

# Cost analysis of the school-based human papillomavirus vaccination programme in Tshwane Health District, South Africa

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**Background.** Cervical cancer is a significant public health concern globally. Persistent infection with high-risk human papillomavirus (HPV) types is the necessary cause of virtually all cervical cancers, although rare HPV-negative cervical cancer cases have been reported. HPV is one of the most common sexually transmitted infections worldwide and is responsible for approximately 90% of all cervical cancer cases globally.

**Objectives.** To estimate the financial costs and cost per fully vaccinated girl (FVG) of the school-based HPV vaccination programme in Tshwane Health District, South Africa.

**Methods.** We conducted a cross-sectional cost analysis of the 2019 vaccination campaign using the World Health Organization Cancer Prevention and Control Costing (C4P) tool. The data for the programme were obtained from the District Health Information System and financial records. Costs were categorised by component and converted to USD.

**Results.** The programme reached 15 734 girls with two doses (71.3% uptake). The total financial cost was ZAR21 127 298 (USD1 458 704). Service delivery (71.8%) and vaccine procurement (27.1%) were the main cost drivers. The cost per FVG was ZAR1 343 (USD92.94).

**Conclusion.** The Tshwane school-based HPV vaccination programme had a high financial cost per FVG compared with other low- and middle-income countries, largely owing to staffing and procurement costs. Optimising delivery strategies can improve cost-efficiency and sustainability.

**Keywords.** HPV, vaccination programme, HPV cost analysis, vaccine uptake, vaccine coverage

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Cervical cancer is a significant public health concern globally. Persistent infection with high-risk human papillomavirus (HPV) types is the necessary cause of most cervical cancers, although rare HPV-negative cases have been reported.<sup>[1]</sup> HPV is the most common sexually transmitted infection worldwide and is responsible for approximately 90% of cervical cancer cases.<sup>[2]</sup> Although over 100 HPV serotypes exist, types 16 and 18 account for over 70% of cervical cancers globally.<sup>[3,4]</sup> The disease burden is disproportionately high in low- to middle-income countries (LMICs), where over 88% of cervical cancer deaths occur.<sup>[5,6]</sup>

In sub-Saharan Africa, cervical cancer incidence and mortality are among the highest globally.<sup>[5]</sup> The risk is further compounded by the HIV epidemic, with HIV-infected women having an up to six times increased risk of co-infection with HPV.<sup>[7-9]</sup> In South Africa (SA), cervical cancer is the leading cause of cancer-related deaths

among women, with an estimated 13 000 new cases and 5 600 deaths annually.<sup>[10]</sup>

Vaccination against HPV has emerged as a highly effective preventive strategy. Since their licensure in 2006, vaccines such as Cervarix, Gardasil and Gardasil 9 have demonstrated excellent safety and efficacy profiles in both clinical trials and post-marketing surveillance.<sup>[11,12]</sup> In high-income countries, HPV vaccination has led to substantial reductions in HPV infection and precancerous lesions among adolescents, with evidence of herd immunity effects.<sup>[13-15]</sup>

Despite the proven effectiveness of the HPV vaccine, implementation of vaccination programmes in LMICs faces numerous challenges, particularly related to financial and operational sustainability.<sup>[16]</sup> The cost of HPV vaccines remains a key barrier to widespread introduction and scale-up, especially in countries that are not eligible for subsidies from Gavi, the

Vaccine Alliance. The average market price of an HPV vaccine dose in non-Gavi countries is approximately USD25, compared with USD4.50 in Gavi-supported settings.<sup>[17,18]</sup>

Moreover, the delivery strategy significantly influences programme costs. School-based vaccination, although effective in reaching the target population, often incurs higher operational costs than facility-based strategies owing to transportation, staffing and outreach requirements.<sup>[19]</sup> For example, studies from Mozambique and Zimbabwe estimated financial costs per fully vaccinated girl (FVG) at USD17.59 and USD15.70, respectively.<sup>[20,21]</sup> By contrast, school-based delivery relies on professional nurses, increasing service delivery costs, largely owing to staffing and travel requirements. The cost structure of HPV vaccination programmes includes both direct financial costs (such as vaccine procurement, service delivery and training) and broader economic costs (such as time lost by health workers and caregivers). However, many LMICs conduct financial costing to inform short-term budgeting and planning. Understanding the cost drivers of programme implementation is critical for policymakers to optimise delivery models and achieve sustainable coverage.

This study aimed to estimate the financial costs of delivering the school-based HPV vaccination programme in Tshwane Health District, SA. By identifying the primary cost components and calculating the cost per FVG, the findings can inform future strategies for scale-up, cost reduction, and integration into national immunisation schedules.

