 000 by 2028 if the country maintains its current level of coverage of HPV vaccination and screening.[43] This reduction means that Australia should be the first country to eliminate cervical cancer as a public health concern in the next 20 years, according to an elimination incidence threshold of four per 100 000 women.[44]

Finally, the ongoing evaluation of the efficacy of a single dose of HPV vaccination in the Indian multicentre cohort study and other ongoing studies around the world will make an important contribution to HPV vaccination programmes in the future.[22,24,45] The results of the effectiveness of a single dose to prevent targeted HPV infections in observational studies done in Costa Rica and India are particularly consistent in showing a high level of prevention of vaccine-targeted HPV infection.[24,45] If the long-term evaluation of the single dose proves efficacious with sustained protection against HPV infection, the logistics and costs of vaccine delivery will become easier. This study provided valuable evidence for the WHO recommendation of a two-dose schedule for girls aged 9–14 years.[46] Similarly, if the continuing evaluation of two doses for girls aged 15–18 years proves efficacious, such a schedule will substantially ease the logistics and reduce the financial costs of catch-up vaccination of girls aged 15–18 years.

An Indian quadrivalent HPV vaccine, which includes virus-like particles of HPV types 6, 11, 16, and 18 made by Serum Institute of India (Pune, India) is currently undergoing phase 2–3 trials for efficacy and safety.[47] A Chinese bivalent vaccine is also being evaluated and is expected to be licensed in China in the near future.[48,49] The feasibility of introducing widespread HPV vaccination in India and other low-income and middle-income countries will substantially increase when either the Indian or the Chinese HPV vaccine is found to be effective and affordable; when any such vaccine is available for prescription and public health use; and when the single dose is shown to be effective in protecting against vaccine-targeted HPV infections and cervical neoplasia.

Search strategy and selection criteria

We identified and reviewed reports related to human papillomavirus vaccines published by the Indian Ministry of Health, Government of India, and Indian Council for Medical Research. References for this Policy Review were identified through searches of PubMed with the search terms "human papillomavirus vaccine", "India", and "immunization programme" for items published between Jan 1, 2007, and April 30, 2019. Articles were also identified through searches of the authors' own files. Only items published in English were reviewed. The final reference list was generated on the basis of originality and relevance to the broad scope of this Policy Review.

Conclusion

A judicious combination of efficient cervical cancer screening programmes and efficient HPV vaccination programmes will be highly conducive for the elimination of cervical cancer in India and the wider world.[50]

Contributors

RS drafted the first version of the manuscript, participated in subsequent revisions, contributed to the final version of the manuscript, and was involved in the collection of data. PB, AP, PSe, and KO contributed extensively to the revision of the initial drafts, and were involved in literature review, collection of data, and finalisation of the manuscript for submission. PK, RB, GBS, PD, RKG, VJ, and SK provided data from Punjab (PK, RB, and GBS), Sikkim (PD), and Delhi (RKG, VJ, and SK) and contributed to the revision of the manuscript. IK contributed in writing the cost-effectiveness of HPV vaccination in India section and in revising and finalising the manuscript. TS, RM, RK, AD, RH, VJ, SK, GKR, PSe, NB, PR, ELT, PSa, and SS contributed to the collection of data and to revising and finalising the manuscript.

Declaration of interests

We declare no competing interests.

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