Cost-Effectiveness of Single-Dose HPV Vaccination in Nepal: An Economic Evaluation

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Executive Summary

Nepal's 2025 nationwide single-dose HPV vaccination campaign achieved 93.7% coverage among 1.46 million girls aged 9-14 years, using Cecolin® delivered through schools, outreach clinics, and health facilities. This economic evaluation used lifetime health-system perspective to assess the program's effectiveness. The program was found to be cost-saving, with an ICER of USD - 50.83 per QALY gained, well below Nepal's cost-effectiveness threshold of USD + 489.65. A negative ICER indicates that the intervention improved health outcomes while reducing the long-term healthcare costs. Every USD 2.99 invested per vaccinated girl was associated with approximately USD 40.70 in averted lifetime treatment costs, yielding a net saving of USD 37.71 per girl. These findings support sustained domestic financing and integration of HPV vaccination within broader cervical cancer prevention strategies, and offer an implementation model for other low- and middle-income countries.

1. Background and Policy Context

Cervical cancer remains one of the leading causes of cancer-related mortality among women in Nepal. According to GLOBOCAN/Cancer Today (2025) estimates, Nepal experiences approximately 14.2 cervical cancer cases and 8.7 deaths per 100,000 women annually. Persistent infection with high-risk HPV types 16 and 18 contributes to over 80% of cases. Rural and underserved women remain disproportionately affected due to low screening uptake, delayed diagnosis, and limited access to treatment services.

In February 2025, Nepal implemented its first nationwide single-dose HPV vaccination campaign using Cecolin®, targeting all girls aged 9 -14 years. Approximately 1.46 million girls were vaccinated, achieving 93.7% coverage through a combined school-based and health facility delivery strategy (Pandav et al., 2025). Cecolin® was made in China and prequalified by World Health Organization (WHO) in 2021.The campaign marks a major milestone toward achieving the WHO cervical cancer elimination targets.

2. Economic Evaluation Framework

This study evaluated the cost-effectiveness of Nepal's nationwide HPV vaccination campaign using a static cohort model from a health system perspective over a lifetime horizon. Costs and health outcomes were discounted at 3% annually in line with standard economic evaluation guidance. All costs are expressed in 2025 US dollars, converted at an exchange rate of 1 USD = 134 Nepalese Rupees (2025 average).

The analysis compared single-dose Cecolin® HPV vaccination (intervention) against no HPV vaccination (comparator), reflecting Nepal's pre-February 2025 status quo, when no national HPV vaccination program existed and adolescent girls remained unprotected against HPV-16 and HPV-18. The evaluation adopted a health system perspective, with health outcomes measured in quality-adjusted life years (QALYs). Value for money was assessed against Nepal's cost-effectiveness threshold of USD 489.65 per QALY gained, equivalent to 0.35 × GDP per capita (Pichon-Riviere et al., 2023). All calculations were performed in Microsoft Excel®, version 16.107.4.

Key Model Inputs

Table 1: Key model inputs and data sources

Parameter	Value	Source
HPV vaccine efficacy against high-grade lesions	87.5% (95% CI: 6.4 - 99.7)	(Zhao et al., 2025) - Phase III Cecolin® trial
Vaccination coverage	93.7%	(Pandav et al., 2025); National campaign data
Discount rate	3% annually	Drummond et al., 2015
Cervical cancer incidence	14.2 per 100,000	(GLOBOCAN, 2022) / Cancer Today, 2025
Cervical cancer mortality	8.7 per 100,000	(GLOBOCAN, 2022) / Cancer Today, 2025
Mean age at diagnosis	51 years	(Ojha et al., 2021)
Average case duration	5 years	(Narasimhamurthy & Kafle, 2022)
Remaining life expectancy (age 54–58)	25.53 years	(National Statistics Office, 2023)
Cost per dose of vaccine	USD 2.90	Health Management Information System (HMIS), 2025
Official vaccine wastage rate	0.054 %	HMIS, 2025
Currency conversion	1 USD = 134 NPR	2025 average

Health-Related Quality of Life (Utility) Weights

Utility weights were sourced from published Indian data as a proxy for Nepal, following consultation with officials from Nepal's Department of Health Services and consistent with the approaches used in comparable Low and Middle Income Countries (LMICs) evaluations. The table below reports all utility values used in the model.

