Girls' preferences for HPV vaccination: a discrete choice experiment

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Abstract

A discrete choice experiment was developed to investigate if girls aged 12-16 years make trade-offs between various aspects of human papillomavirus (HPV) vaccination, and to elicit the relative weight that girls' place on these characteristics. Degree of protection against cervical cancer, protection duration, risk of side-effects, and age of vaccination, all proved to influence girls' preferences for HPV vaccination. We found that girls were willing to trade-off 38% protection against cervical cancer to obtain a life-time protection instead of a protection duration of 6 years, or 17% to obtain an HPV vaccination with a 1 per 750,000 instead of 1 per 150,000 risk of serious side-effects. We conclude that girls indeed made a trade-off between degree of protection and other vaccine characteristics, and that uptake of HPV vaccination may change considerably if girls are supplied with new evidence-based information about the degree of protection against cervical cancer, the protection duration, and the risk of serious side-effects.

Keywords: Cervical cancer; Human papillomavirus; Vaccination; Preferences; Discrete choice experiment

Abbreviated title: Girls' preferences for HPV vaccination

1. Introduction

In countries with cytological screening programmes the mortality of cervical cancer has significantly decreased [1]. Since the discovery of human papillomavirus (HPV) as the cause of cervical cancer [2], new types of cervical cancer prevention, such as HPV screening and HPV vaccination, have been developed [3]. Currently HPV vaccines are available against HPVs 16 en 18, which have been estimated to cause 73-76% of cases of cervical cancer in Europe [4, 5]. HPV vaccination is useful for women who have not been previously infected with these HPV types since the protection against cancer for women with existing or previous infections of type 16 or 18 is low. By the end of 2008 fifteen countries of the European Union had decided to introduce HPV vaccination into their national immunisation schedule for adolescent girls, while another six have started the decision-making process with a recommendation favouring introduction [6].

Attitude towards and uptake of the offered HPV vaccine may be influenced by its perceived advantages and drawbacks. Individuals may be willing to undergo an HPV vaccination despite several drawbacks (risk of side effects, injections needed) in order to maximize health benefit or, vice versa, they may accept a lower health benefit in order to avoid side-effects of vaccination. Research has shown that preferences (i.e. individual's valuation) can have a major impact on the willingness to use health care services [7]. Several qualitative studies gave some insights into girls' preferences for HPV vaccination [8-10]. However, quantitative studies investigating girls' preferences for HPV vaccination and their willingness to trade-off between protection against cervical cancer and other characteristics of HPV vaccination are lacking.

Therefore, this study investigates the preferences of girls aged 12-16 years for HPV vaccination through a discrete choice experiment (DCE), a quantitative approach that is increasingly used in health care [11, 12].

2. Materials and Methods

2.1 HPV vaccination

In the Netherlands, a National Immunisation Programme (NIP) provides vaccinations against diphtheria, pertussis (whooping cough), tetanus, polio, type B Haemophilus influenzae, hepatitis B, mumps, measles, rubella (German measles) and meningococcosis C. In 2009, HPV vaccinations for 12-year-old girls (given as a series of three injections) were added to the NIP. To begin with, a catch-up programme was organised for girls aged 13 to 16 years. In the Netherlands, the HPV vaccine Cervarix is used, which protects against HPV-16 and HPV-18. Parental consent for this vaccination is not needed as teenagers at the age of 12 years or older are officially allowed to decide for themselves whether they want to be vaccinated. All Dutch NIP vaccinations are offered free of charge.

2.2 Discrete Choice Experiment

DCEs, with their origin in marketing, are a novel approach to assess preferences for medical interventions. In DCEs it is assumed that a medical intervention, such as a vaccination programme, can be described by its characteristics (attributes; e.g. protection duration).[13] Those characteristics are further specified by variants of that characteristic (attribute levels; e.g. for protection duration: 6 years, 25 years, and lifetime). A second assumption is that the individual's preference for a medical intervention is determined by the levels of those attributes [13]. The relative importance of attributes and the trade-offs that respondents make between them can be assessed by offering a series of choices between two or more medical intervention alternatives with different combinations of attribute levels (see Table 1 for an example of a choice set) [14]. In comparison to other stated preference techniques, a DCE presents a reasonably straightforward task and one which more closely resembles a real-world decision, i.e. trading-off health and non-health outcomes [15].

