Cost-Effectiveness of Women's Vaccination Against HPV: Results for Czech Republic[1]

*Martina LUŠKOVÁ – Kseniya BORTNIKOVA**

Abstract

This paper assesses the cost-effectiveness of HPV vaccination in the Czech Republic, focusing on cervical cancer prevention. It compares the cost-effectiveness of existing reimbursement policies with proposed changes. A homogeneous multi-state Markov model, based on public health insurance data, simulates disease progression. Our findings show that increasing immunization coverage from 65.8% to 80% is cost-effective, meeting the 1.2 million CZK per quality-adjusted life year threshold. Extending vaccination eligibility from age 13 only to 13 – 15 years old, while boosting coverage, also proves cost-effective. These results support the economic viability of the proposed policy enhancements for increasing HPV vaccination among women.

Keywords: *cost-effectiveness, Markov model, HPV, vaccination, cervical carcinoma, Czech Republic*

JEL Classification: I11, I13, I18, C61

DOI: https://doi.org/10.31577/ekoncas.2026.05-06.02

Article History: *Received*: November 2025 *Accepted*: July 2026

Introduction

Cervical carcinoma is among the most diagnosed cancer diseases in women worldwide (Ferlay et al., 2021). In the Czech Republic, approximately 800 women are diagnosed, and about 300 die from it annually (Hejduk et al., 2018). Most cervical cancers are attributed to Human Papillomavirus (HPV) (Mohan, 2018;

* Martina LUŠKOVÁ – Kseniya BORTNIKOVA, Institute of Economic Studies, Faculty of Social Sciences, Charles University, Opletalova 26, 110 00 Prague, Czech Republic; e-mail: martina.luskova@fsv.cuni.cz, ORCID: 0009-0004-0603-5455; e-mail: kseniya.bornikova.cuni.cz, ORCID: 0000-0002-3639-7551

[1] Martina Lušková acknowledges funding from the Charles University Grant Agency (grant No. 136724).

Serrano et al., 2015). Epidemiological data from the Global Cancer Observatory show that vaccination against HPV types linked to cervical cancer reduces its incidence and mortality (Ferlay et al., 2021; Majek et al., 2021b). According to Act No. 48/1997 Coll., on Public Health Insurance, the costs of voluntary HPV vaccination for 13-year-olds are fully reimbursed for both girls and boys. However, immunization coverage in the Czech Republic is only 65.8%, indicating many eligible individuals remain unvaccinated despite reimbursement (Hejduk et al., 2018). The average cost of treating female genital cancer is approximately 30,000 CZK per patient per year (VZP, 2020).

This study evaluates the cost-effectiveness of vaccinating women against HPV in the Czech Republic. It compares the cost-effectiveness of the current reimbursement policy for HPV vaccination to a proposed policy change. Two strategies are suggested to enhance vaccination coverage: the first involves increasing vaccination coverage through a promotional campaign under the 2021 reimbursement conditions, and the second extends reimbursement for vaccination to the age group of 13 to 15-year-old females, aiming to boost vaccination coverage. To analyze these strategies, we developed a multi-state Markov model that simulates transitions over time among states that represent the progression of the disease. The outcomes from this model are used to calculate the incremental cost-effectiveness ratio (ICER), evaluating the cost-effectiveness of each intervention relative to the existing policy. Given that both assessed strategies demonstrate cost-effectiveness within the established threshold of 1.2 million CZK per quality-adjusted life year (QALY), this study contributes valuable insights to the body of literature on HPV vaccination programs, with a specific focus on the Czech Republic.

Our analysis utilizes data collected before the most recent policy amendments. As such, it offers insights into the cost-effectiveness landscape under the previous vaccination reimbursement scheme. Until January 1, 2024, HPV vaccination coverage in the Czech Republic was restricted to individuals aged 13; however, a notable policy adjustment has since expanded this coverage to include those aged 11 to 15. This significant change in vaccination policy is indicative of evolving strategies designed to improve public health outcomes. Crucially, the extended age range for vaccination is consistent with the policy modifications suggested by our findings, demonstrating the strategic alignment of our analysis with public health objectives. These insights are vital for comprehending the effectiveness of vaccination strategies and could be invaluable for countries with similar vaccination frameworks and disease profiles.

This paper contributes to the literature in three main respects. First, it provides a cost-effectiveness analysis of HPV vaccination strategies in the Czech Republic, where evidence on the economic evaluation of vaccination policies remains limited,

and relies on Czech-grounded transition data to calibrate transition probabilities. Second, our analysis uses empirical evidence on HPV vaccination interventions to relate changes in coverage to campaign costs and to derive realistic cost scenarios. Third, it evaluates these strategies under a range of assumptions and provides evidence relevant for policy discussions on vaccination coverage and reimbursement design.

The paper is structured as follows. Section 1 covers HPV vaccination, including the current state of vaccination in the Czech Republic, the vaccination status in other countries, and a literature review of conducted cost-effectiveness analyses of HPV. Section 2 outlines the methodology of Markov chains used in the survival analysis and introduces the approach for assessing cost-effectiveness. In Section 3, we present the input data. Section 4 presents the modelling process, proposed strategies, and results. Finally, Last section summarizes the study.

1. Literature Review

Vaccination against human papillomavirus has been a pivotal prevention program over the past decade (Albright and Ondrus, 2021a). Complete vaccination prevents both cancers and pre-cancerous changes. The vaccines, containing non-infectious viral proteins, stimulate the immune system to produce antibodies. Consequently, if exposed to the virus later, the immune system is better equipped to suppress the infection. Greatest efficacy is achieved by vaccinating both girls and boys before sexual activity begins, reducing the likelihood of HPV exposure. However, vaccination after sexual activity still lowers the risk of developing HPV-related conditions (Markowitz, 2007; Majek et al., 2021a,b).

In the Czech Republic, a comprehensive vaccination program against HPV has been in place. Since April 1, 2012, health insurance companies cover the cost of voluntary vaccination for girls beginning at the age of 13. The reimbursement applies from the time a girl turns 13 until she reaches 14. An amendment in Act no. 290/2017, effective August 2017, expanded coverage to include boys, funded by public health insurance (Hejduk et al., 2018). In 2017, the immunization coverage rate (the ratio of vaccinated female patients to the total population eligible) for those initiating vaccination at 13 was 65.8% across the Czech Republic, varying by region from 51.5% to 82.7%. These percentages reflect only those women who met the age criteria for vaccination reimbursement under public health insurance (Hejduk et al., 2018). For comparison, uptake among boys in the Czech Republic was negligible in the 2016 – 2017 cohorts (36 vaccinated 13-year-old boys in 2016 and 27 in 2017, compared to more than 30,000 girls per year). This

indicates that reimbursed vaccination for boys became effective only in 2018, and we use the female coverage rate for modelling, as our analysis focuses on women.

Three medical products were used for HPV vaccination in 2021, with their protective scope based on the number of HPV types they protect against (Albright and Ondrus, 2021b). Table 1 provides an overview of the vaccines available in 2021. The maximum reimbursement from public health insurance covers the cost of the least expensive medical product. The prices and surcharges in Table 1 correspond to one dose of the vaccine only. The required number of doses for full immunization varies with the age at which vaccination commences. CERVARIX may be administered in two doses if the first dose is given between the ages of 9 and 14. For those first vaccinated at the age of 15 or older, a three-dose schedule is necessary (State Institute for Drug Control (SUKL), 2021).

T a b l e 1

Overview of Vaccines Available in the Czech Republic

Vaccine	HPV types protection	Selling price (CZK)	Reimbursement (CZK)	Patient surcharge (CZK)
CERVARIX	16, 18	1,765.79	1,765.79	0.00
GARDASIL	6, 11, 16, 18	3,138.54	1,765.79	1,372.75
GARDASIL 9	6, 11, 16, 18, 31, 33, 45, 52, 58	4,032.63	1,765.79	2,266.84

Note: The table provides details on available vaccines in the Czech Republic, including characteristics, prices, and reimbursement. HPV = human papillomavirus.

Source: SUKL (2021).

For GARDASIL and GARDASIL 9, a two-dose schedule is sufficient if the first dose is received between 9 and 13 years old. If vaccination starts at 14 or later, three doses are required (State Institute for Drug Control (SUKL), 2021).

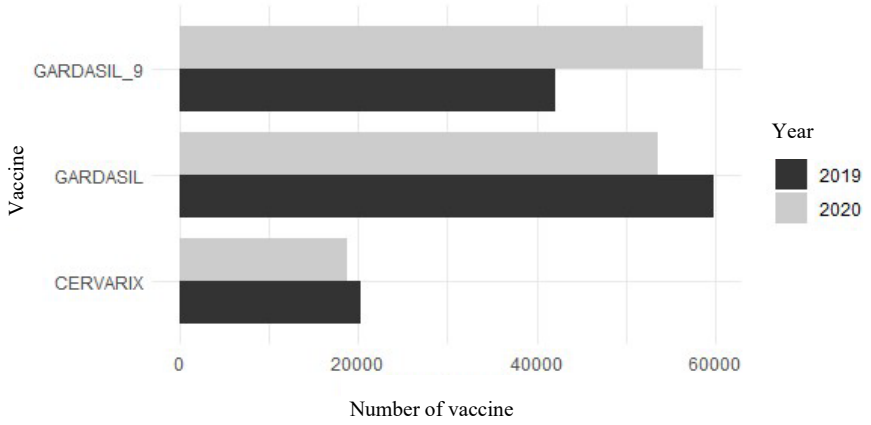
Patients in the Czech Republic can choose their vaccine type. The State Institute for Drug Control (SUKL) publishes summary information on the availability of medicinal products, based on monthly reports from authorized distributors in Czechia as stipulated by Article 23 of the Act on Medicinal Products.

Figure 1 shows the distribution of HPV vaccines provided to medical doctors and pharmacies, which are the primary avenues through which patients access these vaccines. Data on supplies to distribution centers are excluded. In 2019, GARDASIL was the most chosen vaccine; however, GARDASIL 9 became the most supplied in 2020. In both years, the fully reimbursed vaccine, CERVARIX, accounted for approximately 15% of the total (SUKL, 2020a; 2021a).

Additionally, nearly all health insurance funds in the Czech Republic offer supplementary vaccination programs and financial contributions to support their patients (Table 2).

