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The Public Demand for a Dengue Fever Vaccine: A Contingent Valuation Survey in Phnom Penh, Cambodia

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ABSTRACT

Our study estimates the willingness to pay (WTP) for the dengue fever vaccination program at a national level in Cambodia. A double bounded format with an open-ended question was used in this study to estimate the WTP. The contingent valuation method (CVM) scenario was created as a two-year dengue fever vaccination program. Two vaccine levels were used, one with 40% and another with 80% effectiveness, neither with any side effects. Three doses were required for full protection. We used a 600-split sample survey in Phnom Penh, Cambodia of those aged 20-60 years old and with Cambodian nationality. Subjects were asked how much they would be willing to pay for dengue fever vaccination via a 1-time income tax surcharge of either 50,000, 150,000, 200,000, 350,000, 500,000, or 600,000 riel, respectively. As shown by the Tobit Model, the mean of households' willingness to pay to support the dengue fever vaccination program were 98,841 riel and 149,124 riel for the 40% and 80% levels, respectively. Income, gender, marital status, and education were the key factors influencing households' WTP to support a dengue fever vaccination program.

Keywords: Contingent Valuation Method, Dengue Fever Vaccine, Willingness to Pay
JEL Classifications: I11, I12, I13, I15, I18

1. BACKGROUND AND RATIONALE

Dengue fever is considered as an epidemic disease in Cambodia, which is a nation with low health and economic indicators (Asian Development Bank, 2009). The 2008 population estimation for Cambodia was 14.6 million people (National Institute of Statistics, 1998). The first Cambodian dengue infection case was discovered in 1963, after which dengue spread across the nation. The dengue fever infection rate has been reported as fast-rising over the years and has become one of the most significant public health issues. Moreover, dengue fever infections drastically increased in 2008. And since 2008 there have been about 9000-38,000 cases (about 103 cases/100,000 population) and 3-179 deaths (about 1/100,000 population) every year. During 2008-2017, dengue fever infection cases in Cambodia peaked 2012 with 37,675 cases and 179 deaths. In 2012, the mortality and morbidity levels were all high, at 2 and 262, respectively, per 100,000 population (Ministry of Health of Cambodia, 2017).

By 2017, there were 6372 reported cases, while in 2016 there were 12,483 cases. A large part of the reported cases occurred among children from ages of 5 through 10 (2434 cases or 38.2%), followed by children aged 10-15 (2,271 cases or 35.6%), children under 5 years of age (1305 cases or 10.7%), and children over 15 years (362 cases or 5.6%). It should be noted that among the child cases there is not much difference between males (3264 cases, 51.2%) and female (3108 cases, or 48.8%) (Ministry of Health of Cambodia, 2017).

In this study, we intend to derive a useful insight into the public demand from Cambodian households (including both genders) as to how much they are willing to pay to support a 1-year dengue fever vaccine program. Such a program aims to prevent the spread of dengue fever among the population, but to do so, individuals would have to pay a 1-time income tax surcharge of 50,000, 150,000, 200,000, 350,000, 500,000, or 600,000 riel, respectively. This paper examines the factors that influence individuals regarding their household's willingness to pay (WTP) for this vaccination program. Estimating the WTP for a dengue fever vaccination program and thus a potential means of funding it can thus provide policy planners with an understanding of just how a dengue fever vaccination program can be most effective. Our research questions are: (1) What are the key factors influencing how much a household is willing to pay to support a dengue fever vaccination program? and (2) How much would individuals actually be willing to pay to support such a program?

2. LITERATURE REVIEW

Previous research that has focused on estimating the private demand for dengue fever vaccine programs at a country level has been conducted in various countries, such as in Metro Manila, Philippines (Palanca-Tan, 2008), Indonesia (Harapan et al., 2017), Vietnam (Nguyen et al., 2018), Brazil (Godoi et al., 2017), and South Korea (Amarasinghe et al., 2010b). However, none of these has evaluated a nation's ability to financially subsidize a public dengue fever vaccination program nor examined how much the public is willing to pay for it. In addition, key factors influencing the number of vaccines that could be purchased for public use remain undetermined (Hecht and Suraratdecha, 2006). One study (Agmapisarn, 2009) focused on public demand for a free HIV vaccination program and used the double bounded contingent valuation method (CVM) format. This was followed by an open-ended question to estimate the mean willingness to pay for the vaccination program. Our study will follow this research design.