2.3 Attributes and attribute levels

We selected the most relevant HPV vaccination attributes and their levels based on the literature, interviews with experts in the field of HPV vaccination (n=8), and focus groups data (n=4; 36 parents participated (34 female and 2 male), aged 33 to 53 years with at least one child in the age of 8 to 14 years. We did not include girls in the focus groups, because at that time it was expected that the target group for HPV vaccination would be 9-year old girls, who are under Dutch law not allowed to decide themselves about the vaccination uptake). In the focus groups we collected data on the attributes that individuals expected to be important or that had been important in their decision to participate in an HPV vaccination programme. Experts were asked to comment on a list of attributes, which were derived from a literature review, and to rank them in order of importance. Based on these data we selected the five most important attributes as identified by both groups: 1) degree of protection against cervical cancer; 2) protection duration; 3) serious side-effects (e.g. hospitalization); 4) mild side-effects (e.g. nausea); and 5) age of vaccination. Attributes that were plausible and relevant both clinically and from a policy viewpoint were determined. A sufficiently wide range of levels was used to avoid respondents ignoring attributes because of too small differences in levels. The attributes and levels are presented in Table 2.

2.4 Study design and questionnaire

The combination of five attributes with three levels each resulted in 243 (3^5) hypothetical HPV vaccination alternatives. Since it is not feasible to present a single individual with all these alternatives (i.e. full factorial design), we generated a sample of alternatives from all these 243 alternatives (i.e., we used a fractional factorial design) by means of a catalogue, which contains a library of orthogonal arrays [16]. Fifty-four HPV vaccination alternatives

proved sufficient to estimate all main effects and a number of two-way interactions between attributes in a regression analysis. In this fractional factorial design, attributes were independent of each other, thus guaranteeing orthogonality (i.e. the design was defined in such a way that the attributes could not represent the same facts), and attribute levels occurred with equal frequency, maintaining level balance [17]. Choice sets were designed using the discrete choice experiment software of Street and Burgess [18]. Our design, which contained 54 choice sets, had an efficiency of 82% compared with an optimal choice design. This means that our design was a near optimal design that counterbalanced statistical reasons and practical reasons (a higher amount of choice sets will result in a more precise estimation of the coefficients, however as a consequence (much) more respondents are needed). Choice sets consisted of two HPV vaccination alternatives and a 'no HPV vaccination' option to allow respondents to 'opt out' (Table 1); HPV vaccination is a preventive medical intervention and, as in real life, respondents are not obliged to opt for HPV vaccination. Respondents were asked to consider all three options in a choice set as realistic alternatives and to choose the option that appealed most to them. Presenting a single individual with a large amount of choice sets is expected to result in a lower response rate and/or lower response reliability [19, 20]. To avoid this, we used a blocked design [14], which resulted in dividing the 54 choice sets over six types of questionnaires containing nine choice sets each.

Each questionnaire started with a detailed description of the attributes and their levels (the (complete) questionnaire is available from the authors on request). Pictures, graphs and pictograms were included to demonstrate percentages and rates. To assess the understanding of the attributes (protection levels against cervical cancer, levels of serious side effects, and levels of mild side-effects) the questionnaire contained a dominant choice set (rationality test). In this set one of two HPV vaccination alternatives was characterised by equal or logically preferable levels on all attributes.

The main part of each questionnaire comprised nine choice sets. Furthermore, the following data were collected: age at completing the questionnaire, level of education, religious affiliation, country of birth, parents' countries of birth, history of childhood vaccinations, and of vaccinations against HPV. To check the convergent validity of the DCE, respondents were asked to rank the five attributes of HPV vaccination from most important to least important. The questionnaire was pilot tested to check for any problems in interpretation and face validity (n=16).