F i g u r e 1

The Number of Vaccines Supplied to Medical Doctors and Pharmacies



Note: The figure shows the number of vaccines supplied to medical doctors and pharmacies in the years 2019 and 2020. The supplied medical products are used to vaccinate both female and male patients.

Source: State Institute for Drug Control (SUKL, 2019; 2020a).

T a b l e 2

HPV Vaccination Programs and Financial Contributions Insurance Funds

Insurance fund	**Financial contribution [CZK]**	
	Children	*Adults*
Ministry of the Interior Health Insurance Fund (ZPMV) (2021)	1500	1000
Coalfield Brotherhood Cash Office, a health insurance company (RBP) (2021)	4000	4000
Czech Industry Health Insurance Fund (CPZP) (2021)	1500	1000
Occupational Health Insurance Company for Employees of the Banking, Insurance and Building Industry (OZP) (2021)	1000	1000
Skoda Employees Health Insurance Fund (ZPS) (2021)	4000	800
General Health Insurance Company of the Czech Republic (VZP) (2021)	–	–
Military Health Insurance Company of the Czech Republic (VoZP) (2021)	–	–

Note: The table presents HPV vaccination programs and the maximum financial contributions from Czech insurance funds in 2021.

Source: ZPMV (2021); RBP (2021); CPZP (2021); OZP (2021); ZPS (2021); VZP (2021); VoZP (2021).

HPV vaccination programs are widely implemented across the European Union and the European Economic Area, but vary considerably in their design, including target age groups, gender neutrality, catch-up policies, and funding arrangements, as documented by the European Centre for Disease Prevention and Control (2021). In the international context, we discuss vaccination plans (including catch-up programs) in three European countries (Austria, Germany, and Latvia), for which sufficiently detailed and comparable program information was publicly available during the period relevant to the analysis. These countries illustrate both similarities with the Czech setting (Austria and Germany, as neighboring EU countries

with comparable health-system structures) and differences in program design and epidemiological burden (Latvia, which has implemented a compulsory program for females and reports relatively high cervical cancer incidence).

More specifically, in Austria, non-mandatory vaccination is offered to both girls and boys aged 10 to 12, with a catch-up program for ages 13 to 30, although national health system funding for the vaccination only extends up to the age of 15 (ECDC, 2021). Vaccination coverage rates in Austria are reported at 60% for girls and 40% for boys (Boiron et al., 2016). In 2018, the age-standardized incidence rate of new cervical cancer cases in Austria was 5.5 per 100,000 women, compared to 9.9 in the Czech Republic. Moreover, the cervical cancer mortality rate in Austria was 1.7 deaths per 100,000 women, lower than in the Czech Republic (Bruni et al., 2019), indicating that the number of deaths due to cervical cancer is almost 2.4 times higher in the Czech Republic. Both countries started immunization programs recently: Austria in 2012 and the Czech Republic in 2014. A significant difference between the two countries is the implementation of national screening programs: Austria implemented its screening program in 1974, whereas the Czech Republic did so in 2009 (Duskova et al., 2014; Austrian Institute for Health Technology Assessment, 2018). Germany has a gender-neutral program for ages 9 to 14, with a catch-up program for females up to 17. Estimates from 2018 indicate that the incidence of newly diagnosed cases per 100,000 women stands at 7.5, with the age-standardized mortality rate at 2.2 per 100,000. Vaccination coverage among the youth is reported to be 50%, according to Damm et al. (2017). In contrast, Latvia has implemented a compulsory vaccination program for females at the age of 12 (ECDC, 2021), likely in response to a cervical cancer incidence rate of 25.0 cases per 100,000 women (Bruni et al., 2019). Vaccination strategies and catch-up programs are revised annually, and the true impact of these programs will become clearer once the vaccinated population reaches the age at which cervical carcinoma is typically diagnosed.

In addition to differences in program design across countries, an expanding literature evaluates interventions designed to increase HPV vaccination uptake. This literature provides evidence on how vaccination coverage responds to policy measures and promotional campaigns. Systematic reviews and meta-analyses find that behavioral and organizational interventions (such as reminder systems, provider prompts, education-based programs, and multicomponent outreach activities) can enhance vaccination coverage, although the magnitude of the effect varies substantially across settings and intervention types.

A recent meta-analysis by Rahman et al. (2026) finds that digital and multicomponent interventions increase vaccination uptake, with odds ratios between 1.40 and 2.17 (corresponding to roughly 8 – 19 percentage point increases under

plausible baseline coverage). Evidence from systematic reviews (Mavundza et al., 2021; Akumbom et al., 2022) points to substantial heterogeneity in intervention effects on vaccination uptake: simpler interventions, such as reminders, tend to yield relatively small improvements, whereas more intensive or multicomponent strategies generate larger increases. Studies included in these reviews report increases in vaccination coverage of approximately 11 – 18 percentage points following interventions that combine financial support with provider-focused strategies.

Quasi-experimental and experimental studies based on policy changes, such as Fisher et al. (2020), which examine changes in consent rules in England, find small but meaningful effects, ranging from about 1 – 2 percentage points in individual-level analyses to around 11 percentage points in aggregate difference-in-differences estimates. Hansen et al. (2020) document the decline and recovery of HPV vaccination in Denmark, where uptake fell from approximately 90% to below 40% following negative media coverage and subsequently recovered to pre-crisis levels during a national information campaign launched in 2017. The campaign, which combined personal stories from cervical cancer patients with evidence-based messaging on social media and in traditional media, cost approximately 1 million USD and led to roughly 16,000 additional vaccinations per year, implying a cost of about 62.5 USD per additional vaccinated girl (WHO, 2018; University of North Carolina at Chapel Hill, 2020). Complementary evidence on intervention costs is provided by Hung et al. (2025), who conducted a trial-based cost analysis of clinic-level strategies in the United States. They report incremental costs per additional patient receiving a vaccine dose of 47.41 USD, 202.47 USD, and 71.96 USD for parent reminder/recall, healthcare professional audit and feedback, and combined interventions, respectively, with sensitivity ranges spanning from 32.71 USD to 233.37 USD. Kamenský et al. (2025) provide a recent contribution focusing on the Czech Republic. The authors evaluate the cost-effectiveness of both routine and catch-up HPV vaccination strategies using a Markov multistate model. The study models cohorts aged 11 and 15 – 21 and finds that catch-up vaccination is cost-effective and, in the female cohort, cost-saving (dominant), while in the male cohort ICERs remain below 42,000 CZK/QALY. These estimates are below commonly used cost-effectiveness thresholds.

Selected literature on the cost-effectiveness of HPV vaccination and cervical cancer prevention in Europe is examined. Westra et al. (2011) analyzed vaccination in the Netherlands, focusing on health-economic and clinical impacts for women aged 12 to 50. A Markov transition model was employed to analyze transitions among stages, including HPV susceptibility, HPV infection, pre-cancer, cancer, and cancer mortality. Findings indicate that vaccinating women against HPV is

highly cost-effective for those aged 12 to 16. Notably, as the age of vaccine recipients increases to 25 years, the cost-effectiveness decreases gradually, suggesting significant health benefits at reasonable costs. However, the cost-effectiveness of vaccinating women older than 25 diminishes rapidly. It is concluded that vaccination remains cost-effective for women even after the initiation of sexual activity. The study by Demarteau et al. (2013) analyzed the incremental cost-effectiveness of administering the HPV vaccine to Belgian women both before and after the onset of sexual activity. This analysis utilized multiple-stage Markov model designed to simulate the lifetime trajectory of a cohort of women. This model accounts for the natural progression of HPV infection, the impact of regular screening, and the benefits of HPV vaccination (Debicki et al., 2008). Findings from the study indicate that vaccinating 12-year-old females, with a catch-up program, alongside screening, significantly reduces cervical cancer, and the bivalent HPV-16/18 vaccine remains cost-effective for women up to 33 to 40 years old. Favato et al. (2012) evaluated HPV prevention strategies in Italy using a Bayesian multi-cohort Markov model. This model makes use of probability distributions derived from either observed data or the expert opinions regarding uncertain parameters. The findings indicate that the primary scenario, which involves vaccinating cohorts of women aged 12 and 16, as well as an expanded multi-cohort scenario that additionally encompasses age groups of 18 and 25, are deemed cost-effective. It is noteworthy that several recent studies employ Markov-type models to evaluate HPV vaccination strategies, including vaccination of older women and broader age cohorts, with a number of articles originating from Asian settings (e.g., Zou et al., 2023; Tantitamit et al., 2026).

2. Methodology

2.1. Survival Analysis – Markov Chains

Markov models are widely used in health economic modeling to evaluate the cost-effectiveness of healthcare strategies and guide public policy decisions (Russell, 1996). They are particularly effective for analyzing processes with inherent uncertainties over time and are well suited to scenarios where timing and recurrence of events are critical, making them ideal for assessing sequential or repetitive strategies (Gray et al., 2011). A Markov model employs a Markov process to simulate transitions between different states. A stochastic process, denoted as $X(t), t \in T$, is a first-order Markov process if, for any sequence $t_0 < t_1 < \cdots < t_n$, the conditional probability distribution of $X(t_n)$, given the values of $X(t_0)$, $X(t_1)$, ..., $X(t_{n-1})$, relies solely on $X(t_{n-1})$. This principle, expressed by the equation below,

suggests that the future state depends only on the current state and not on the sequence of events that preceded it.

$$P\left[X\left(t_n\right) \le X_n \mid X\left(t_{n-1}\right) = x_{n-1}, X\left(t_{n-2}\right) = x_{n-2}, \ldots, X\left(t_0\right) = x_0\right] = \\ = P\left[X\left(t_n\right) \le x_n \mid X\left(t_{n-1}\right) = x_{n-1}\right] \tag{1}$$

Markov chains model transitions over time among states that represent different health statuses. The discrete-time process denoted by X_k, $k = 0,1,2, \ldots$ qualifies as a homogeneous Markov chain if, for any indices i, j and any time step $k \geq 0$, the following condition is satisfied:

$$P\left[X_k = j \mid X_{k-1} = i, X_{k-2} = n, \ldots, X_0 = m\right] = P\left[X_k = j \mid X_{k-1} = i\right] = p_{ij} \tag{2}$$