Dengue vaccine is a potentially effective method of preventing dengue fever in the long run. Various public and private sectors have given assurances that a dengue fever vaccine was being developed and tested (DeRoeck et al., 2003). In 2007, one news report claimed that a dengue fever vaccine could be produced within the next 10 years. This news raised a lot of questions regarding policy implementation, such as to whom and how dengue fever vaccine could be supplied. For example, should a dengue vaccine be provided by the private or the public sector? In the case of the vaccine being provided by the private sector, the next question that arises is how much vaccine will be demanded by the market and at what price? And who will be able to receive the injections? On the other hand, if the public sector provides the vaccine, an evaluation of the estimated benefits of such a preventive measure needs to be made. Willingness to pay (WTP) is the monetary valuation put on a vaccine by survey respondents and is derived from a contingent valuation survey. It is derived by assessing a household's perceived benefit from preventing dengue disease. This WTP approach is more accurate and comprehensive than the cost of illness (COI) approach, comprised of treatment cost reduction and productivity gain that can occur place from illness prevention. This is the approach that is normally employed in the public health literature (Palanca-Tan, 2008).

In Vietnam, the escalation of dengue fever cases in recent years and the occurrence of a large-scale dengue fever outbreak in 2017 underlined the importance of dengue vaccines. Given the potential benefits of dengue vaccines and the need for the private sector to pay for healthcare service coverage, Nguyen et al. (2018) decided to evaluate the WTP for a dengue fever vaccination program for hospital patients in northern Vietnam. Cross-sectional data were collected from 330 inpatients and outpatients in Bach Mai Hospital. The contingent valuation method was used to evaluate the WTP for dengue vaccines. Results showed that around 95% of respondents were willing to pay an average of $67.4 USD for the vaccine. Moreover, the study recommended that the government should subsidize the cost of the vaccine so as to increase the coverage of the population, especially the poor, in the future.

In December 2015, the first dengue fever vaccine, developed by Sanofi Pasteur, was approved in Brazil. However, given that the vaccine would potentially be paid for via the public health system, information was needed regarding consumers' willingness to pay for the vaccine in order to discuss about the possible inclusion of this vaccine into the public health system in the first place needed to take place. Godoi et al. (2017) addressed these issues using a cross-sectional data set with residents of Greater Belo Horizonte, Minas Gerals to estimate their willingness to pay for dengue fever vaccine. After interviewing 507 respondents, they found that the maximum median value of consumers' WTP was $33.61 USD. The study suggested that manufacturers in Brazil should asses the possibility of lowering prices in order to reach more people.

One study claimed that a dengue vaccine would be available in the next three to 5 years (Amarasinghe et al., 2010a). The authors emphasized that such a vaccine was direly needed in both public and private markets for nations experiencing widespread dengue outbreaks. These estimations were based on population projections from 2015 to 2020 in Asian and American endemic nations. Moreover, it made an expectation for specific countries' vaccination programs in the public, private, and traveler sectors. There were 54 countries that were categorized as dengue endemic, comprising a total population of 2.8 billion, among which were 54 million children aged 1-2 years old. In the following 5 years, it was estimated that 645 million doses would be needed for children to strengthen their immunity against the dengue fever virus and up to two billion doses for immunization catch-up, with 80% in the nations with dengue endemic for being in the public sector. Also, it was estimated that for the traveler market, 59 to 89 million doses would be needed.