2.5 Study sample

A representative sample of 359 girls aged 12 to 16 years were randomly approached at 30 classes from four secondary schools and cities located in the north-east (rural area) and west part (urban area) of the Netherlands. This age range was chosen based on current Dutch policy guideline. Calculation of optimal sample sizes for estimating non-linear discrete choice models from DCE data is complicated as it depends on the true values of the unknown parameters estimated in the choice models [21]. Lancsar and Louviere [21] mentioned that one rarely requires more than 20 respondents per parameter to estimate reliable models; our DCE contained eight parameters in the main effects model (see Equation 1), which meant that we had to include at least 160 respondents. Taking into account a suboptimal response rate, and some two-way interactions between attributes, we aimed at having at least 300 questionnaires completed.

2.6 Procedure

Questionnaires were completed in the classroom or auditorium in the presence of a researcher or assistant. First, general information was given about HPV, cervical cancer, the causal link between them, HPV vaccinations, cervical cancer screening and the NIP (± 5 minutes). This

was followed by an explanation of DCE questions (± 5 minutes). Subsequently, respondents completed the questionnaire on paper (± 20-30 minutes). The whole procedure lasted at most 45 minutes. Beforehand parents had received an information letter covering the purpose, voluntariness and anonymity of the study and an opt-out form. Approval for the study was obtained from the Medical Ethics Committee, Erasmus MC, University Medical Centre Rotterdam.

2.7 Statistical analyses

The DCE was analysed by taking each choice among the three options (two HPV vaccination alternatives, and a 'no HPV vaccination' alternative) as an observation, i.e. two 'no' and one 'yes'. The observations were analysed by a mixed logit regression model to take heterogeneity as well as correlation between the choice task completed by each individual into account [14]. After testing for linear continuous effects of one or more attributes, the following utility model was estimated:

$$V = \beta_0 + \beta_1 \text{EFFECTIVENESS} + \beta_2 \text{DURATION\_25Y} + \beta_3 \text{DURATION\_LIFETIME} + \beta_4 \text{SERIOUS\_1/150,000} + \beta_5 \text{SERIOUS\_1/30,000} + \beta_6 \text{MILD} + \beta_7 \text{AGE\_12Y} + \beta_8 \text{AGE\_14Y} \quad \textit{(Eq. 1)}$$

V is the observable relative utility that is composed of the preference scores for the individual β-coefficients of the model. β_0 is a constant reflecting respondents' preference for receiving HPV vaccination relative to 'no HPV vaccination'. β_1-β_8 are coefficients of the attributes indicating the relative weight individuals place on a certain attribute(level). The statistical significance of a coefficient (p-value ≤ 0.05) indicates that individuals differentiated between one attribute (or attribute level) and another in making stated choices. A priori, we expected

all attributes to be statistically significant. The sign of a coefficient reflects whether the attribute has a positive or negative effect on preference score. We expected that only the attribute 'mild' and the estimated attribute levels of 'serious side-effects' would have a negative effect (i.e., a negative sign).

The value of each coefficient represents the importance respondents assign to an attribute(level). However, different attributes utilise different units of measurement. For example, the coefficient for 'protection against cervical cancer' represents the importance per absolute 10% protection rate. When looking at an HPV vaccination that generates a 70% protection rate, the coefficient should be multiplied seven times (7 * coefficient of 'protection against cervical cancer' of 10% = coefficient of 'protection against cervical cancer' of 70%).

To explore the impact of respondents who failed the rationality test, sensitivity analyses were conducted by excluding such individuals from the sample and rerunning the analysis.[22, 23] Also, two-way interactions were added to the main effects model to test which two-way interactions were significant and improved the fit of the model.

To investigate the willingness of girls to trade-off protection against cervical cancer to achieve an improvement in one level of the other HPV vaccination attributes, we calculated the ratios between the coefficients of the attributes with protection against cervical cancer as the denominator. For example, $-\beta_6/\beta_1$ indicates how much protection against cervical cancer girls were willing to forego to get an HPV vaccination programme that had a five percent lower risk in mild side-effects.