The quantity p_{ij} represents the state transition probability in a Markov process, which is characterized by time independence. This implies that the probability p_{ij} for transitioning from state i at time $k - 1$ to state j at time k remains constant, regardless of time. Therefore, the future state of the Markov process, given its current state, does not depend on its history. This is known as the Markov property (Filipovic-Pierucci et al., 2017; Ibe, 2013). In a homogeneous Markov chain, the state transition probability p_{ij} has two primary properties:

1. The probability p_{ij} is confined to the interval between zero and one:

$$0 \leq p_{ij} \leq 1$$

2. The sum of the probabilities of transitioning from state i to all other possible states j equals one, as each state i must transition to some state j in the next time step. This is represented by:

$$\sum_{j=1}^{N} p_{ij} = 1, \textit{for all } i = 1,\ 2,\ \ldots N$$

These principles, derived from the conditions that states are mutually exclusive and collectively exhaustive, underscore the foundational logic of Markov chain models in analyzing transitions over time. The state transition probabilities between different states can be represented by a state transition probability matrix, denoted as P. The matrix P consists of N rows and N columns, where each entry p_{ij}, at the intersection of the i-th row and j-th column, represents the probability of transitioning from state i to state j, and where N denotes the total number of states. The sum of all entries in any given row must equal one, reflecting the stochastic nature of the matrix P, indicating that the total probability of moving from any state to all possible subsequent states is certain, as formalized below:

$$\begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1N} \\ p_{21} & p_{22} & \cdots & p_{2N} \\ \cdots & \cdots & \ddots & \cdots \\ p_{N1} & p_{N2} & \cdots & p_{NN} \end{bmatrix} \tag{3}$$

Assuming a finite Markov chain, the state transition probability at the *n*-th step, denoted as $p_{ij}^{(n)}$ represents the probability of transitioning to state *j* after *n* steps, given it is currently in state *i*. This probability $p_{ij}^{(n)}$ is determined by the specific dynamics of the Markov process and is expressed as:

$$p_{ij}^{(n)} = P\left[X_{m+n} = j \mid X_m = i\right] \tag{4}$$

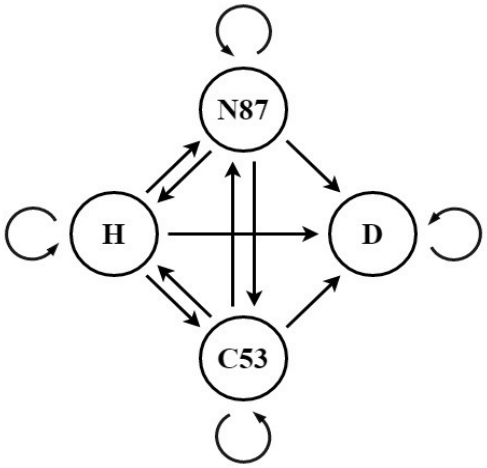
Additionally, the probability $p_{ij}^{(n)}$ can be determined for all possible combinations of *i* and *j*. Through this, it is possible to construct an *N*-state Markov chain matrix P^n encompassing all probabilities $p_{ij}^{(n)}$. Each entry $p_{ij}^{(n)}$ at the intersection of the *i*-th row and *j*-th column within the matrix P^n, represents the probability of transitioning from state *i* to state *j* after *n* steps. The matrix P^n is derived by raising the initial transition matrix *P* to the *n*-th power, effectively multiplying *P* by itself *n* times:

$$\begin{bmatrix} p_{11}(n) & p_{12}(n) \cdots & p_{1N}(n) \\ p_{21}(n) & p_{22}(n) \ldots & p_{2N}(n) \\ \cdots & \cdots \ddots & \cdots \\ p_{N1}(n) & p_{N2}(n) \cdots & p_{NN}(n) \end{bmatrix} \tag{5}$$

A Markov chain is characterized by various types of states. A state *j* is considered accessible from state *i* if there exists some $n > 0$ such that the transition probability $p_{ij}^{(n)} > 0$. Accessibility implies the potential of eventually transitioning into the state. When two states are mutually accessible, they are described as communicating with each other. A Markov chain is irreducible if every state in the model can communicate with every other state. A state *i* is recognized as an absorbing or trapping state if, once reached, the process cannot transition to any other state *j*, which means $p_{ij} = 0$ for every $j \neq i$. For an absorbing state, the probability of remaining in state *i*, $p_{ii} = 1$. A Markov chain that contains at least one absorbing state, and from every other state there exists a nonzero probability of transitioning to this absorbing state, is termed an absorbing Markov chain (Ibe, 2013).

F i g u r e 2

Graphical Representation of Markov Model



Note: The figure shows the graphical representation of the Markov model for transition analysis. H = healthy state, N87 = cervical neoplasia, precancerous state, C53 = cervical carcinoma, cancerous state, D = dead.

Source: Authors' own construction.

In our model, we evaluate transitions in annual cycles, that is, one Markov cycle corresponds to one year. Figure 2 presents a graphical illustration of the developed model, featuring four mutually exclusive and collectively exhaustive states: H (Healthy), N87 (Cervical Dysplasia), C53 (Cervical Carcinoma), and D (Death). These states are delineated based on the diagnoses reported for the corresponding year, utilizing the International Classification of Diseases and Related Health Problems (ICD-10). This classification system organizes and codifies human diseases, disorders, health issues, and various symptoms, situations, or conditions (Institute of Health Information and Statistics of the Czech Republic (UZIS, 2021). Specifically, the diagnoses considered are N87, representing cervical dysplasia (a precancerous stage), and C53, indicating cervical carcinoma (a cancerous stage). The state termed" Healthy" signifies the absence of these diagnoses. The model developed for this study categorizes the health status of women into four distinct states, each representing a specific condition within the cycle of observation:

- H (Healthy) denotes the state of women who, in each cycle, were not diagnosed with either N87 (cervical neoplasia) or C53 (cervical carcinoma) and were not deceased. The designation" H" facilitates clearer identification of this state, implying that a woman classified under" H" may still have conditions other than N87 and C53.

• N87 (Cervical Neoplasia, Precancerous State) identifies women diagnosed with cervical dysplasia, coded as N87, during a specific cycle. This state represents the precancerous stage of cervical disease.

• C53 (Cervical Carcinoma, Cancerous State) refers to women whose medical condition was identified as cervical carcinoma, coded as C53, within a particular cycle, indicating the cancerous stage of the disease.

• D (Death) encompasses women who have passed away in a certain cycle. By definition, deceased individuals are not categorized within any of the model's" alive" states for that cycle.

2.2. Cost-Effectiveness Analysis

Cost-effectiveness analysis is a critical method employed for economic evaluation in healthcare. It involves comparing a new intervention with an existing treatment program, considering the incremental costs and effects of both the new and the existing treatments (Olsen, 2009). To facilitate this comparison, the Incremental Cost-Effectiveness Ratio (ICER) is utilized:

$$ICER = \frac{C_A - C_B}{E_A - E_B} = \frac{\Delta C}{\Delta E} \tag{6}$$

In this context, C_A and E_A denote the costs and effects of intervention A, respectively, while C_B and E_B correspond to the costs and effects of the existing treatment (Gray et al., 2011). The effectiveness of an intervention is assessed using the metric of quality-adjusted life years (QALYs), which integrates both the length and quality of life. The QALY metric is calculated by multiplying the duration of life, expressed in years, by a health-related quality of life (HRQoL) score associated with those years:

$$QALY = T * HRQoL \tag{7}$$

HRQoL is quantified on a utility scale ranging from zero to one, where zero signifies the utility value of the" dead" state, and one represents the utility of living in" perfect health." This metric is derived from patient surveys, such as the EQ-5D, which evaluate various dimensions including mobility, pain, mental health, among others (Prieto and Sacristan, 2003; Whitehead and Ali, 2010; Komorowski and Raffa, 2016). To determine the cost-effectiveness of an intervention, a cost-effectiveness threshold is required. In line with the decision-making practices of SUKL, a threshold of 1.2 million CZK per QALY is generally considered acceptable for assessing cost-effectiveness (State Institute for Drug Control (SUKL), 2020b).

3. Data

3.1. Data for Survival Analysis

To assess survival duration, a data request was submitted to the National Health Information System (NZIS). This dataset comprises the number of women categorized into three health states (healthy, precancerous, and cancerous) in 2018, along with their health status in the following year. A total of 5,446,053 women are included, each precisely classified into one of the defined health states. These data facilitate the calculation of transition probabilities between states, encompassing the probability of mortality. Further details about the requested data are available in Appendix A.

T a b l e 3

Inconsistencies between Official Statistics and Data Provided by UZIS

Measure	Value	Definition	Source
Incidence C53	1,928	Newly observed C53 in 2019 among women without C53 recorded in 2018.	Data request UZIS
	830	The number of newly diagnosed diseases in the monitored population over a certain time interval.	NOR
Prevalence C53	7,065 (6,853)	Annual treated prevalence: women carrying C53 during 2018 (2019).	Data request UZIS
	17,750	The number of living people who currently have a given disease or have had the disease in the past.	NOR
Mortality C53	393	Deaths in 2019 among women with C53 recorded in 2018, all-cause, died with C53 in prior year).	Data request UZIS
	280	The number of recorded deaths due to a given diagnosis (so-called specific mortality) in the monitored population over a certain time interval.	NOR

Note: The table shows the inconsistencies between the NOR and UZIS data – due to different definitions. NOR = National Cancer Registry, UZIS = Institute of Health Information and Statistics of the Czech Republic.

Source: UZIS, and Krejci (2022).

