

Supplementary Table III. Study characteristics

Authors & year	HPV vaccination uptake & awareness (%)	Barriers to HPV vaccination	Facilitators & recommendations	HPV prevalence & impact of vaccination
Basu <i>et al</i> ¹⁰ (2021)	Study focused on vaccine efficacy rather than uptake.	No significant barriers studied (study focused on vaccine efficacy).	Single-dose 95.4% effective, justifying policy shift towards single-dose vaccination.	HPV 16/18 infection rates significantly reduced in vaccinated cohorts. Protection was similar across single, two, and three-dose groups.
Sharma <i>et al</i> ¹¹ (2023)	Study focused on vaccine immunogenicity and safety, not uptake.	No major barriers found (study focused on clinical trials).	Supports introduction of an Indian-made HPV vaccine (Cervavac), which may lower costs.	New vaccine was non-inferior to Gardasil, supporting its use in national programs.
Hussain <i>et al</i> ¹² (2014)	HPV awareness: 15% Willingness to vaccinate: 13%	Lack of awareness (only 15% knew about HPV), stigma, and misinformation.	Education campaigns needed to improve knowledge among parents and students.	Study did not focus on HPV prevalence but highlighted public misconceptions.
Mandal <i>et al</i> ¹³ (2021)	Vaccination completion: 98% (in rural community project).	Access barriers in rural settings. Parents needed encouragement and follow-ups.	School-based and community-led vaccination programs improve acceptance.	Study did not focus on HPV prevalence but demonstrated high vaccine feasibility.
Hussain <i>et al</i> ¹⁴ (2012)	Study did not focus on uptake but provided biological evidence for vaccination.	Low awareness & late vaccination timing. Higher infection rates in adolescents >13 years old.	Early vaccination (before 13 years) should be prioritized. Gender-neutral vaccination could be beneficial.	HPV prevalence in girls: 3.2% 66.6% of infected girls had high-risk HPV (16/18).
Rehman <i>et al</i> ¹⁵ (2022)	HPV awareness: 18% HPV vaccine uptake: 0.6%	Limited knowledge, cultural stigma, and cost concerns.	Incorporating HPV vaccination into government immunization programs can increase uptake.	No HPV prevalence data but showed major gaps in vaccination coverage.
Man <i>et al</i> ¹⁶ (2022)	Modeled vaccine impact, not actual uptake.	No direct barriers studied, but emphasized need for sustained vaccination programs.	Single-dose HPV vaccination could reduce HPV prevalence by 97% in 50 years.	Projected lifetime cervical cancer risk reduction: 71–78%.
Madhivanan <i>et al</i> ¹⁷ (2009)	Parental willingness to vaccinate: 72.5%	Concerns about safety, cost (vaccine priced at ₹5,800 per dose), and perceived stigma of HPV as an STI.	High trust in government immunization programs can improve uptake.	Study did not focus on HPV prevalence but emphasized positive attitudes despite low awareness.
Degarege <i>et al</i> ¹⁸ (2018)	Willingness to vaccinate daughters: 79.9%	Family disapproval (AOR: 0.45), belief that daughters have low cervical cancer risk (AOR: 0.52), and pain concerns (AOR: 0.53).	Family support (AOR: 2.86) and belief in vaccine safety (AOR: 2.11) increased acceptance.	Study did not focus on HPV prevalence but emphasized high vaccine acceptability despite misinformation barriers.
Madhivanan <i>et al</i> ¹⁹ (2014)	71% of parents accepted vaccination	- Concerns about pain & side effects - Lack of awareness about HPV & cervical cancer	- Parental recommendation played a key role - Addressing safety concerns through education suggested	Supports WHO estimates that HPV vaccination can reduce cervical cancer by 70%
Ramavath <i>et al</i> ²⁰ (2013)	72% unaware of HPV, 74.4% willing to vaccinate	56.7% cited cost as a barrier	Youth-focused awareness campaigns	-
Prinja <i>et al</i> ²¹ (2014)	Not assessed	High vaccine cost	Supports national immunization inclusion	Cost per QALY: INR 73 (USD 1.12)