Finally, choice probabilities were also calculated to provide a way to convey DCE results to decision makers that is more easily understandable. The probability that an individual says "yes" to an HPV vaccination programme is equal to:

$$P = 1 / (1+e^{-V})$$

(Eq. 2)

where V is defined as in Equation 1. We calculated the choice probability (i.e. the mean uptake) for the base case. The base case used in this study represents an HPV vaccination programme at the age of 12 years, a 1/30 risk of mild side-effects, a 1/150,000 risk of serious side-effects; a protection duration of 6 years, and a 70% protection against cervical cancer. We presented these results in a 'tornado' graph [17] to illustrate the marginal effect of varying one attribute level at a time from the base case, holding all other attributes constant. This base was chosen to correspond i) with an HPV vaccination programme that contained most plausible levels based on literature, and ii) with the Dutch situation (HPV vaccination programme at the age of 12 years). The graph shows how each attribute systematically affects choices relative to the base case. Noteworthy, in the calculation of the mean uptake we took all heterogeneity into account as the mean uptake is not just equal to the uptake of someone with average coefficient values. Additionally, we calculated the minimum acceptable efficacy and maximum acceptable risk of mild side-effects, in which the base case HPV vaccination programme is preferred over no HPV vaccination (i.e. relative utility composed of the preference scores for the individual β-coefficients and standard deviations of the model is higher than zero).

3. Results

3.1 Respondents

The response rate was 312/359 (87%). The respondents had a mean age of 13.3 years (SD=1.0). Of all respondents, 58% had at least one dose of HPV-vaccine, 62% had a higher secondary educational level, and 38% considered themselves to be religious (Table 3). Results of direct ranking showed that the protection against cervical cancer, the protection duration, and the risk of serious side-effects of HPV vaccination were considered the most important attributes of an HPV vaccination programme (Figure 1).

3.2 DCE results

The 'no HPV vaccination' option was chosen in 21.4% of the choice sets. Twenty-one out of 312 girls (6.7%) always chose the 'no HPV vaccination' option. All five vaccination characteristics proved to influence girls' preferences for HPV vaccination ($p<0.05$; Table 4). The positive or negative directions of the coefficients of the characteristics were consistent with our a priori hypotheses and showed, therefore, theoretical validity. The positive sign given to the coefficients 'degree of protection against cervical cancer' and 'protection duration' indicated that respondents preferred an HPV vaccination generating a higher degree of protection and a longer protection duration over an HPV vaccination that generates a lower degree of protection and a shorter protection duration. The negative signs for 'side-effects' indicate that girls preferred an HPV vaccination programme with low serious and low mild side-effects. The non-significant coefficient of the characteristic level 'vaccination at age 14 years' indicated that respondents did not significantly prefer this age of vaccination over a vaccination at age 9 years. However, respondents significantly preferred vaccination at age 12 years over vaccination at age 9 years. Most estimated standard deviations were significant,

which indicated preference heterogeneity among girls for several characteristics of HPV vaccination.

The results of the sensitivity analyses indicated that i) excluding respondents who 'failed' the rationality test (2.6% of the respondents) had no relevant impact on the size or relative importance of the attributes, and ii) none of the two-way interactions were significant and improved the fit of the model (data not shown).

Comparing our DCE results with the results of the direct ranking in our questionnaire, both preference methods showed that protection against cervical cancer, protection duration, and risk of serious side-effects of HPV vaccination were considered the most important attributes of an HPV vaccination programme. These results support convergent validity of the DCE results.

3.3 Trade-offs

Based on the expressed preferences, girls showed their willingness to trade-off protection against cervical cancer to achieve an improvement in one level of the other HPV vaccination attributes (Table 5). On average, girls were willing to trade-off 38% protection against cervical cancer to obtain an HPV vaccination programme with a life-time protection duration instead of a protection duration of 6 years. Girls were willing to trade-off 17% protection against cervical cancer to obtain a vaccination with a risk of serious side effects of 1/750,000 instead of 1/150,000, 9% protection against cervical cancer to get an HPV vaccination that had a five percent lower risk in mild side-effects, and 7% protection against cervical cancer to get an HPV vaccination at age 12 years instead of age 9 years. Considering the relative trade-off between the risk of mild and serious side effects, girls were willing to accept a 9.7% (7.1% to 13.2%) increased risk of mild side effects if the risk of serious side effects decreased from 1/150,000 to 1/750,000.