The data provider, UZIS, highlighted limitations due to the reliance on patient identification from health care reimbursement reports within the public health insurance system. This dataset is not derived from a clinical database, and it excludes cases not covered by public health insurance. Table 3 summarizes the differences between the provided data and the official statistics on the incidence, prevalence, and mortality rates of cervical carcinoma in the Czech Republic. The main reason is the difference in the definitions of these statistics. Official statistics define incidence as newly diagnosed cases, prevalence as the number of living persons who currently have, or have had, the disease (typically reported as a point prevalence), and mortality as cause-specific deaths due to the diagnosis (Krejci, 2022). On the other hand, the UZIS/NZIS extracted data use annual presence of diagnosis codes

in reimbursed care and year-to-year transitions. (The definitions are included in Appendix A). Consequently, our incidence proxy captures women who are newly diagnosed with C53 in 2019 among those without a recorded C53 in 2018, which may include women diagnosed earlier whose C53 was not recorded in reimbursement data in 2018. Similarly, our prevalence measure reflects annual treated prevalence rather than registry prevalence. Where the registry prevalence also counts women who have had C53 in the past. The difference in the mortality is consistent with counting deaths among women previously recorded with C53 ("died with") rather than deaths due to C53 ("died of") (Krejci, 2022).

These differences are primarily attributed to the distinction between clinical registries and reimbursement data. Other potential sources of inaccuracy include errors in the reporting of diagnoses, the omission of patients who missed their check-ups during the observation period (thus not appearing in the reimbursement data), and the possibility of multiple diagnoses for a single patient. Despite these challenges, the focus of this study is on evaluating the costs and financial implications of the current situation versus the proposed change. Therefore, the data on actual reimbursed costs are deemed representative for this purpose.

To evaluate the benefits of HPV vaccination, two state-transition matrices are required. The matrix for unvaccinated women (Table 4) is derived from data supplied by UZIS, capturing state transitions for the general population, which includes both vaccinated and unvaccinated women. Given that HPV vaccination commenced in the Czech Republic in 2012, the impact of vaccinated women on the number of diagnosed cases and, consequently, on transition probabilities is considered marginal. This marginal impact is attributed to the extensive period required for the development of (pre)cancerous conditions.

For vaccinated women, the matrix (Table 5) is adjusted by reducing the probability of transitioning from state H to states N87 and C53 by 90%, reflecting the assumed vaccine efficacy. To ensure the probabilities in the row sum up to one, the adjusted amounts are reallocated to the probability of remaining in state H. The probability of transitioning from state H to state D remains unchanged.

T a b l e 4

Transition Matrix for the Unvaccinated

	H	**N87**	**C53**	**D**
H	0.9740	0.0150	0.0010	0.0100
N87	0.5510	0.4450	0.0020	0.0020
C53	0.2620	0.0270	0.6550	0.0560
D	0.0000	0.0000	0.0000	1.0000

Note: The table shows the transition matrix for unvaccinated women. H = healthy state, N87 = cervical neoplasia, precancerous state, C53 = cervical carcinoma, cancerous state, D = dead.

Source: Authors' calculations based on data provided by UZIS.

T a b l e 5

Transition Matrix for the Vaccinated

	H	N87	C53	D
H	0.9884	0.0015	0.0001	0.0100
N87	0.5510	0.4450	0.0020	0.0020
C53	0.2620	0.0270	0.6550	0.0560
D	0.0000	0.0000	0.0000	1.0000

Note: The table shows the transition matrix for vaccinated women. H = healthy state, N87 = cervical neoplasia, precancerous state, C53 = cervical carcinoma, cancerous state, D = dead.

Source: Authors' calculations based on data provided by UZIS.

3.2. Health-Related Quality of Life

Health-related quality of life (HRQoL) is assigned to each health state within the Markov model, with values ranging from zero to one. HRQoL values for the precancerous and cancerous stages are derived from the literature. State N87, representing the precancerous stage, has HRQoL values ranging from 0.87 to 0.91, depending on the progression of precancerous conditions. State C53, indicative of cervical carcinoma, sees HRQoL values vary from 0.48 to 0.76 based on the stage of carcinoma (local, regional, distant) (Elbasha et al., 2007; Boiron et al., 2016). For this analysis, HRQoL for N87 and C53 has been standardized to 0.89 and 0.67, respectively.

The HRQoL for state D, representing death, is set to zero. Although state H, denoting healthiness, is assigned an HRQoL of one, it is important to clarify that this does not equate to "perfect health". The rationale behind this assignment is that the average HRQoL for the general population without conditions would likely be lower than that for state N87 (Elbasha et al., 2007), suggesting an incongruity where being in a precancerous state would seemingly be preferred over being free from C53 or N87 in terms of quality of life. This is a simplification for modeling purposes.

3.3. Costs of Vaccination and Vaccine Efficacy

The analysis includes only direct health-care costs related to vaccination, covering medical products and administration. These costs vary depending on the age at which vaccination begins. Total vaccination costs are calculated by summing the costs of the medical products and administrative expenses. The price of the medical product is based on the least expensive option available. Administrative costs for the vaccine account for both the vaccine's application and a general examination conducted by a medical doctor. These costs are determined according to Regulation No. 269/2019 Coll., which amends Regulation No. 134/1998 Coll. This regulation issues a list of medical services with associated point values, as further amended by Regulation No. 428/2020 Coll. The latter regulation specifies

point values, payment amounts for reimbursed services, and regulatory limits for the year 2021. Table 6 outlines the total vaccination costs for both two- and three-dose schedules.

T a b l e 6

Costs Associated with Vaccination

Price per one dose of vaccine	1,765.79 CZK
Price of application and examination per one dose	263.32 CZK
Total costs of administration per one dose	2,029.11 CZK
Total costs of administration of two doses	4,058.22 CZK
Total costs of administration of three doses	6,087.33 CZK

Note: The table outlines the breakdown of vaccination costs. Vaccine application and general examination values are 138 and 89 points, respectively, with each point valued at 1.16 CZK.

Source: Ministry of Health, CR (2019; 2020); SUKL (2021).

Vaccine efficacy against the precancerous stage is derived from the summary of product characteristics for each vaccine, as published by State Institute for Drug Control (2021). The reported efficacy of vaccines against precancerous ranges from 78% and 100% across all three vaccines. Due to the long development period of cervical carcinoma, efficacy data against the cancerous stage are not yet available. Based on information from European Medicines Agency (2007; 2008; 2015), CERVARIX was approved for use in 2007, GARDASIL in 2006, and GARDASIL 9 in 2015. For this analysis, we assume a vaccine efficacy of 90%. Additionally, a sensitivity analysis is conducted using an efficacy rate of 80% to assess potential variations in outcomes.

3.4. Costs Assigned to the Specific States

The costs for specific health states are derived from the 2019 VZP Yearbook, covering nearly 6 million insured individuals, representing about 60% of the Czech population (General Health Insurance Company of the Czech Republic (VZP), 2020). Therefore, the VZP insured cohort serves as a representative sample of the Czech Republic's population. For the H (healthy) state, costs are based on the median of the average total annual healthcare expenses for 5-year age groups, ranging from 10 to 14 years to 80 to 84 years, amounting to 22,270 CZK. The costs for the D (dead) state are assumed to be zero, reflecting no ongoing healthcare costs after death. The costs for the N87 state (precancerous condition) are calculated by adding the average costs for diagnoses N80 – N98 to the H state costs, resulting in a total of 22,270 CZK + 1,621.34 CZK = 23,891.34 CZK. Similarly, the costs for the C53 state (cervical carcinoma) are derived by adding the average costs for diagnoses C51 – C58 to the costs for the H state, yielding a total of 22,270 CZK + 30,113.38 CZK = 52,383.38 CZK (General Health Insurance Company of the

Czech Republic, 2020). Table 7 summarizes the average total annual costs for each state, the potential transitions among states, and the HRQoL values assigned to each.

T a b l e 7

Average Total Annual Costs Assigned to Each State

State	In	Out	HRQoL	Costs
H	H, N87, C53	H, N87, C53, D	1.00	22,270.00 CZK
N87	H, N87, C53	H, N87, C53, D	0.89	23,891.34 CZK
C53	H, N87, C53	H, N87, C53, D	0.67	52,383.38 CZK
D	H, N87, C53, D	D	0.00	0.00 CZK

Note: The table lists states, possible transitions, assigned Health-related quality of life values, and average annual costs per cycle and person. H = healthy, N87 = precancerous, C53 = cancerous, D = dead.

Source: VZP (2020); Elbasha et al. (2007); Boiron et al. (2016).

The total costs assigned to states N87 (precancerous condition) and C53 (cervical carcinoma) may not fully capture the expenses for these specific stages, as the costs for these diagnoses are already factored into the average total costs. It's important to note that the prevalence of women diagnosed with these conditions is relatively low compared to the total number of women insured by VZP. VZP insured 2,968,195 women as of 31 December 2018, and 2,967,365 women as of 31 December 2019 (General Health Insurance Company of the Czech Republic (VZP), 2019; 2020). In the NZIS/UZIS reimbursement extract (which is not insurer-disaggregated), 7,065 women had a reimbursed record of C53 in 2018, and 6,853 in 2019 (Table 3). Relative to the female VZP-insured population, this implies an upper bound of 0.24% (7,065 / 2,968,195) in 2018, and 0.23% (6,853 / 2,967,365) in 2019 for the share of women with reimbursed C53 care in a given year. 142,307 women or an upper bound of 4.79% (142,307 / 2,968,195) had a reimbursed record of N87 in 2018 and 143,978 or an upper bound of 4.85% (143,978 / 2,967,365) in 2019. These numbers represent an upper bound when all the reimbursed women would be VZP-insured. Additionally, the presented costs are not for individual diagnoses but rather for a broader group of related diagnoses. However, the costs associated with specific diagnoses are likely to be similar to those for the broader group, making this approach a valid approximation for the analysis.

4. Results

4.1. Modelling Process

To conduct a cost-effectiveness analysis, the costs and benefits of various vaccination strategies are calculated. The Incremental Cost-Effectiveness Ratio evaluates the cost-effectiveness of each alternative relative to the current approach.

Benefits are quantified by multiplying the length of survival by the Health-Related Quality of Life, with survival duration derived from transition analysis. This analysis offers detailed insights into the duration of persistence in each health state, which, in turn, informs the cost calculations for these states. Assumptions regarding the costs for each state are detailed in Table 7.

The proposed model comprises a cohort of 13-year-old girls, initially in the healthy state (H), reflecting the age at which health insurance in the Czech Republic fully reimburses HPV vaccination. The cohort size is established at 50,000 women to reflect the age composition of the population (Czech Statistical Office (CSU), 2020a). The model spans 68 cycles, corresponding to the average life expectancy of 81 years for Czech women (CSU, 2020b), subtracting the entry age of 13. Each cycle in the model equates to one year. In line with standard practices for cost-effectiveness analysis, a 3% discount rate is applied to both costs and effects. Additionally, sensitivity analyses are conducted using discount rates of 0% and 5% to evaluate the impact of these rates on the outcomes (State Institute for Drug Control (SUKL), 2020b).