Recently, there have also been reports of dengue fever vaccine that has been produced and approved for use in some countries (Lee et al., 2015). Specifically, such vaccines have been deployed in countries in which a high risk of dengue has been reported. Nevertheless, there might be an impediment toward dengue vaccine strategic adoption in some specific areas, especially in low- and middle-income nations (Lee et al., 2015). Such nations normally encounter difficulties in making decisions about how to allocate their limited budgets to cover vaccines, which are very expensive to produce. Hence, they are faced with budget constraints (Hadisoemarto and Castro, 2013). Thus, it is very important to fully understand the benefits of public dengue vaccination programs in terms of preventing the diseases and incurring even greater social and economic costs if vaccinations were not given. Such an understanding is crucial before bringing proposals for a vaccination program to the public sector or to private markets (Harapan et al., 2017).

Among all five of the studies cited above, not one evaluates a nation's ability to financially subsidize a public dengue vaccination program. Nor do any examine how much the public would be willing to pay for such a program. However, there is a study of public demand of a free HIV vaccination program that used the double bounded CVM format followed by an open-ended question to estimate the mean willingness to pay for a vaccination program (Agmapisarn, 2009). A 600-split sample survey was conducted by asking respondents aged 20-60 years old living and working in Bangkok whether they were willing to pay (WTP) to support an HIV vaccination program using either a 30% or 70% effectiveness vaccine with an initial tax payment of either 500, 1500, 2000, 3500, 5000, or 6000 baht. The mean WTP values that were found were 2050 baht and 1746 baht for 70% and 30% effectiveness, respectively. The author recommended that, in addition to people using condoms to prevent HIV infection in the meantime, when a vaccine becomes available the Thai government should use a progressive tax to fund such a program.

As we have described above, most research so far has estimated private demand for a dengue fever vaccine at country level. However, none has evaluated a nation's ability to subsidize a public dengue fever vaccination program nor examined how much the public is willing to pay for it. Our objective here is to derive a useful insight into the demand among Cambodian households (including both sexes) as to how much they are willing to pay to support a 1-year public dengue fever vaccination program.

3. METHODS

3.1. Contingent Valuation Method (CVM)

We employ a double-bounded approach with open questions at the end to derive an estimation of how much people surveyed would be willing to pay for dengue fever vaccine coverage as shown in Figure 1. Initial payment amount levels were 50,000, 150,000, 200,000, 350,000, 500,000, and 600,000 riel, respectively. When respondents gave a Yes answer to the initial rate, we followed up by posing further questions for the respondents to answer, presenting them with a higher rate (HR) equal to one and a ½ times of initial rate. However, when respondents answered "No" to the initial rate (R), we gave them another question, offering them a lower rate (LR), equal to two-thirds of the initial rate as shown in Table 1.

In the last stage, we asked respondents to state the maximum amount they would be willing to pay to support a dengue fever vaccination program. If respondents stated that their maximum level of WTP was not zero, then we continued asking them more questions to identify the reason that they gave this amount for the program. Moreover, if the respondents gave a zero amount for WTP for the program, then we asked them again the questions to find the reason why they were willing to give nothing at all for the program. This is a confirmation question to truly identify whether a zero amount of WTP for the program is valid or biased. If we found that respondents who gave a zero WTP for the program were biased, then the answers of those respondents were categorized as "Non-Response." In addition, all respondents were advised to consider their budget constraints, and we also informed them that there were no right or wrong answers for this interview. Moreover, in order to make sure that they told us the truth, we have talked with them using a cheap talk script before starting the interview to encourage them to answer truthfully.

3.2. Survey Sampling

In this study, we randomly selected 600 samples and conducted interviews in Phnom Penh, the capital city of Cambodia. The population in Phnom Penh accounts for 14% of the total population of the country. Moreover, there is a vast inflow of migrants from across the nation. This has made Phnom Penh the nation's largest city and one with fast economic growth. At the same time, this has increased social pressures and has aggravated problems such as slums and sanitation, resulting in Phnom Penh having the greatest number of dengue fever cases in the country. We used multistage sampling since a sampling frame was not needed in this method. Moreover, multistage sampling is easier and less expensive than a single-stage random sampling when we use a CVM to survey a huge population (Bateman et al., 2002). The defined targeted population was people aged 20-60 years old with Cambodian nationality since these people are the taxpayers and the ones who have been living and working in Phnom Penh regardless of where they originally came from. We then used a multistage random sampling with three-stage sampling.