## Methods

### Study design and setting

This cross-sectional cost analysis was conducted in Tshwane Health District, Gauteng Province, SA. The school-based HPV vaccination programme targets Grade 4 girls aged 9 - 14 years enrolled in public schools. In 2019, 360 public schools participated in the programme. The analysis focused on the financial cost of delivering the two-dose HPV vaccine to eligible girls over 1 calendar year (1 January - 31 December 2019), using a provider (health system) perspective.

The cost analysis was selected because it provides essential information for short-term programme budgeting and resource allocation within the district health system. Unlike broader economic costing or cost-effectiveness evaluations, financial costing focuses on actual expenditures incurred by the health system and is particularly useful for programme managers and policymakers in LMICs where funding constraints and sustainability are major concerns.

### Data collection and costing approach

Programme data were obtained from the District Health Information System, routine monitoring databases, and financial records from Tshwane Health District, Gauteng Province, SA. Extracted variables included the number of eligible girls, doses administered, and detailed expenditure on logistics, personnel, training, and communication activities.

The World Health Organization's Cancer Prevention and Control Costing (C4P) tool was used to estimate programme costs. This

Excel-based tool enables the estimation of incremental costs associated with HPV vaccine introduction in LMICs. Only financial costs were considered, excluding opportunity costs or broader economic inputs.

### Cost categories and calculations

Cost categories were vaccine and injection supplies, cold-chain expansion, microplanning, training, sensitisation, social mobilisation, service delivery, and supervision. Costs were captured in ZAR and converted to USD using the 2019 World Bank exchange rate of ZAR14.5 per USD. The cost per FVG was calculated by dividing total programme costs by the number of girls who received two vaccine doses.

### Ethical considerations

Ethics approval was obtained from the South African Medical Research Council Human Research Ethics Committee (ref. no. EC011-5/2020). Permission to access data was granted by the Gauteng Department of Health. Individual-level data were anonymised prior to analysis.

## Results

### Programme coverage

In 2019, the programme targeted 22 057 grade 4 girls. Of these, 16 122 (73.1%) received the first dose of vaccine and 15 734 (71.3%) received both doses, excluding catch-up vaccinations. The average vaccine uptake rate across participating schools was 72%. Programme coverage and total costs are summarised in Table 1.

### Total programme costs

The total financial cost of the HPV vaccination programme was ZAR21 127 298 (USD1 458 704). Service delivery accounted for the majority of expenditure (71.8%), followed by vaccine and injection supply costs (27.1%).

### Cost per FVG

The estimated cost per FVG, including vaccine and injection supplies, was ZAR1 343 (USD92.94). Excluding the cost of vaccine and supplies, the delivery cost per FVG was ZAR979 (USD67.78). The cost per FVG is shown in Table 2.

### Sensitivity analysis

The base case cost per FVG was estimated at USD92.94. When varying the vaccine cost between USD20 and USD30 and the service delivery cost between USD55 and USD80, the total cost per FVG ranged from USD80.00 to USD110.00. The results of the sensitivity analysis are presented in Fig. 1.

## Discussion

This study sought to present a detailed cost analysis of a school-based HPV vaccination programme in Tshwane District, SA. With a vaccine uptake rate of 71.3%, the programme was moderately successful in reaching its target population. However, the estimated financial cost per FVG (USD92.94) was considerably higher than costs reported from comparable LMIC settings such as Mozambique (USD17.59) and Zimbabwe (USD15.70).<sup>[20,21]</sup>

**Table 1. Financial costs of the HPV vaccination programme, Tshwane District, 2019**

| Cost component                 | Cost (ZAR) | Cost (USD) | Proportion of total cost (%) |
|--------------------------------|------------|------------|------------------------------|
| Vaccine and injection supplies | 5 720 490  | 394 172    | 27.1                         |
| Service delivery               | 15 179 384 | 1 046 844  | 71.8                         |
| Training                       | 72 250     | 4 983      | 0.34                         |
| Social mobilisation            | 80 000     | 5 517      | 0.38                         |
| Sensitisation                  | 31 200     | 2 155      | 0.15                         |
| Supervision                    | 30 900     | 2 131      | 0.15                         |
| Cold chain (annualised)        | 5 954      | 411        | 0.03                         |
| Microplanning                  | 7 120      | 491        | 0.03                         |

HPV = human papillomavirus.