To evaluate the benefits of HPV vaccination, we model the transitions among the states for both vaccinated and unvaccinated women using the transition matrices described by Tables 4 and 5. These matrices depict the life-long transition probabilities for a cohort of women, tracking their movement among the states over 68 cycles, equivalent to years. In each cycle, women residing in states H, N87, and C53 are credited with one year of life, whereas no years are added for those in state D. The accumulated years of life in each state, for every cycle, are then multiplied by the respective HRQoL scores, resulting in QALY as the measure of effect. The total costs are calculated by multiplying the duration of stay in each state by the corresponding state's total annual cost. The model was developed using the R software, employing the *heemod* package, which is specifically designed for constructing Markov models for health economic evaluations (Filipovic-Pierucci et al., 2017).

4.2. Proposed Strategies

This subsection outlines two vaccination strategies devised by the authors to enhance HPV immunization coverage. Strategy 1 aims to increase the vaccination rate among 13-year-olds from the current 65.8% (Hejduk et al., 2018) to 80%. The calculation of costs and QALYs is adjusted based on the proportion of vaccinated women, with vaccination expenses incorporated into the total costs of the proposed strategy. Detailed calculations can be found in Appendix B. The anticipated increase in vaccination coverage is supported by a promotional campaign whose cost is derived from published estimates of HPV vaccination promotion interventions

(Hansen et al., 2020; Hung et al., 2025). Raising coverage from 65.8% to 80% in a cohort of 50,000 women requires 7,100 additional vaccinations. Using a baseline cost of USD 62.5 USD per additional vaccinated individual and a 2021 average exchange rate of 21.682 CZK/USD (Czech National Bank, 2021), the baseline campaign cost amounts to approximately 9.6 million CZK. The lower bound, based on the least costly intervention arm (32.71 USD per additional vaccinated), yields a campaign cost of approximately 5.0 million CZK, while the upper bound (233.37 USD per additional vaccinated) yields approximately 35.9 million CZK.

Strategy 2 suggests extending vaccination to include women aged 13 to 15 and aims to achieve a vaccination coverage of 80%. Unlike the first strategy, this approach necessitates a different model for the baseline scenario. Initially, 50,000 women are in state H, with an additional 50,000 women entering the model at the beginning of the first and second cycles, simulating a scenario where only 13-year-olds receive vaccination. This reflects the current practice. The costs include immediate expenses and those discounted for future cycles, representing the present vaccination strategy. Conversely, this strategy models a single cohort of 150,000 women, evenly divided among 13-, 14-, and 15-year-olds, with a third requiring three vaccine doses and the rest needing two. Cost calculations based on this setup are provided in Appendix C. Using the same unit cost estimates as in Strategy 1, the 21,300 additional vaccinations required to reach 80% coverage imply a baseline campaign cost of approximately 28.9 million CZK, with a lower bound of 15.1 million CZK and an upper bound of 107.8 million CZK.

4.3. Cost-Effectiveness Results

Table 8 presents the ICER calculations for the first strategy, applying various discount rates to both costs and QALYs. As indicated in Table 8, Panel A, the intervention is cost-effective across all discount rates and campaign cost assumptions, with all ICER values falling well below the cost-effectiveness threshold of 1.2 million CZK/QALY. At a 3% discount rate, the baseline ICER is 46,494 CZK/QALY, ranging from 32,217 CZK/QALY (lower bound) to 128,386 CZK/QALY (upper bound). At a 0% discount rate, the intervention is cost-saving (dominant) under both the baseline and lower-bound campaign cost assumptions, meaning it generates health gains while reducing total costs. Even under the upper-bound campaign cost and a 5% discount rate (the most conservative combination) the ICER remains at 196,096 CZK/QALY, well within the accepted threshold. The discount rates of 0% and 5% are included as sensitivity analyses in alignment with standard cost-effectiveness assessment methods (State Institute for Drug Control

(SUKL), 2020b). Given the established vaccine efficacy against precancerous stages, the analysis was reiterated under the assumption of an 80% vaccine efficacy. Table 8, Panel B, demonstrates that the intervention retains its cost-effectiveness relative to the 1.2 million CZK/QALY threshold, even with reduced vaccine efficacy.

T a b l e 8

ICER Computation – Strategy 1

Discount rate	0%	3%	5%
Panel A: 90% vaccine efficacy			
Baseline Δ C [CZK]	–18,470,676	14,934,040	23,166,451
Lower bound Δ C [CZK]	–23,056,614	10,348,102	18,580,513
Upper bound Δ C [CZK]	7,833,428	41,238,144	49,470,554
Δ QALY	487	321	252
Baseline ICER [CZK/QALY]	–39,923	46,494	91,829
Lower bound ICER [CZK/QALY]	–47,338	32,217	73,651
Upper bound ICER [CZK/QALY]	16,083	128,386	196,096
Panel B: 80% vaccine efficacy			
Baseline Δ C [CZK]	–12,010,421	17,601,010	24,898,449
Lower bound Δ C [CZK]	–16,596,359	13,015,072	20,312,511
Upper bound Δ C [CZK]	14,293,683	43,905,114	51,202,553
Δ QALY	432	285	224
Baseline ICER [CZK/QALY]	–27,813*	61,790	111,328
Lower bound ICER [CZK/QALY]	–38,433*	45,691	90,823
Upper bound ICER [CZK/QALY]	33,101	154,133	228,941

Note: The table shows ICER calculations for 90% and 80% vaccine efficacy for Strategy 1, including campaign costs. C = costs, QALY = Quality-adjusted life year, ICER = Incremental cost-effectiveness ratio, * marks a dominant (cost-saving) intervention, yields health gains at lower total cost.

Source: Baseline campaign costs derived from Hansen et al. (2020), lower and upper bound derived from Hung et al. (2025).

Strategy 2 also demonstrates cost-effectiveness in the base-case analysis using a 3% discount rate. Under 90% vaccine efficacy (Panel A), the baseline ICER is 31,060 CZK/QALY, with a range of 30,054 – 36,828 CZK/QALY across the lower- and upper-bound campaign-cost scenarios. Under 80% vaccine efficacy (Panel B), the baseline ICER is 31,948 CZK/QALY, with a corresponding range of 30,934 – 37,766 CZK/QALY.

Table 9, Panel A, illustrates the ICER values across different discount rates, while Panel B assesses the strategy under the assumption of 80% vaccine efficacy. In both cases, the strategy remains cost-effective when evaluated against the cost-effectiveness threshold of 1.2 million CZK/QALY. Given the ICER values for both strategies, we recommend a policy shift regarding HPV vaccination in the Czech Republic. Expanding reimbursement for vaccination to include women aged 13 to 15 and/or enhancing vaccination coverage would yield significant health benefits.

T a b l e 9

ICER Computation – Strategy 2

Discount rate	0%	3%	5%
Panel A: 90% vaccine efficacy			
Baseline Δ C [CZK]	35,020,758	424,955,502	524,415,715
Lower bound Δ C [CZK]	21,262,944	411,197,687	510,657,901
Upper bound Δ C [CZK]	113,933,069	503,867,813	603,328,026
Δ QALY	1,743	13,682	16,502
Baseline ICER [CZK/QALY]	20,097	31,060	31,779
Lower bound ICER [CZK/QALY]	12,202	30,054	30,945
Upper bound ICER [CZK/QALY]	65,380	36,828	36,561
Panel B: 80% vaccine efficacy			
Baseline Δ C [CZK]	54,785,924	433,345,064	530,660,325
Lower bound Δ C [CZK]	41,028,109	419,587,249	516,902,510
Upper bound Δ C [CZK]	133,698,235	512,257,375	609,572,636
Δ QALY	1,571	13,564	16,383
Baseline ICER [CZK/QALY]	34,881	31,948	32,391
Lower bound ICER [CZK/QALY]	26,122	30,934	31,511
Upper bound ICER [CZK/QALY]	85,124	37,766	37,208

Note: The table shows ICER calculations for 90% and 80% vaccine efficacy under Strategy 2, including campaign costs. C = costs, QALY = Quality-adjusted life year, ICER = Incremental cost-effectiveness ratio.

Source: Baseline campaign costs derived from Hansen et al. (2020), lower and upper bound derived from Hung et al. (2025).

Conclusion

This paper evaluates the cost-effectiveness of HPV vaccination strategies for women in the Czech Republic, with a focus on cervical cancer prevention. Using a multistate homogeneous Markov model, we assess both the current vaccination policy and proposed strategies that increase vaccination uptake. We evaluate two policy-oriented strategies: increasing vaccination coverage among 13-year-old girls and extending full reimbursement to girls aged 13 to 15. The increase in vaccination coverage is based on campaign costs derived from empirical estimates of HPV vaccination interventions, which allows us to construct lower, baseline, and upper bounds for campaign costs. The results show that both strategies are cost-effective across all scenarios.

Even under conservative assumptions (including high campaign costs, higher discount rates, and lower vaccine efficacy), the estimated ICERs remain below the cost-effectiveness threshold. In some cases, specifically for the first strategy under low discount rates, the intervention is cost-saving.

While the findings are consistent with the existing empirical literature, the analysis has several limitations. First, our model relies on administrative reimbursement data from the NZIS/UZIS, which differs from clinical data in the definition and measurement of incidence, prevalence, and mortality. Specifically, the data

capture treated prevalence and year-to-year transitions in reimbursed care rather than true epidemiological measures, which may influence the calibration of transition probabilities. At the same time, the use of reimbursement data means that cost estimates reflect actual expenditures and are therefore well suited for evaluating the financial implications of alternative vaccination strategies. Second, the analysis assumes that women without cervical disease are in perfect health (HRQoL = 1) and does not account for potential reductions in health-related quality of life following disease resolution. This simplification may lead to a slight overestimation of the health gains associated with vaccination. Third, the baseline scenario reflects the vaccination policy prior to 2024, when full reimbursement was limited to 13-year-old girls. Since then, vaccination coverage has been expanded to girls aged 11 to 15, meaning that part of the policy change considered in Strategy 2 is already implemented in practice. As a result, the incremental benefits of extending coverage to older cohorts may be smaller than estimated, potentially leading to higher ICERs. Incorporating the updated policy would require redefining the baseline scenario and recalibrating the model accordingly. However, given that the estimated ICERs remain well below the cost-effectiveness threshold, the main conclusions of the analysis are unlikely to change.

