

# Valuation of the Economic Benefits of Human Papillomavirus Vaccine in Taiwan

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## ABSTRACT

**Objectives:** The study aims to apply the contingent valuation method to elicit the willingness-to-pay (WTP), and measure the value of a statistic life (VSL), for human papillomavirus (HPV) vaccine in Taiwan.

**Methods:** A total of 512 questionnaires were completed on women aged 20 to 55 years with at least one daughter, during March through May 2007. The respondents' WTP for the vaccines was elicited by double-bounded binary-choice questions under two scenarios: one was to protect themselves from cervical cancer (CC) and the other was for their daughter(s). The WTP was modeled as a function of the respondents' knowledge score, attitudes toward CC and HPV vaccine, the vaccination outcome scenarios, and individual characteristics. A log-normal survival model

was constructed and the maximum-likelihood method was used for estimation.

**Results:** The median regression-adjusted WTP was estimated at US\$1098 to US\$1233 (US\$913–1004) for vaccinating the daughter (mother); and the VSL was estimated at approximately US\$0.65 to US\$4.09 (US\$0.56–3.16) million for vaccinating the daughter (mother).

**Conclusions:** The study results provided important evidences on the monetary value women placed on a HPV vaccine, and the differential benefits between vaccinating the women and their daughters.

**Keywords:** contingent valuation method, human papillomavirus vaccine, value of a statistical life, willingness-to-pay.

## Introduction

Pap smear tests for women aged  $\geq 30$  years aimed at preventing cervical cancer (CC) have been covered by the National Health Insurance in Taiwan ever since 1995. Although studies show that these tests have significantly reduced the incidence and mortality of CC in women attending regular screening and follow-up [1,2], incidences of CC in Taiwan remain among the highest in Asia [3]. According to official statistics, in 2007, only 51.5% of women aged 30+ years had received at least one Pap smear test in the previous 3-year period [2].

Because this limited coverage rate is incapable of providing comprehensive protection against CC [4], alternative strategies should be considered to relieve the bottleneck in current CC prevention practices. Nevertheless, new hope was recently provided by the results of clinical research, with scientists discovering that the primary underlying cause of CC is human papillomavirus (HPV) infection, a very common sexually-transmitted virus [5].

Quadrivalent (Gardasil, Merck & Co., Whitehouse Station, NJ) and bivalent (Cervarix, GlaxoSmithKline Biologicals, Rixensart, Belgium) HPV vaccines were respectively licensed by the Taiwan Bureau of Pharmaceutical Affairs in 2006 and 2007; however, given the list price for either vaccine at approximately US\$364 (US\$1 = NT\$33 in 2007) for a three-dose course, the vaccines may not be affordable for all girls, the Taiwanese government has considered introducing a national HPV-vaccination program to combat CC in teenage girls. An evaluation of investment in HPV-vaccination programs from a cost-benefit

perspective is therefore imperative to aid policy decision-making on vaccines.

The contingent valuation method (CVM), using willingness-to-pay (WTP), evaluates a life according to specific amounts that individuals are willing to pay to reduce the probability of illness/death, while also allowing participants to express their motivation and perceptions on their personal preventive care/treatment needs, which are key elements to the success of high acceptance and coverage rates of vaccination programs. CVM has been extensively applied in the prior studies to elicit WTP and estimate the benefits of actual/hypothetical vaccines [6–11], with value of a statistic life (VSL) based on the CVM-elicited WTP or wage-differential approach [12] also being estimated in many developed and developing countries when drawing up government policies and regulations [13].

The study aims to apply the CVM to elicit WTP for a hypothetical HPV vaccine capable of reducing the risks and/or subsequent death from CC attributable to HPV infections. VSL is also estimated to demonstrate how much women attach to a life under a CC risk-reduction scenario.

## Methods

The including criteria were women aged 20–55 years with at least one daughter, with face-to-face interviews being undertaken, as suggested in the prior CVM studies [14,15]. Patients were interviewed by well-trained interviewers between March and May 2007 while awaiting their treatment at gynecological outpatient clinics in Taipei Medical University Hospital and Municipal Wan Fang Hospital.

A questionnaire was designed to elicit respondents' WTP for an HPV vaccine capable of preventing CC. For the content and administration of the questionnaire, please see Valuation of the Economic Benefits of Human Papilloma Virus Vaccine in Taiwan

Address correspondence to: Chao-Hsiung Tang, School of Health Care Administration, Taipei Medical University, 250 Wu-Xin Street, Taipei 110, Taiwan. E-mail: chtang@tmu.edu.tw  
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*Value in Health* Supporting Information, Part I at: [http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3\\_Tang.asp](http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3_Tang.asp). One point was awarded for each question answered correctly from the five true/false/don't-know questions, thereby providing a variable "knowledge score" for HPV. Basic information was provided by the interviewers to those with no prior knowledge of HPV before inquiring into their attitudes toward HPV vaccine and WTP for the vaccines. A five-point Likert scale was used, with higher scores indicating higher positive attitudes toward the CC and HPV vaccine.