3.4 Expected uptake of HPV-vaccination

We found an expected uptake of the base case HPV vaccination programme (70% protection against cervical cancer, at age 12 years, 1/30 risk of mild side-effects, 1/150,000 risk of serious side-effects, and protection duration of 6 years) of approximately 77% (CI: 74-80%). Especially an increased risk of serious side-effects from 1/150,000 to 1/30,000, a life-time protection instead of a protection duration of 6 years, or a decrease in protection against cervical cancer from 70% to 50% had a relatively large impact on the average expected uptake (a decrease of 14.6%, an increase of 12.0%, and a decrease of 7.3%, respectively) (Figure 2). Assuming an HPV vaccination at age 12 years, a 1/30 risk of mild side-effects, a 1/150,000 risk of serious side-effects, and a protection duration of 6 years, the minimum efficiency of this HPV vaccination should be 15% to be preferred over no vaccination. Or assuming an HPV vaccination at age 12 years, a 1/150,000 risk of serious side-effects, a protection duration of 6 years, and a 70% protection rate against cervical cancer, the maximum risk for mild side effects should be 34% to be preferred over no vaccination.

4. Discussion

The present study shows that girls made a trade-off between vaccine characteristics. Degree of protection against cervical cancer, duration of protection, risk of serious side-effects (e.g. hospitalization), risk of mild side-effects (e.g. nausea), and age of vaccination, all proved to influence girls' preferences for HPV vaccination. On average, girls were willing to forego protection against cervical cancer if the protection duration of HPV vaccination was longer, or if the risk of serious or mild side-effects of HPV vaccination was lower. An increase in protection duration, an increase in risk of serious side-effects, or a decrease in degree of protection against cervical cancer had a relatively large impact on the average expected uptake.

There are no previous DCEs investigating how characteristics of HPV vaccination determine girls' preferences for participation in HPV vaccination. However, Dahlström et al. [24] investigated the attitudes to HPV vaccination among parents of children aged 12-15 years. They found that beliefs about vaccine safety and efficacy were strong correlates of willingness to vaccinate. Dempsey et al. [25], who investigated the reasons why mothers do or do not have their adolescent daughters vaccinated against HPV, concluded that addressing safety concerns may be one of the most useful targets for future interventions to increase HPV vaccine utilisation. Brown et al. [26], who estimated how features of HPV vaccines affect mothers' perceived benefit for daughters aged 13-17 years, showed that cervical cancer protection and duration of effectiveness were the most important attributes. All these results are in line with the findings of our study, which show that protection against cervical cancer, protection duration, and serious side-effects play an important role in girls' choices for HPV vaccination. In a vaccination context, Hall et al. [27] used a DCE to study the introduction of varicella vaccination. They showed that immunisation rates would increase in case of a lower incidence of mild and severe side-effects, which is similar to our study results.

The possibility to estimate the willingness to forego protection against cervical cancer is an additional advantage of DCE. However, in our opinion this additional advantage is limited. In the context of willingness to pay (WTP), earlier studies showed that the WTP derived from a DCE changed if a wider cost range was chosen [28], or that the WTP derived from an open-ended question differed from the WTP derived from a DCE [29]. This same phenomenon might be possible for the willingness to forego protection against cervical cancer derived from a DCE. Further research in this area is needed and, meanwhile, we recommend the interpretation of these absolute willingness values to forego protection against cervical cancer in a relative manner (i.e. ranking order).

Our results showed that the expected uptake of the base case HPV vaccination programme was much higher (76%) than the attendance rate in the first HPV vaccination round in the Netherlands in 2009 (49%) [30]. This 49% is also relatively low compared to the Dutch National Immunisation Programme for protection against childhood infectious disease (>95%).[31] Possible clarifications are uncertainty about the degree of protection against cervical cancer, protection duration, and serious side-effects (all of which played the most important role in girls' preferences for HPV vaccination). To date, follow-up data on HPV vaccinated young women are available for 7.3 years [32, 33].