Overall, the results show that increasing vaccination coverage and expanding eligibility are cost-effective strategies, even under conservative assumptions. Our analysis provides a quantitative basis for evaluating HPV vaccination policies in the Czech Republic and similar settings.

References

AKUMBOM, A. M. – LEE, J. J. – REYNOLDS, N. R. – THAYER, W. – WANG, J. – SLADE, E. (2022): Cost and Effectiveness of HPV Vaccine Delivery Strategies: A Systematic Review. Preventive Medicine Reports *26*, No. 8, 101734. DOI: 10.1016/j.pmedr.2022.101734.

ALBRIGHT, M. – ONDRUS, J. (2021a): Očkování proti HPV | HPV College. Available at: <https://www.hpv-college.cz/ ockovani-proti-hpv>. Last accessed on 2021-07-01.

ALBRIGHT, M. – ONDRUS, J. (2021b): Prevence | HPV College. Available at: <https://www.hpv-college.cz/prevence>. Last accessed on 2021-07-06.

AUSTRIAN INSTITUTE FOR HEALTH TECHNOLOGY ASSESSMENT (2018): Prevention of Cervical Cancer in Austria – Implementation of HPV Testing into the Existing Screening Programme. Available at: <https://aihta.at/page/praevention-zervix-karzinom-implementierung-eines-hpv-screenings/en>. Last accessed on 2021-07-11.

BOIRON, L. – JOURA, E. – LARGERON, N. – PRAGER, B. – UHART M. (2016): Estimating the Cost-Effectiveness Profile of a Universal Vaccination Programme with a Nine-Valent HPV Vaccine in Austria. BMC Infectious Diseases, *16*, No. 1, pp. 153. DOI: 10.1186/s12879-016-1483-5.

BRUNI, L. – ALBERO, G. – SERRANO, B. – MENA, M. – GOMEZ, D. – MUNOZ, J. – BOSCH, F. X. – De SANJOSE S. (2019): Human Papillomavirus and Related Diseases in Europe: Summary Report.

COALFIELD BROTHERHOOD CASH OFFICE, A HEALTH INSURANCE COMPAN (RBP) (2021): Preventivní a bonusový program. Available at: <https://www.rbp213.cz/pojistenci/bonusy-a-prevencepreventivni-a-bonusovy-program/a-55/>. Last accessed on 2021-07-09.

CZECH INDUSTRY HEALTH INSURANCE FUND (CPZP) (2021): Preventivní programy. Available at: <https://www.cpzp.cz/preventivni-programy>. Last accessed on 2021-07-09.

CZECH NATIONAL BANK (2021): Central Bank Exchange Rates Fixing – Monthly Cumulative Averages. Available at: <https://www.cnb.cz/en/financial-markets/foreign-exchange-market/central-bank-exchange-rate-fixing/central-bank-exchange-rate-fixing/currency_average.html?currency=USD>. Last accessed on 2026-04-01.

CZECH STATISTICAL OFFICE (CSU) (2020a): Věkové složení obyvatelstva – 2020. Available at: <https://www.czso.cz/csu/czso/vekove-slozeni-obyvatelstva-2020>. Last accessed on 2021-07-24.

CZECH STATISTICAL OFFICE (CSU) (2020b): Umrtnostní tabulky za ČR, regiony soudržnosti a kraje – 2019 – 2020. Available at: <https://www.czso.cz/csu/czso/umrtnostni-tabulky-za-cr-regiony-soudrznosti-a-kraje-i09aftm7w4>. Last accessed on 2021-07-24.

DAMM, O. – HORN, J. – MIKOLAJCZYK, R. T. – KRETZSCHMAR, M. E. E. – KAUFMANN, A. M. – DELERE, Y. – ULTSCH, B. – WICHMANN, O. – KRAMER, A. – GREINER, W. (2017): Cost-Effectiveness of Human Papillomavirus Vaccination in Germany. Cost Effectiveness and Resource Allocation, *15*, No. 1, p. 18. DOI: 10.1186/s12962-017-0080-9.

DEBICKI, D. – FERKO, N. – DEMARTEAU, N. – GALLIVAN, S. – BAUCH, C. – ANONYCHUK, A. – MANTOVANI, L. – CAPRI, S. – CHOU, C.-Y. – STANDAERT, B. – ANNEMANS, L. (2008): Comparison of Detailed and Succinct Cohort Modelling Approaches in a Multi-Regional Evaluation of Cervical Cancer Vaccination. Vaccine, *26*, pp. F16 – F28. DOI: 10.1016/j.vaccine.2008.02.040.

DEMARTEAU, N. – Van KRIEKINGE, G. – SIMON, P. (2013): Incremental Cost-Effectiveness Evaluation of Vaccinating Girls Against Cervical Cancer Pre- and Post-Sexual Debut in Belgium. Vaccine, *31*, No. 37, pp. 3962 – 3971. DOI: 10.1016/j.vaccine.2013.06.008.

DUSKOVA, J. – BEKOVA, A. – DVORAK, V. – MAJEK, O. – DUSEK, L. (2014): Results of the Czech National Cervical Cancer Screening Programme. Klinická Onkologie: Časopis Ceske a Slovenské Onkologické Společnosti, *27*, pp. 79 – 86. DOI: 10.14735/amko20142S79.

ELBASHA, E. H. – DASBACH, E. J. – INSINGA, R. P. (2007): Model for Assessing Human Papillomavirus Vaccination Strategies. Emerging Infectious Diseases, *13*, No. 1, pp. 28 – 41. DOI: 10.3201/eid1301.060438.

EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL (ECDC) (2021): Human Papillomavirus Infection: Recommended Vaccinations. Available at: <https://vaccine-schedule.ecdc.europa.eu/Scheduler/ByDisease?>. Last accessed on 2021-07-11.

EUROPEAN MEDICINES AGENCY (2007): Medicines: Gardasil. Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/gardasil>. Last accessed on 2021-07-23.

EUROPEAN MEDICINES AGENCY (2008): Medicines: Cervarix. Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/cervarix>. Last accessed on 2021-07-23.

EUROPEAN MEDICINES AGENCY (2015): Medicines: Gardasil 9. Available at: <https://www.ema.europa.eu/en/medicines/human/EPAR/gardasil-9>. Last accessed on 2021-07-23.

EUROPEAN CENTRE FOR DISEASE PREVENTION AND CONTROL (2021): Vaccine Scheduler: Human Papillomavirus (HPV). Available at: <https://vaccine-schedule.ecdc.europa.eu/>.

FAVATO, G. – BAIO, G. – CAPONE, A. – MARCELLUSI, A. – COSTA, S. – GARGANESE, G. PICARDO, M. – DRUMMOND, M. – JONSSON, B. – SCAMBIA, G. – ZWEIFEL, P. – MENNINI, F. S. (2012): Novel Health Economic Evaluation of a Vaccination Strategy to Prevent HPV-Related Diseases: The BEST Study. Medical Care, *50*, No. 12, pp. 1076 – 1085. DOI: 10.1097/MLR.0b013e318269e06d.

FERLAY, J. – ERVIK, M. – LAM, F. – LAVERSANNE, M. – COLOMBET, M. – MERY, L. – PINEROS, M. – ZNAOR, A. – SOERJOMATARAM, I. – BRAY, F. (2021): Global Cancer Observatory: Cancer Today. Lyon, France: International Agency for Research on Cancer. Data Visualization Tools for Exploring the Global Cancer Burden. Available at: <http://gco.iarc.fr/today/home>. Last accessed on 2021-07-26.

FILIPOVIC-PIERUCCI, A. – ZARCA, K. – DURAND-ZALESKI, I. (2017): Markov Models for Health Economic Evaluations: The R Package Heemod. DOI: 10.48550/arXiv.1702.03252.

FISHER, H. – HICKMAN, M. – FERRIE, J. – EVANS, K. – BELL, M. – YATES, J. – RODERICK, M. – REYNOLDS, R. – MACLEOD, J. – AUDREY S. (2020): Impact of New Consent Procedures on Uptake of the Schools-Based Human Papillomavirus (HPV) Vaccination Programme. Journal of Public Health, *44*, No. 1, pp. 199 – 206. DOI: 10.1093/pubmed/fdaa164.

GENERAL HEALTH INSURANCE COMPANY OF THE CZECH REPUBLIC (VZP) (2019): VZP ČR Ročenka 2018.˘ Available at: <https://media.vzpstatic.cz/media/Default/rocenky/rocenka_vzp_2018.pdf>. Last accessed on 2026-03-05.

GENERAL HEALTH INSURANCE COMPANY OF THE CZECH REPUBLIC (VZP) (2020): VZP ČR Ročenka 2019. Available at: <https://media.vzpstatic.cz/media/Default/rocenky/rocenka_vzp_2019.pdf>. Last accessed on 2021-03-05.

GENERAL HEALTH INSURANCE COMPANY OF THE CZECH REPUBLIC (VZP) (2021): Výhody a příspěvky. Available at: <https://www.vzp.cz/pojistenci/vyhody-a-prispevky>. Last accessed on 2021-07-09.

GRAY, A. M. – CLARKE, P. M. – WOLSTENHOLME, J. L. – WORDSWORTH, S. (2011): Applied Methods of Costeffectiveness Analysis in Healthcare. OUP Oxford. ISBN 978-0-19-922728-0.

HANSEN, P. R. – SCHMIDTBLAICHER, M. – BREWER, N. T. (2020): Resilience of HPV Vaccine Uptake in Denmark: Decline and Recovery. Vaccine, *38*, No. 7, pp. 1842 – 1848. DOI: 10.1016/j.vaccine.2019.12.019.