WTP for HPV vaccines was elicited by double-bounded binary-choice (DBBC) questions as suggested in the prior studies [16,17], with respondents being asked to respond to CVM questions under two scenarios; whether they would be willing to pay for HPV vaccinations at a specified price, 1) for themselves, and 2) for their daughter(s).

To examine the question order effect, respondents were randomly assigned to answer either the WTP for vaccinating themselves first, followed by the WTP for vaccinating their daughter(s), or vice versa. The following three key parameters regarding the features of CC epidemiology and the HPV vaccines were also randomly assigned to assess the respondents' WTP.

First, the risk of CC was described as either 50 or 100 per 100,000 per year in Taiwan. Second, mortality, conditional on being afflicted by CC, was described as either 0.05 or 0.1. Third, to test the sensitivity of the elicited WTP to the scope of the benefits, the duration of the vaccine protection was assumed to be either 10 or 20 years.

In the pretest interviews, the specified first-bid price was divided into four subsamples: US\$152, US\$303, US\$606, and US\$909. The proportion of the subsamples answering "Yes" to the highest price of US\$909 was 69% (56%) for vaccinating the daughter (mother). To better capture the extremes, the starting-point prices of the first bid for the four random subsamples were therefore raised to US\$303, US\$606, US\$909, and US\$1212.

If the respondent's answer to the first bid offered was "Yes", the interviewer then doubled the bid and asked the same question again. If the initial answer was "No", the interviewer then reduced the bid price by half and continued by asking the same question again; this procedure resulted in WTP values being provided at intervals between the "Yes" and "No" responses in the double-bounded questions.

The validity and reliability have been critical issues requiring further investigation when applying CVM in health-care decision-making processes [18]. In the early stages of developing the questionnaire, one CC epidemiologist, two physicians specializing in gynecological cancers, and two academic researchers were invited to examine the content validity. Furthermore, it has been suggested in the prior studies that the results of the relationships between income the elicited WTP, and the scope effect in the regression model could be used to test theoretical validity [18].

Finally, there were two questions in the questionnaire which were designed to test the reliability of the respondents' answers. First, an open question on WTP was elicited to examine the reliability of the values elicited from the DBBC questions. Second, at the end of the interview the respondents were asked if they felt that it was reasonable for manufacturers to charge US\$364 for an actual HPV vaccine in the market.

Respondents considered to have provided contradictory answers were: 1) those whose WTP amount elicited from the open question lay outside the WTP intervals elicited from the double-bounded questions; or 2) those whose higher WTP interval bound elicited from the double-bounded questions was below US\$364, while nevertheless agreeing that US\$364 was a reason-

able price for the HPV vaccines. Such contradictory responses were received from 53 respondents; these were therefore discarded from the sample, with another 53 interviews being conducted to replace these unreliable samples.

Among those who responded "No" to both the first and second bid questions, the "protest" samples, who indicated that the government should be responsible for paying for the vaccines, were excluded [15,19,20]. Invalid samples were further excluded when respondents indicated that they could not conceive of any contingent situation as described in the scenario.

Because the WTP values were interval censored with right-skewed distribution, the log-normal model in the survival analysis was estimated using the maximum-likelihood method. The logarithm of WTP was assumed to be normally distributed with a mean comprising of a linear function knowledge score, attitudes toward HPV and CC, whether background information was provided, and individual characteristics. The predicted WTP was calculated at the sample mean to represent the value placed on the HPV vaccine among the sample population.

All analyses were carried out using SAS software, Version 8.02 (SAS Institute, Cary, NC), with the VSL being estimated using the following equation:

$$VSL = \frac{WTP}{\text{statistical life}} = \frac{WTP}{\text{duration} \times \text{risk} \times \text{mortality}}$$

## Results

Of the total of 512 respondents, 47 (9%) and 36 (7%) invalid samples were excluded from the analyses for the two scenarios, leaving 465 cases for the "vaccinating mother" scenario, and 476 cases for the "vaccinating daughter(s)" scenario. For the demographic characteristics, knowledge and attitude scores, please see Valuation of the Economic Benefits of Human Papilloma Virus Vaccine in Taiwan *Value in Health* Supporting Information, Part II at: [http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3\\_Tang.asp](http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3_Tang.asp).

For the initial bids and the respective numbers of respondents answering "Yes", please see Valuation of the Economic Benefits of Human Papilloma Virus Vaccine in Taiwan *Value in Health* Supporting Information, Part III at: [http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3\\_Tang.asp](http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3_Tang.asp). First, with a rise in the stated price, there was a significant corresponding fall in the proportion of respondents willing to pay for vaccinating both themselves and their daughter(s). Second, the WTP proportion increased with the valid duration of the vaccination treatment from 10 to 20 years. Finally, at each starting point, women were more likely to be willing to pay for the vaccination for their daughter(s) than for themselves.