The present study had several limitations. First, our sample contained a relatively large number of high educated respondents, which precludes generalisation of the findings to all girls. Second, we selected the most relevant attributes in our DCE using literature, interviews with experts in the field of HPV vaccination, and focus group data; however, this careful procedure does not guarantee that we included all attributes that are relevant to girls' preferences for HPV vaccination. Third, we did not include genital warts protection as an attribute of HPV vaccination as we did not receive signals that genital warts protection would play a role in the decision about HPV vaccination uptake, and as the Dutch vaccination

programme offers only Cervarix, which provides no protection against HPV types causing warts. However, girls may well have a preference for HPV vaccines offering warts protection. Fourth, the inclusion of percentages and rates in our discrete choice experiment, especially the inclusions of small risk levels, might have caused difficulties with understanding the choice task. Finally, the current results should preferably be validated by comparing them with the actual behaviour of girls in an HPV vaccination programme.

In conclusion, this study shows that girls made trade-offs between protection against cervical cancer and other characteristics of HPV vaccination. Especially the degree of protection against cervical cancer, protection duration, and risk of serious side-effects influenced HPV vaccination preferences. We conclude that, uptake of HPV vaccination may change considerably if girls are supplied with new evidence-based information about the degree of protection against cervical cancer, the protection duration, and the risk of serious side-effects.

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Table 1: Example of choice set

Attributes	**Program A**	**Program B**	**No vaccination**
Protection against cervical cancer	70%	90%	0%
Protection duration	Lifetime	6 years	n.a.
Serious side-effects	1:750,000	1:750,000	No risk
Mild side-effects	1:50	1:30	No risk
Age at vaccination	14 years	9 years	n.a.
Which vaccination program do you prefer?	☐ **A**	☐ **B**	☐ **None**

n.a. = not applicable

Table 2: Considered attributes and attribute levels for HPV vaccination

	Regression analysis	
Attributes and levels	**Coefficient**	**Attribute name**
Protection against cervical cancer	β_1	EFFECTIVENESS
50%		
70%		
90%		
Protection duration		
6 years (reference level)		
25 years	β_2	DURATION_25Y
lifetime	β_3	DURATION_LIFETIME
Serious side effects		
1/750,000		
1/150,00	β_4	SERIOUS_1/150,000
1/30,000	β_5	SERIOUS_1/30,000
Mild side effects	β_6	MILD
1/50		
1/30		
1/10		
Age of vaccination		
at age 9 years (reference level)		
at age 12 years	β_7	AGE_12Y
at age 14 years	β_8	AGE_14Y

Table 3: Respondent characteristics

Characteristics	**Respondents** (n=312)	
	Mean	**(SD)**
Age (years)	13.3	(1.0)
	n	**(%)**
Educational level		
Lower secondary education	38	(12.2)
Intermediate secondary education	81	(26.0)
Higher secondary education	193	(61.9)
Religion		
None	191	(61.2)
Christian (incl. Catholic, Protestant)	104	(33.3)
Moslim	11	(3.5)
Other	4	(1.3)
Country of birth		
The Netherlands	293	(93.9)
Other (UK, France, Poland, Albania, Mexico, Aruba, Afghanistan, Pakistan, China, India, Iraq, Kazakhstan, Philippines	15	(4.9)
Country of birth of parents		
Both parents in the Netherlands	256	(82.1)
One parent outside the Netherlands	23	(7.4)
Both parents outside the Netherlands	26	(8.3)
HPV vaccinated		
Yes	181	(58.0)
Vaccinated against childhood diseases		
Yes	259	(83.0)
No	5	(1.6)
Unknown	47	(15.1)