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Gupta <i>et al</i> ²² (2021)	Not assessed	Lack of awareness in rural areas	Need for subsidized vaccines	95% of HPV-positive cases were HPV-16
Basu <i>et al</i> ²³ (2011)	Acceptance increased from 27% to 74% after education	Vaccine hesitancy due to misinformation	Awareness programmes significantly improve uptake	Not assessed
Singh <i>et al</i> ²⁴ (2018)	63.14% accepted HPV vaccination for daughters	Fear of side effects	Government-sponsored programs can improve uptake	The study focuses on awareness, knowledge, and acceptance related to cervical cancer and HPV vaccination
Sankaranarayanan <i>et al</i> ²⁵ (2018)	One-dose provides some protection	Safety concerns	Advocates for school-based programs	High immunogenicity with two doses
Sankaranarayanan <i>et al</i> ²⁶ (2016)	Two-dose schedule found non-inferior to three-dose	Cost concerns	Supports a reduced-dose approach	HPV 16/18 infections: 10.8% in unvaccinated, 1.3% in three-dose recipients
Degarege <i>et al</i> ²⁷ (2018)	73.6% had never heard of HPV	Rural parents less likely to believe HPV causes cancer	Targeted rural engagement needed	Not assessed
Degarege <i>et al</i> ²⁸ , (2018)	Awareness levels varied by religion and education	Religious beliefs, misinformation, low perceived risk	Community-based interventions to address misconceptions	Identified lack of awareness as a major barrier
Datta <i>et al</i> ²⁹ , (2012)	The study focuses on HPV prevalence (PCR: 7%, HC2: 8.4%)	Not assessed	HPV vaccination recommended for high-risk groups	HPV16 had the highest prevalence; persistent infections were common
Degarege <i>et al</i> ³⁰ , (2020)	Parental education increased vaccination rates	Misinformation, cost concerns, access issues	Health education and government policies to improve access	Full childhood vaccination rate was 52.2%
Ray <i>et al</i> ³¹ , (2024)	79% willing to vaccinate daughters, but low willingness to pay	Cost of the vaccine	Subsidies and government programs recommended	HPV vaccine price reduction could improve uptake
Joshi <i>et al</i> ³² , (2018)	Pre-education awareness: 20.63%; improved post-education	High cost, lack of knowledge, misinformation	Education significantly improved awareness but did not fully change vaccine hesitancy	40.11% refused vaccination, 32.17% undecided
Jacob <i>et al</i> ³³ , (2021)	HPV vaccination prevalence increased from 4.4% to 7.1% after education	17.8% believed vaccination was unnecessary, 10.42% concerned about safety, 4.46% socioeconomic barriers	School-based education programs improved awareness & willingness	Education led to statistically significant improvement in knowledge
Raychaudhuri <i>et al</i> ³⁴ , (2012)	Awareness: 3.6%-14.5% on various aspects of HPV & cervical cancer	Low education, rural disparities, cultural stigma	Large-scale awareness programs needed in rural areas	Higher prevalence of risk factors in rural women
Holroyd <i>et al</i> ³⁵ , (2022)	Awareness was low; many parents unaware of HPV vaccine	School-based delivery excluded out-of-school girls	Community-based & flexible vaccine delivery recommended	Targeted vaccine programs needed for at-risk populations
Degarege <i>et al</i> ³⁶ , (2019)	78% of parents intended to vaccinate daughters	Negative parental beliefs, misinformation	Countering negative beliefs through education and awareness programs	Parental attitudes were key predictors of vaccine acceptance

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Krupp <i>et al</i> ³⁷ (2013)	72% of parents willing to vaccinate their daughters	- Vaccine safety concerns (OR: 0.64) - Side effects (OR: 0.65) - Fear of encouraging sexual activity (OR: 0.71)	- Doctor's recommendation increased uptake (OR: 5.04) - Spousal approval (OR: 5.01) was influential	Study estimated widespread vaccination could reduce cervical cancer incidence by two-thirds
Apurva <i>et al</i> ³⁸ (2024)	Baseline awareness was only 2.5%, but increased by 94% after an educational intervention	- Lack of awareness about HPV - No prior knowledge of the vaccine	- Health education improved knowledge & vaccine-seeking behavior (by 17.5%)	Study suggests health education could increase vaccine uptake significantly
Swain <i>et al</i> ³⁹ (2018)	86% of participants agreed to vaccination, and 58.3% received the HPV vaccine	- Limited access to vaccination centers - Misconceptions about HPV & cervical cancer	- Educational intervention improved willingness to vaccinate	Results indicate educational programs can enhance HPV vaccine acceptance
Jacob <i>et al</i> ⁴⁰ (2010)	Parents, policymakers, & adolescents support vaccination if affordable & accessible	- High cost of HPV vaccines - Lack of integration into routine immunisation programmes	- Merging HPV vaccination with routine adolescent health services is recommended	Study suggests that policy-level integration can improve vaccine access
Divakar ⁴¹ (2012)	Low awareness among both students & urban women	- Lack of knowledge about cervical cancer & HPV	- Parental education improved vaccine acceptability	Study found better-educated parents are more likely to vaccinate their daughters
Paul <i>et al</i> ⁴² (2014)	Parents had positive attitudes toward HPV vaccination despite limited knowledge	- Concerns about side effects, vaccine cost, & missing work to vaccinate daughters	- Healthcare provider recommendations played a crucial role in acceptance	Study suggests reducing cost & misinformation would improve uptake
Dhinu K <i>et al</i> ⁴³ (2024)	Acceptance increased from 61.4% to 88.6% after education	- Concerns about vaccine safety & perceived barriers	- Awareness campaigns significantly improved perceived benefits of vaccination	Study found education & re-enforcement could increase vaccine coverage
Budukh <i>et al</i> ⁴⁴ (2018)	No HPV vaccine uptake reported	- Poor menstrual hygiene practices may contribute to non-sexual HPV transmission	- Better menstrual hygiene education recommended	HPV prevalence among adolescent girls was 10.7%
Ahlawat <i>et al</i> ⁴⁵ (2018)	61% of mothers & 52% of daughters had heard of cervical cancer	- Limited awareness of HPV & cervical cancer risk factors	- Higher maternal education improved vaccine awareness among daughters	Mothers' education plays a key role in shaping HPV vaccine awareness
Madhivanan <i>et al</i> ⁴⁶ , (2009)	Low awareness; most parents preferred vaccination at later ages	Concerns about safety and necessity	Trusted sources should promote HPV vaccination	Awareness linked to vaccine acceptance

This supplementary table presents detailed characteristics such as HPV vaccination uptake and awareness, barriers, facilitators, recommendations, prevalence rate, and the impact of vaccination from all included studies