Table 2: Health-related quality of life parameters

Health State / Parameter	Value	Source
General population utility - women aged 40–49	0.831	(Jyani et al., 2023))(EQ-5D-5L norms, India)
General population utility - women aged 50–59	0.766	(Jyani et al., 2023) (EQ-5D-5L norms, India)
Blended population utility used in model aged 40-59 (average)	0.792	Derived from (Jyani et al., 2023)
Cervical cancer-specific utility (with active disease)	0.671	(Jyani et al., 2020), (Indian cervical cancer patients)
Utility decrement per year living with cervical cancer	0.121	Difference: 0.792 − 0.671
Composite disability weight for cervical cancer	0.344	GBD 2013 (Salomon et al., 2015); stage distribution from Ojha et al., 2021 (34.5% early, 65.5% late-stage)

Note: *The composite disability weight of 0.344 reflects Nepal's observed stage distribution at diagnosis - 34.5% early-stage and 65.5% late-stage - which is a Nepal-specific input and meaningfully influences morbidity QALY estimates.*

The model incorporated vaccine efficacy (87.5%), coverage (93.7%), and a 3% annual discount rate over the 39.5-year interval between mean vaccination age and expected diagnosis. Using these inputs, it estimated discounted lifetime cervical cancer risk rather than directly subtracting efficacy from crude incidence. This yielded 1.77 cases per 100,000 vaccinated females compared with 14.20 without vaccination.

QALY losses were estimated from two components. Morbidity losses were calculated as the utility decrement of 0.121 per year multiplied by the discounted disease duration of 4.58 years, resulting in 0.55 QALYs lost per case. Mortality losses were calculated by multiplying the discounted remaining life expectancy at the mean age of death by cervical cancer utility weight of 0.671, yielding 11.85 QALYs lost per death. Combined morbidity and mortality losses amounted to 12.40 QALYs per case, producing 31.72 QALYs lost per 100,000 females in the vaccination scenario after applying efficacy and coverage adjustments.

Cost Derivation:

These health gains were translated into the substantial cost savings because vaccination delivery costs were far lower than the averted treatment expenditures - a finding rooted in the cost inputs detailed below. Treatment costs were derived from Khanal et al. (2025), the only published Nepal-specific study on the financial burden of cervical cancer. The study estimated an average total cost of USD 3,276 per cervical cancer patient per year, comprising direct medical, direct non-medical and indirect costs.

Table 3: Cervical cancer treatment cost components

Cost Component	USD per Patient per Year	Source
Direct medical costs (consultations, diagnostics, medicines, procedures)	USD 1,567	Khanal et al., 2025
Direct non-medical costs (transport, accommodation, caregiving)	USD 555	Khanal et al., 2025
Indirect costs (productivity losses from illness and premature death)	USD 1,154	Khanal et al., 2025
Total annual treatment cost per patient	USD 3,276	

3. Key Findings

Table 4: Health and economic outcomes: vaccination vs. no vaccination

Outcome	No Vaccination	HPV Vaccination
Cervical cancer cases per 100,000	14.20	1.77
Deaths per 100,000	8.70	1.08
QALYs lost per 100,000	176.13	31.72
QALYs gained per 100,000	-	144.41
Vaccination cost (USD per girl)	USD 0.00	USD 2.99
Lifetime treatment cost (USD per girl)	USD 46.50	USD 5.80
Net lifetime cost (USD per girl)	USD 46.50	USD 8.79
ICER (USD per QALY gained)	-	USD - 50.83

For every vaccinated girl, the program reduced lifetime cervical cancer treatment costs by approximately USD 40.70 while requiring only USD 2.99 in vaccination-related expenditures. This generated an estimated net saving of USD 37.71 per vaccinated girl.