**Table 2. Cost per fully vaccinated girl**

| Cost item                 | Cost (ZAR) | Cost (USD) |
|---------------------------|------------|------------|
| Total cost with vaccines  | 1 343      | 92.94      |
| Cost excluding vaccines   | 979        | 67.78      |
| Vaccine and supplies only | 364        | 25.16      |

The primary cost driver was service delivery, which accounted for 71.8% of total costs. This figure is consistent with findings from other studies that report increased operational costs associated with school-based strategies, especially where professional nurses are used for vaccine administration. In contrast, programmes using lay workers or community outreach teams often report lower service delivery costs.<sup>[22]</sup>

Vaccine procurement ranked as the second-highest cost factor. Since SA does not receive Gavi support and incurs greater per-dose expenses compared with countries with subsidies, this highlights the importance of global procurement strategies, such as pooled purchasing and domestic production, to lower costs in the long term.<sup>[17,23]</sup>

The findings also highlight that schools' geographical dispersion and small target populations may have increased travel and co-ordination costs. Strategies such as task shifting to enrolled nurse assistants, decentralising operations to sub-district level, or integrating HPV vaccination with broader school health initiatives may improve efficiency.

### Policy implications

To ensure financial sustainability, HPV vaccination programmes in middle-income countries must address service delivery inefficiencies. Greater use of non-professional cadres, improved microplanning, and community engagement can help reduce costs and improve uptake. Local economic evaluations such as this one are vital for informing resource allocation and advocating for cost-effective strategies in national immunisation schedules.

### Study limitations

This was a retrospective financial cost analysis limited to one calendar year and geographical setting. It did not include economic costs, such as the value of existing infrastructure, or opportunity costs. Additionally, uptake barriers were not explored in detail, limiting understanding of non-financial determinants of coverage. Furthermore, this analysis did not account for non-financial barriers such as parental consent processes, vaccine hesitancy or logistical challenges, which may have influenced coverage rates and programme efficiency. Finally, the findings may have limited generalisability beyond Tshwane, as health system structures, cost drivers and school-based delivery models vary across districts and provinces in SA.

### Conclusion

The school-based HPV vaccination programme in Tshwane achieved moderate coverage at relatively high financial cost. Service delivery

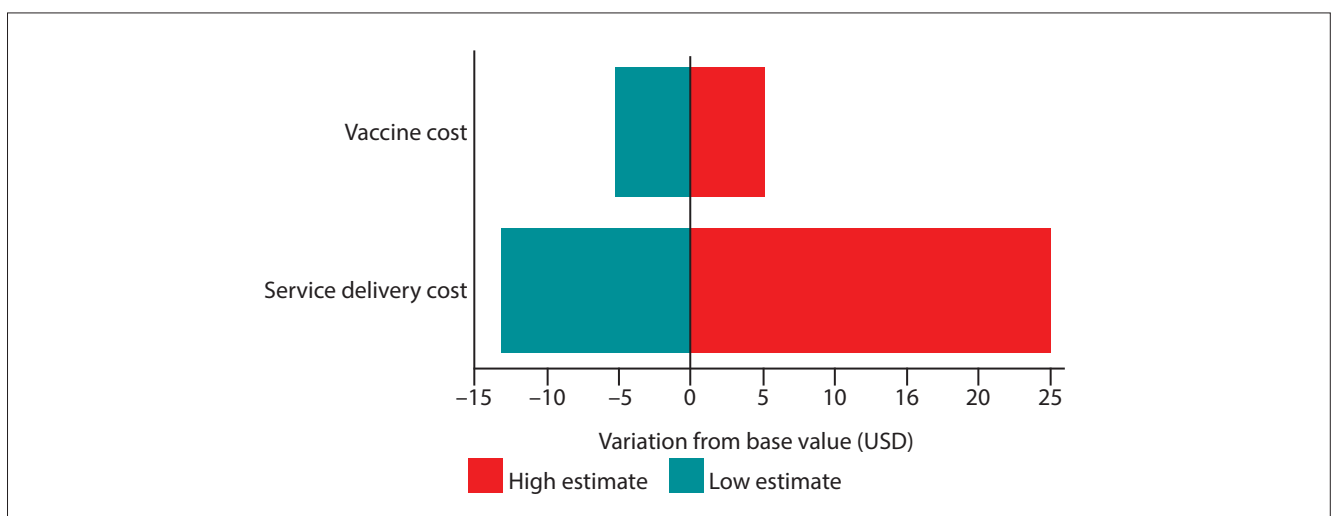


Fig. 1. Sensitivity analysis: variation in cost per fully vaccinated girl (USD).

and vaccine procurement were the largest contributors to cost per FVG. These findings support the need for strategic adjustments to improve the cost-efficiency of HPV vaccine delivery in Tshwane and similar settings.

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**Author contributions.** TDL conceived and designed the study, curated and analysed the data, and prepared the original draft of the manuscript. NRL contributed to data curation and analysis and assisted with reviewing and editing the manuscript. MM provided methodological input, supervised the study, and contributed to reviewing and editing the manuscript.

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**Data availability statement.** The data generated and analysed during the present study are available from the corresponding author upon reasonable request.

**Conflicts of interest.** None.

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