HEJDUK, K. – MANDELOVA, L. – NGO, O. – CHLOUPKOVA, R. – VYSKOT, T. – GREGOR, J. – MAJEK, O. (2018): Národní screeningové centrum ÚZIS ČR: Očkování dívek i chlapců proti lidským papilomavirům (HPV) zabranuje vzniku řady važných nádorových onemocnění a chrání lidské životy. Available at: <https://nsc.uzis.cz/index.php?pg= aktualityandaid=29>. Last accessed on 2021-07-02.

HUNG, A. – FINNEY RUTTEN, L. J. – GRIFFIN, J. M. – MACLAUGHLIN, K. L. – JENKINS, G. – HERRIN, J. ... JACOBSON, R. M. (2025): Trial-Based Costs for Interventions to Improve HPV Vaccine Uptake. JAMA Network Open, *8*, No. 12, e2550657. DOI: 10.1001/jamanetworkopen.2025.50657.

IBE, O. (2013): Markov Processes for Stochastic Modeling. Elsevier Insights. Elsevier Science. ISBN 978-0-12407795-9.

INSTITUTE OF HEALTH INFORMATION AND STATISTICS OF THE CZECH REPUBLIC (UZIS) (2021): MKN-10 klasifikace diagnóz. Available at: <https://mkn10.uzis.cz/>. Last accessed on 2021-07-22.

KAMENSKÝ, V. – DOSTÁLEK, L. – ROŽÁNEK, M. – TICHOPÁD, A. – PRYMULA, R. – ŠARKANOVÁ, I. (2025): Burden of HPV-Induced Diseases and Cost Effectiveness of Catch-Up Vaccination in Czech Republic: A Model-Based Study. BMC Public Health, *25*, No. 1, p. 481. DOI: 10.1186/s12889-025-21599-6.

KOMOROWSKI, M. – RAFFA, J. (2016): Markov Models and Cost Effectiveness Analysis: Applications in Medical Research. Secondary Analysis of Electronic Health Records. Springer International Publishing, pp. 351 – 367. DOI 10.1007/978-3-319-43742-2_24.

KREJCI, D. – MUZIK, J. – DUSEK, L. (2022): Novotvary 2019 – 2021 ČR-Cancer incidence 2019 – 2021 in the Czech Republic. Ústav zdravotnických informací a statistiky ČR. Zdravotnická statistika ČR. Available at: <https://www.uzis.cz/res/f/008447/novotvary2019-2021.pdf>. Last accessed on 2026-03-02.

MAJEK, O. – DVORAK, V. – NGO, O. – DUSEK, L. – MUZIK, J. – SNAJDROVA, L. – HEJDUK, K. (2021a): Cervix.cz – program cervikálního screeningu v ČR: Prevence a screening rakoviny děložního čípku. Available at: <https://_www.cervix.cz/cs/verejnost/prevence-a-screening-rakoviny-delozniho-cipku/>. Last accessed on 2021-07-01.

MAJEK, O. – DVORAK, V. – NGO, O. – DUSEK, L. – MUZIK, J. – SNAJDROVA, L. – HEJDUK, K. (2021b): Cervix.cz – Program cervikálního screeningu v ČR: Rakovina děložního čípku. Available at: <https://www.cervix.cz/cs/verejnost/rakovina-delozniho-cipku/>. Last accessed on 2021-06-25.

MARKOWITZ, L. E. (2007): HPV Vaccines – Prophylactic, Not Therapeutic. JAMA, *298,* No. 7, pp. 805 – 806. DOI: 10.1001/jama.298.7.805.

MAVUNDZA, E. J. – IWU-JAJA, C. J. – WIYEH, A. B. – GAUSI, B. – ABDULLAHI, L. H. – HALLE-EKANE, G. – WIYSONGE, C. S. (2021): A Systematic Review of Interventions to Improve HPV Vaccination Coverage. Vaccines, *9*, No. 7, p. 687. DOI: 10.3390/vaccines9070687.

MILITARY HEALTH INSURANCE COMPANY OF THE CZECH REPUBLIC (VoZP) (2021): Příspěvky na prevenci. Available at: <https://www.vozp.cz/prispevky-na-prevenci>. Last accessed on 2021-07-09.

MINISTRY OF HEALTH, CR (2019): Regulation No. 269/2019 Coll. Amending Regulation No. 134/1998 Coll., Which Issues a List of Medical Procedures with Point Values, as Amended.

MINISTRY OF HEALTH, CR (2020): Regulation No. 428/2020 Coll. Setting Point Values, Reimbursement Levels for Covered Services and Regulatory Limits for 2021.

MINISTRY OF THE INTERIOR HEALTH INSURANCE FUND (ZPMV) (2021): Program prevence infekčních onemocnění – očkování. Available at: <https://www.zpmvcr.cz/pojistenci/bonusy-na-prevenci/program-prevence-infekcnich-onem-ocneni-ockovani>. Last accessed on 2021-07-09.

MOHAN, H. (2018): Textbook of Pathology. Jaypee Brothers Medical Publishers. ISBN 978-93-5270-547-4.

NATIONAL CANCER INSTITUTE (NCI) (2021): Definition of Catch-Up Vaccination – NCI Dictionary of Cancer Terms. Available at: <https://www.cancer.gov/publications/dictionaries/cancer-terms/def/catch-up-vaccination>. Last accessed on 2021-07-11.

OCCUPATIONAL HEALTH INSURANCE COMPANY FOR EMPLOYEES OF THE BANKING, INSURANCE AND BUILDING INDUSTRY (OZP) (2021): Benefity OZP. Available at: <https://www.ozp.cz/benefity/benefityozp>. Last accessed on 2021-07-09.

OLSEN, J. A. (2009): Principles in Health Economics and Policy. Oxford: Oxford University Press.

PRIETO, L. – SACRISTAN, J. A. (2003): Problems and Solutions in Calculating Quality-Adjusted Life Years (QALYs). Health and Quality of Life Outcomes, *1*, p. 80. DOI: 10.1186/1477-7525-1-80.

RAHMAN, L. – GAO, T. – NAM, J. – ZENG, Y. – LI, G. – ZENG, W. (2026): The Effect of Digital Interventions on the Uptake of HPV Vaccination in the United States: A Systematic Review and Meta-Analysis. Vaccine, *71*, 128117. DOI: 10.1016/j.vaccine.2025.128117.

RUSSELL, L. B. (1996): The Role of Cost-Effectiveness Analysis in Health and Medicine. JAMA: The Journal of the American Medical Association, *276*, No. 14, pp. 1172 – 1177.

SERRANO, B. – De SANJOSE, S. – TOUS, S. – QUIROS, B. – MUNOZ, N. – BOSCH, X. – ALEMANY L. (2015): Human Papillomavirus Genotype Attribution for HPVs 6, 11, 16, 18, 31, 33, 45, 52 and 58 in Female Anogenital Lesions. European Journal of Cancer, *51*, No. 13, pp. 1732 – 1741. DOI: 10.1016/j.ejca.2015.06.001.

SKODA EMPLOYEES HEALTH INSURANCE FUND (ZPS) (2021): Příspěvky na očkování. Available at: <http://www.zpskoda.cz/pro-pojistence/zdravotni-programy-2021/prispevky-na-ockovani>. Last accessed on 2021-07-09.

STATE INSTITUTE FOR DRUG CONTROL (SUKL) (2019): Dodávky léčiv – se zaměřením na léčivé přiıpravky. Available at: <https://www.sukl.cz/2019>. Last accessed on 2021-07-08.

STATE INSTITUTE FOR DRUG CONTROL (SUKL) (2020a): Dodávky léčiv – se zaměřením na léčivé přípravky. Available at: <https://www.sukl.cz/2020>. Last accessed on 2021-07-08.

STATE INSTITUTE FOR DRUG CONTROL (SUKL) (2020b): Postup pro posuzování analýzy nákladové efektivity. Methodological procedure SP-CAU-028-W. Last accessed on 2021-07-24.

STATE INSTITUTE FOR DRUG CONTROL (SUKL) (2021): Databáze léků. Available at: <https://www.sukl.cz/modules/medication/search.php>. Last accessed on 2021-07-07.

TANTITAMIT, T. – VASURATNA, A. – KHEMAPECH, N. – HAVANOND, P. – TERM-RUNGRUANGLERT, W. (2026): Cost-Effectiveness of HPV Catch-Up Vaccination Program in Women Aged 13 – 24 Years in a Middle-Income Country. Journal of Gynecologic Oncology, *37*, No. 2, e27. DOI: 10.3802/jgo.2026.37.e27.

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL (2020): Correcting Vaccine Misinformation Is a Difficult Process, Study Shows. ScienceDaily. Available at: <www.sciencedaily.com/releases/2020/01/200107104948.htm>. Last accessed on 2026-04-05.

WESTRA, T. A. – ROZENBAUM, M. H. – ROGOZA, R. M. – NIJMAN, H. W. – DAEMEN, T. POSTMA, M. J. – WILSCHUT, J. C. (2011): Until Which Age Should Women Be Vaccinated Against HPV Infection? Recommendation Based on Cost-effectiveness Analyses. The Journal of Infectious Diseases, *204*, No. 3, pp. 377 – 384. DOI: 10.1093/infdis/jir281.

WHITEHEAD, S. J. – ALI, S. (2010): Health Outcomes in Economic Evaluation: The QALY and Utilities. British Medical Bulletin, *96*, No. 1, pp. 5 – 21. DOI: 10.1093/bmb/ldq033.

WHO (2018): Denmark Campaign Rebuilds Confidence in HPV Vaccination. Available at: <https://www.who.int/news-room/feature-stories/detail/denmark-campaign-rebuilds-confidence-in-hpv-vaccination>. Last accessed on 2026-04-05.

ZOU, M. – LIU, H. – LIU, H. – WANG, M. – ZOU, Z. – ZHANG, L. (2023): Vaccinating Women Previously Treated for Human Papillomavirus-Related Cervical Precancerous Lesions Is Highly Cost-Effective in China. Frontiers in Immunology, *14*, 1119566. DOI: 10.3389/fimmu.2023.1119566.

Appendix A

Request for the Data from NZIS

1. The number of women who had a reported diagnosis of C53 at any time during the year 2018 and at the same time did not have a reported diagnosis of N87. Only women who did not die in 2018 and were born before 2018 would be identified.