Using Nepal's cervical cancer incidence of 14.2 cases per 100,000 females and the annual treatment cost of USD 3,276 per patient, the model estimated a population-level treatment cost of USD 46,519 per 100,000 unvaccinated females annually. After discounting over the 39.5-year gap between vaccination and expected diagnosis, lifetime treatment costs reached a present value of USD 956,238 per 100,000 females without vaccination versus USD 172,242 with vaccination – supporting the cost-saving conclusion.

Program delivery costs were modest. The total economic program cost of USD 4,356,102 (~USD 4.36 million) comprised vaccine procurement and operational expenditures, illustrated as follows:

Table 5: Program delivery cost breakdown

Cost Component	Value	Notes
Unit price per vaccine dose (Cecolin®)	USD 2.90	Gavi Secretariat & Partners, 2022
Total doses used (accounting for 0.054% wastage)	1,462,444 doses	DHS/IHMIS, Nepal
Total vaccine procurement cost	USD 4,241,087	Unit price × doses used
Total operational cost (personnel, logistics, training, cold-chain, supervision)	USD 115,015	DHS, Government of Nepal
Total program cost	USD 4,356,102	Procurement + operational
Unit cost per vaccinated girl	USD 2.99	Total cost ÷ 1,461,654 girls

Operational costs were estimated using a standardized immunization delivery costing approach consistent with WHO guidance (Levin et al., 2022), capturing personnel time, training, logistics, supervision, and cold-chain management. The delivery cost of USD 2.99 per girl reflects high session turnout, efficient use of existing health infrastructure, and economies of scale from nationwide

implementation. It is consistent with the lower range of HPV delivery costs reported in recent LMIC systematic reviews (USD 1.48 - USD 48.70; Slavkovsky et al., 2024).

4. Policy Implications

The findings provide strong evidence supporting continued domestic financing of HPV vaccination within Nepal's national immunization program. The combination of high coverage, low delivery cost, and substantial long-term health gains demonstrates that cervical cancer prevention is achievable and affordable in low- and middle-income settings.

Priority policy actions include:

- Sustaining domestic co-financing of HPV vaccination to maintain program coverage and continuity.
- Integrating HPV vaccination with cervical cancer screening and treatment services.
- Expanding catch-up vaccination strategies for unvaccinated cohorts.
- Strengthening school-based and community-based delivery systems in rural and underserved areas.
- Reinvesting program efficiency gains into women's health services.
- Strengthening national cancer surveillance and health information systems.
- Conducting probabilistic sensitivity analysis and long-term effectiveness surveillance as the program matures.

Nepal's HPV vaccination program demonstrates that large-scale cancer prevention can be both economically efficient and operationally feasible in resource-constrained settings. The combination of high coverage, low delivery cost, and substantial lifetime health gains supports continued domestic investment and provides an implementation model for other LMICs pursuing WHO cervical cancer elimination targets.

5. Limitations

This analysis has several limitations, which are acknowledged below:

- Utility weights and some epidemiological parameters were sourced from India as a validated proxy due to limited Nepal-specific data. While epidemiologically relevant, residual uncertainty remains regarding transferability to the Nepali context.
- The model assumes all cervical cancer cases occur at the mean age of diagnosis (51 years), simplifying age-specific incidence patterns.
- Although indirect costs from the published Nepal-specific treatment study (Khanal et al., 2025) were incorporated within treatment cost estimates, the analysis did not adopt a full societal perspective and therefore may underestimate broader household and productivity impacts beyond those captured in treatment expenditures.
- The model assumes 100% of cervical cancer cases would be treated in public tertiary hospital, which likely overestimate averted treatment costs.
- Probabilistic sensitivity analysis was not conducted; this would better characterize uncertainty around the ICER estimate. Deterministic sensitivity analysis confirms the cost-saving conclusion remains robust under higher wastage, lower efficacy, and higher discount rate scenarios.
- Vaccine efficacy inputs were derived from clinical trial and modelling evidence rather than Nepal-specific effectiveness data. Continued surveillance will be important to validate these assumptions as the program matures.

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