For the multivariate analysis on the prediction of WTP values, please see Valuation of the Economic Benefits of Human Papilloma Virus Vaccine in Taiwan Supporting Information, Part IV at: [http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3\\_Tang.asp](http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3_Tang.asp). The estimated coefficients on the duration of the vaccines and the logarithm of personal monthly income, aggregated across the crude and adjusted models for the women and their daughter(s), were all positive, with significance at the 5% level. Furthermore, the sequence of the two WTP questions significantly influenced WTP under the "vaccinating daughter(s)" scenario.

We also find that the higher the knowledge scores toward HPV, the higher the WTP for vaccinating both the mother and the daughter(s). The WTP amount was higher for those who agreed that CC was a serious disease, that CC was preventable, that HPV vaccines were effective in preventing CC, and that HPV

vaccines are safe; however, under both scenarios, only the coefficient on "safety" reached statistical significance.

The median regression-adjusted WTP was estimated at US\$1098 to US\$1233 (US\$913–1004) for vaccinating the daughter (mother); and the VSL was estimated at approximately US\$0.65 to US\$4.09 (US\$0.56–3.16) million for vaccinating the daughter (mother). For details, please see Valuation of the Economic Benefits of Human Papilloma Virus Vaccine in Taiwan Value in Health Supporting Information, Part V at: [http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3\\_Tang.asp](http://www.ispor.org/Publications/value/ViHsupplementary/ViH12s3_Tang.asp).

## Discussion

Validity is an issue of major concern in CVM studies; as regards theoretical validity in this study, we find a significantly positive correlation between personal monthly income and the mothers' WTP for the hypothetical HPV vaccine under both scenarios [16,18], also revealing that respondents would pay more if the vaccine duration was extended from 10 to 20 years, thereby clearly indicating the existence of scope effects. Nevertheless, the educational-level coefficients had no significance in predicting WTP, thereby contradicting the prior studies [6,10,21]. The insignificance of the educational-level coefficients may be attributable to the collinearity of educational level with income and age.

We find that the WTP for vaccinating the daughter(s) is higher than that for the mothers themselves, with similar results having been observed in several prior studies [10,21–23]. The reasons may be that the vaccination protection could be of longer-term importance to their children. Respondents may also be well-informed of the finding that HPV vaccines are most efficacious for those not yet exposed to sexual activity.

Question order effects were found in the WTP for vaccinating daughter(s), with the results indicating that respondents have a higher WTP if they were first asked the question on their WTP for vaccinating themselves. After answering the first question, they tended to raise the WTP amount in response to the second WTP question on vaccinating their daughter(s).

The WTP for a hypothetical HPV vaccine was quite high compared with several CVM studies on vaccination interventions in Taiwanese setting [7–10]. According to the prior studies, the characteristics of the target disease, in terms of speed of progression [24], oncogenic disease [24] or degree of severity [11,22,23] were positively related to WTP. Therefore, the higher WTP for HPV vaccines may indicate that women are deeply concerned with the morbidity and mortality of CC.

Nevertheless, several limitations of this study may potentially lead to higher estimations of WTP. First, convenient sampling was adopted in two Taiwanese hospitals, with a representative sample population of middle-aged women residing in the urban areas of Taipei City. Thus, the resultant estimated WTP and economic VSL found in this study may be upwardly biased, and potentially inapplicable to all women in Taiwan.

Second, in a simplified version of the contingent scenario, we assumed that the hypothetical HPV vaccine was 100% effective in preventing CC, which does not actually reflect the current practices in the real world. This assumption may also upwardly bias the WTP and VSL estimates. There are further complex and unresolved issues regarding the possible waning of HPV vaccines over time which are not considered under contingent scenario studies. Future studies should involve characteristics of effectiveness and vaccine boosters to develop a framework for explaining the participants' WTP for the vaccines.

Despite these limitations, our study should provide policy-makers with important evidence on the monetary value placed

on HPV vaccines, the differential benefits between vaccinating women and their daughter(s), and VSL. The differences in the cost of the vaccination program and the WTP for HPV vaccines estimated in this study provide an estimate of the net benefits of vaccinating women or young girls. The potential net benefits of a national vaccination program should be even greater, essentially because the vaccine costs can be further reduced through government mass purchasing power. The estimated VSL in this study was within the prior wage-differential and CV estimate ranges in Taiwan [8,24–27]. Thus, our estimated VSL is potentially applicable for reference purposes in cost-benefit analyses aimed at assessing the potential lives saved by national HPV vaccination programs.

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