- The number of women from the part **1.**, who had a reported diagnosis of C53 in 2019 as well. At the same time, did not have a reported diagnosis of N87 and did not die in 2019.
- The number of women from the part **1.**, who had a reported diagnosis of N87 in 2019 and did not die in 2019. (These women may or may not have a reported diagnosis of C53 in 2019.)
- The number of women from the part **1.**, who did not have a reported diagnosis of either C53 or N87 in 2019 and did not die in 2019.
- The number of women from the part **1.**, who died in 2019.

Each woman from the part **1.**, would thus fall into just one of the above sub-points.

2. The number of women who had a reported diagnosis of N87 at any time during the year 2018 and at the same time did not have a reported diagnosis of C53. Only women who did not die in 2018 and were born before 2018 would be identified.

- The number of women from the part **2.**, who had a reported diagnosis of N87 in 2019 as well. At the same time, did not have a reported diagnosis of C53 and did not die in 2019.
- The number of women from the part **2.**, who had a reported diagnosis of C53 in 2019 and did not die in 2019. (These women may or may not have a reported diagnosis of N87 in 2019.)
- The number of women from the part **2.**, who did not have a reported diagnosis of either C53 or N87 in 2019 and did not die in 2019.
- The number of women from the part **2.**, who died in 2019.

Each woman from the pert **2.**, would thus fall into just one of the above sub-points.

3. The number of women who did not have a reported diagnosis of either N87 or C53. Only women who did not die in 2018 and were born before 2018 would be identified.

- The number of women from the part **3.**, who had a reported diagnosis of N87 in 2019. At the same time, did not have a reported diagnosis of C53 in 2019 and did not die in 2019.
- The number of women from the part **3.**, who had a reported diagnosis of C53 in 2019 and did not die in 2019. (These women may or may not have a reported diagnosis of N87 in 2019.)
- The number of women from the part **3.**, who did not have a reported diagnosis of either C53 or N87 in 2019 and did not die in 2019.
- The number of women from the part **3.**, who died in 2019.

Each woman from the part **3.**, would thus fall into just one of the above sub-points.

Appendix B

Calculations of Costs and QALY for Strategy 1

T a b l e B.1

Total Costs and QALY of the Whole Cohort Assuming the Efficacy of the Vaccine to be 90%

90%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis							
0% VACC		55,302	2,459,371	26,009	1,157,091	18,248	812,018
100% VACC		54,901	2,462,801	25,843	1,159,353	18,140	813,795
Current setup							
Vaccinated	0.658	36,125	1,620,523	17,005	762,854	11,936	535,477
Unvaccinated	0.342	18,913	841,105	8,895	395,725	6,241	277,710
SUBTOTAL		55,038	2,461,628	25,900	1,158,579	18,177	813,187
VACC	32,900	134		134		134	
TOTAL		55,172		26,034		18,310	
Intervention							
Vaccinated	0.8	43,921	1,970,241	20,675	927,482	14,512	651,036
Unvaccinated	0.2	11,060	491,874	5,202	231,418	3,650	162,404
SUBTOTAL		54,981	2,462,115	25,877	1,158,901	18,161	813,440
VACC	40,000	162		162		162	
TOTAL		55,144		26,039		18,329	

Note: This table shows the total costs and QALYs for Strategy 1 and the current situation, excluding campaign costs from the ICER calculation. It assumes 90% vaccine efficacy and adjusts the percentages of vaccinated and unvaccinated women based on 0% and 100% coverage scenarios shown above. Vaccination costs are included.

Source: Authors' calculations based on data provided by UZIS.

T a b l e B.2

Total Costs and QALY of the Whole Cohort Assuming the Efficacy of the Vaccine to be 80%

80%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis							
0% VACC		55,302	2,459,371	26,009	1,157,091	18,248	812,018
100% VACC		54,947	2,462,412	25,862	1,159,097	18,152	813,593
Current setup							
Vaccinated	0.658	36,155	1,620,267	17,017	762,686	11,944	535,344
Unvaccinated	0.342	18,913	841,105	8,895	395,725	6,241	277,710
SUBTOTAL		55,068	2,461,372	25,912	1,158,411	18,185	81,3055
VACC	32,900	134		134		134	
TOTAL		55,202		26,046		18,318	
Intervention							
Vaccinated	0.8	43,957	1,969,930	20,690	927,278	14,522	650,875
Unvaccinated	0.2	11,060	491,874	5,202	231,418	3,650	162,404
SUBTOTAL		55,018	2,461,804	25,892	1,158,696	18,171	813,278
VACC	40,000	162		162		162	
TOTAL		55,180		26,054		18,334	

Note: The table shows total costs (in millions) and QALYs for Strategy 1 and the current scenario. Campaign costs are excluded here but included in the ICER calculation. It assumes 80% vaccine efficacy, with vaccinated and unvaccinated percentages based on 0% to 100% coverage scenarios. Vaccination costs are factored in.

Source: Authors' calculations based on data provided by UZIS.

Appendix C

Calculations of Costs and QALY for Strategy 2

Table C.1

Total Costs and QALY for Current Setting Assuming 90% Vaccine Efficacy

90%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis: 13 only							
Inflow	I	6,085	272,367	5,815	260,249	5,645	252,686
Inflow	II	160,601	7,141,114	72,276	3,214,450	48,978	2,178,618
0% VACC		166,686	7,413,481	78,091	3,474,699	54,624	2,431,304
Inflow	I	6,075	272,716	5,805	260,581	5,636	253,007
Inflow	II	159,418	7,151,216	71,799	3,220,859	48,674	2,183,529
100% VACC		165,494	7,423,932	77,604	3,481,440	54,311	2,436,537
Current setup							
Vaccinated	0.658	108,895	4,884,947	51,064	2,290,788	35,736	1,603,241
Unvaccinated	0.342	57,007	2,535,410	26,707	1,188,347	18,681	831,506
SUBTOTAL		165,901	7,420,358	77,771	3,479,135	54,418	2,434,747
VACC	32,900	401		389		382	
TOTAL		166,302		78,160		54,800	

Note: The table calculates total costs (in millions) and QALY for the current scenario, assuming 90% vaccine efficacy. Percentages of vaccinated and unvaccinated women are based on 0% to 100% coverage levels. Vaccination costs are included.

Source: Authors' calculations based on data provided by UZIS.

Table C.2

Total Costs and QALY for Strategy 2 Assuming 90% Vaccine Efficacy

90%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis: 13 – 15							
Inflow	I	6,629	296,499	6,343	283,695	6,164	275,696
Inflow	II	160,070	7,117,204	72,039	3,203,641	48,818	2,171,269
0% VACC		166,699	7,413,703	78,382	3,487,336	54,982	2,446,964
Inflow	I	6,616	296,957	6,330	284,130	6,152	276,116
Inflow	II	158,885	7,127,243	71,559	3,210,057	48,512	2,176,204
100% VACC		165,500	7,424,200	77,889	3,494,187	54,663	2,452,320
Current setup							
Vaccinated	0.8	132,400	5,939,360	62,311	2,795,349	43,730	1,961,856
Unvaccinated	0.2	33,340	1,482,741	15,676	697,467	10,996	489,393
SUBTOTAL		165,740	7,422,100	77,988	3,492,817	54,727	2,451,249
VACC	120,000	568		568		568	
TOTAL		166,308		78,556		55,295	

Note: The table shows total costs (in millions) and QALY for Strategy 2, assuming 90% vaccine efficacy. Percentages of vaccinated and unvaccinated women align with rows for 0% and 100% coverage. Vaccination costs are included.

Source: Authors' calculations based on data provided by UZIS.

T a b l e C.3

Total Costs and QALY for Current Setting Assuming 80% Vaccine Efficacy

80%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis: 13 only							
Inflow	I	6,085	272,367	5,815	260,249	5,645	252,686
Inflow	II	160,601	7,141,114	72,276	3,214,450	48,978	2,178,618
0% VACC		166,686	7,413,481	78,091	3,474,699	54,624	2,431,304
Inflow	I	6,076	272,677	5,806	260,544	5,636	253,007
Inflow	II	159,553	7,150,095	71,854	3,220,142	48,709	2,182,980
100% VACC		165,630	7,422,772	77,660	3,480,686	54,345	2,435,987
Current setup							
Vaccinated	0.658	108,984	4,884,184	51,100	2,290,292	35,759	1,602,879
Unvaccinated	0.342	57,007	2,535,410	26,707	1,188,347	18,681	831,506
SUBTOTAL		165,991	7,419,594	77,807	3,478,639	54,441	2,434,385
VACC	32,900	401		389		382	
TOTAL		166,392		78,196		54,822	

Note: The table shows total costs (in millions) and QALY for the current scenario, assuming 80% vaccine efficacy. Percentages of vaccinated and unvaccinated women are based on 0% to 100% coverage. Vaccination costs are included.

Source: Authors' calculations based on data provided by UZIS.

T a b l e C.4

Total Costs and QALY for Strategy 2 Assuming 80% Vaccine Efficacy

80%		Costs 0%	QALY 0%	Costs 3%	QALY 3%	Costs 5%	QALY 5%
Calculation basis: 13 – 15							
Inflow	I	6,629	296,499	6,343	283,695	6,164	275,696
Inflow	II	160,070	7,117,204	72,039	3,203,641	48,818	2,171,269
0% VACC		166,699	7,413,703	78,382	3,487,336	54,982	2,446,964
Inflow	I	6,617	296,906	6,331	284,082	6,153	276,069
Inflow	II	159,020	7,126,125	71,614	3,209,338	48,547	2,175,650
100% VACC		165,637	7,423,031	77,945	3,493,420	54,699	2,451,719
Intervention							
Vaccinated	0.8	132,510	5,938,424	62,356	2,794,736	43,760	1,961,375
Unvaccinated	0.2	33,340	1,482,741	15,676	697,467	10,996	489,393
SUBTOTAL		165,849	7,421,165	78,033	3,492,203	54,756	2,450,768
VACC	120,000	568		568		568	
TOTAL		166,417		78,601		55,324	

Note: The table presents total costs (in millions) and QALY for Strategy 2, assuming 80% vaccine efficacy. It adjusts percentages of vaccinated and unvaccinated women based on 0% and 100% coverage rows. Vaccination costs are included.

Source: Authors' calculations based on data provided by UZIS.