Table 4: Girls' preferences for HPV vaccination

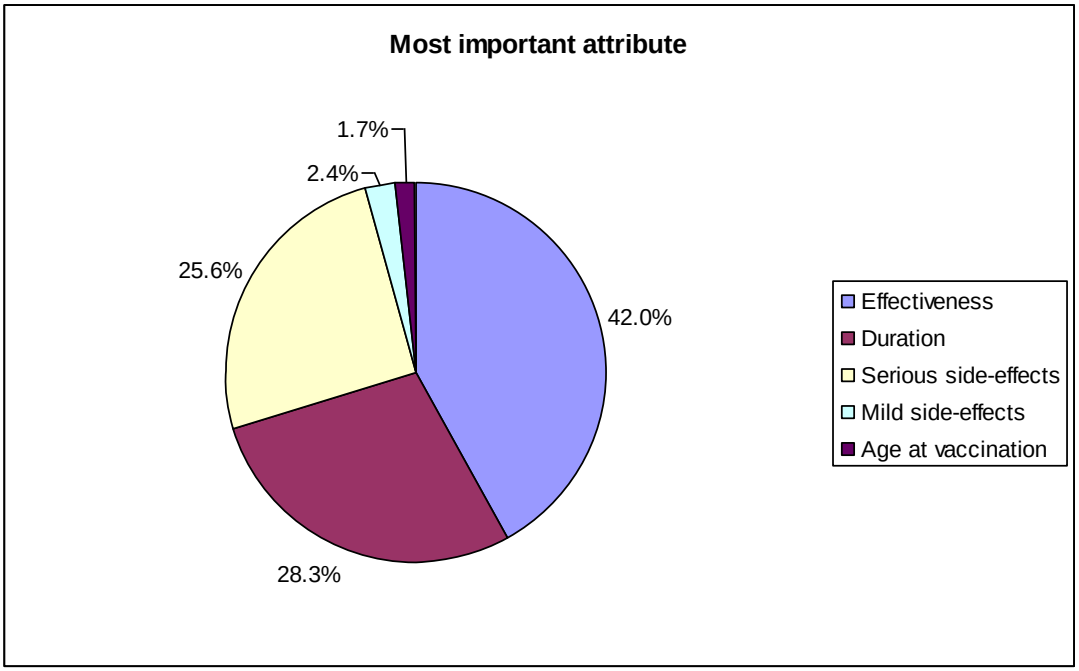
Attributes	Coefficient	**Mixed logit**	
		Value	(95% CI)
Constant (vaccination)	Mean	-0.28	(-0.92 to 0.36)
	S.D.	3.60 ***	(3.03 to 4.17)
Protection against cervical cancer (per 10%)	Mean	0.64 ***	(0.55 to 0.72)
	S.D.	0.36 ***	(0.30 to 0.42)
Protection duration 6 years (omitted)	Mean	-1.41 ***	(-1.70 to -1.12)
	S.D.	0.88 ***	(0.87 to 0.90)
Protection duration 25 years	Mean	0.20 ***	(0.08 to 0.33)
	S.D.	0.07	(-0.22 to 0.35)
Protection duration lifetime	Mean	1.20 ***	(1.03 to 1.37)
	S.D.	0.88 ***	(0.71 to 1.05)
1/750,000 risk on serious side effects (omitted)	Mean	2.15 ***	(1.89 to 2.40)
	S.D.	0.80 ***	(0.78 to 0.83)
1/150,000 risk on serious side effects	Mean	-0.55 ***	(-0.68 to -0.43)
	S.D.	0.18 *	(0.04 to 0.40)
1/30,000 risk on serious side effects	Mean	-1.60 ***	(-1.78 to -1.42)
	S.D.	0.78 ***	(0.56 to 1.01)
Mild side effects (per 5%)	Mean	-0.57 ***	(-0.71 to -0.44)
	S.D.	0.50 ***	(0.30 to 0.71)
Vaccination at age 9 years (omitted)	Mean	-0.24 ***	(-0.37 to -0.11)
	S.D.	0.34 ***	(0.32 to 0.35)
Vaccination at age 12 years	Mean	0.21 ***	(0.09 to 0.33)
	S.D.	0.04	(-0.36 to 0.27)
Vaccination at age 14 years	Mean	0.03	(-0.08 to 0.14)
	S.D.	0.34 ***	(0.18 to 0.49)
Number of responses		8,424	
Number of respondents		312	
Log-likelihood		-1,735.60	

Notes: (1) Effects coded variables used for protection duration, serious side effects, and age at vaccination; (2) Normal distribution for random coefficients used on all attributes; (3) The value of the omitted term equals the negative sum of the coefficients of the included attributes; (4) *** denotes p<.01, ** p<.05, *p<0.10 for statistical significance; (5) S.D. = standard deviation

Table 5: Girls' trade-offs between risk reduction and different aspects of a vaccination programme

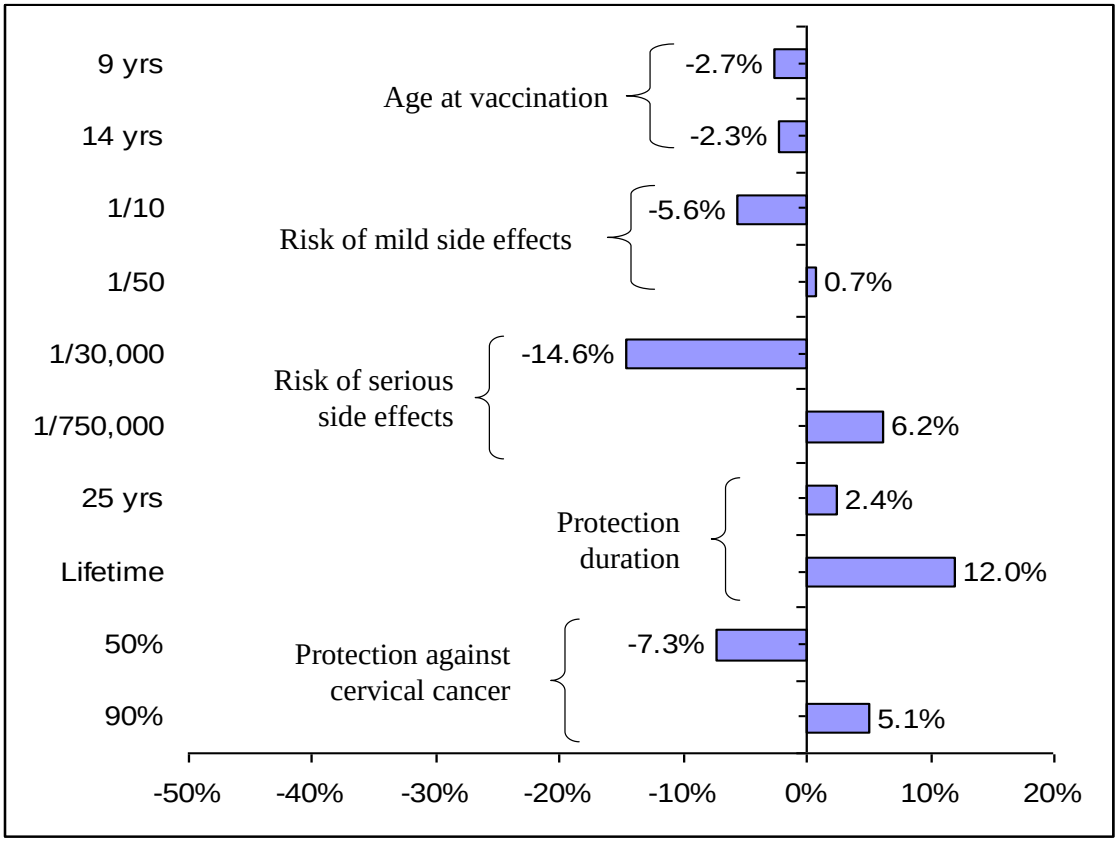
	Girls		Interpretation note
	were willing to forego protection against cervical cancer of…(%; CI)		
Protection duration	37.8	(32.1 to 44.3)	….to get a vaccination with life-time protection instead of a protection duration of 6 years
Serious side effects	17.4	(13.4 to 22.0)	….to get a vaccination with a risk of serious side effects of 1/750,000 instead of 1/150,000
Mild side effects	9.0	(6.9 to 11.2)	….to get a vaccination with a 5% lower risk of mild side-effects
Age of vaccination	6.6	(2.6 to 10.6)	…to get a vaccination at age 12 years instead of age 9 years

Figure 1: Most important vaccination characteristic based on direct ranking (n=290 respondents).



Country of birth of parents

Figure 2: Univariate marginal estimates for predicted probability of participation; highest and lowest values for attributes level changes versus base case



Note: The base case is an HPV vaccination at age 12 years, 1/30 risk of mild side-effects, 1/150,000 risk of serious side-effects; protection duration of 6 years and 70% protection against cervical cancer. This base case is indicated as zero change in the probability of the x-axis.