First, we randomly selected a sample from 6 of the 12 districts or "Khan" in Phnom Penh. After that we set a quota that took into account population density in order to select sample units in the second stage within each sample district. As a result, we selected the sample within a district by its proportion to the population density of each district. Hence, we ended up with a total sample of 600 selected units. With regard to the sampling of 600 respondents, we randomly selected any person aged 20-60 years old in each sampling quota to form a final stage sample choice, as shown in Table 2. Randomly selected individuals had to be Cambodian nationals and taxpayers who had a job in Phnom Penh, regardless of where they originally came from.

Table 1: The WTP rate structure for respondent's bid

Initial rate (R)	Higher rate (RH)	Lower rate (RL)
50,000	75,000	30,000
150,000	225,000	100,000
200,000	300,000	130,000
350,000	525,000	230,000
500,000	750,000	330000
600,000	900,000	400000

Table 2: Multistage area sampling of 6 sampled districts conducted in the survey

Sampled district	Area (km^2)	Population	Population density	Sampled quota
Chamkar Mon	10.56	182,004.00	17,235	98
Doun Penh	7.44	126,550.00	17,009	96
Prampir Makara	2.21	91,895.00	41,581	235
Tuol Kork	7.99	171,200.00	21,427	121
Dangkao	197.89	257,724.00	1,302	7
Mean Chey	43.79	327,801.00	7,486	42
Total	269.88	1,157,174.00	106,040.98	600

Source: (Municipality of Phnom Penh, 2004)

3.3. Research Design

The dengue fever vaccine program will be a 1-year program and it will be free to the public. The dengue fever vaccine itself will be separated into two different levels in terms of its effectiveness, namely, 40% and 80%, in order to protect our target group of Cambodian citizens aged 20-60 years old. We also created different levels of 1-time income tax surcharge from which respondents were to choose: 50,000, 150,000, 200,000, 350,000, 500,000, 600,000 riel, respectively. This range of 1-time income tax surcharge payment was to be matched with the two different levels of effectiveness of the dengue fever vaccine. Hence, there were 12 possible outcomes from combinations of tax payment rates and of dengue vaccine effectiveness (Table 3).

The sample size of 600 will be significantly depending on the sample of the fifty interviewed respondents per sampling point in every dengue fever vaccine effectiveness and range of tax payment rate combination. We also use the split sample approach to make an estimation on the WTP of respondents and testify the respondents' answer consistency and reliability. (Whittington, 1998; 2004). Consequently, each sample in the survey was randomly given the question on their WTP for dengue fever vaccine program regarding to its level of effectiveness as well as the range of tax payment rate from 12 combinations (Table 3).

3.4. Contingent Valuation Scenario

In order to make our respondents understand our scenario, we used illustrations in order to create a clear understanding about dengue fever vaccine's effectiveness in the context of a contingent valuation scenario approach.

Table 3: Sampling of respondents distribution with regard to different vaccination effectiveness and range of tax payments

Target	Total sample=600 (n=600)	
Vaccine effectiveness	40% (n=300)	80% (n=300)
Tax payment=R 50000	50	50
Tax payment=R 1,50000	50	50
Tax payment=R 2,00000	50	50
Tax payment=R 3,50000	50	50
Tax payment=R 5,00000	50	50
Tax payment=R 6,00000	50	50

The CV scenario is as follows: dengue fever is an epidemic disease caused by a mosquito-borne flavivirus that can spread to most tropical and subtropical regions. Dengue fever viruses 1-4 are the main viruses that cause the illness. Dengue fever vaccine is a protective method to prevent and control the spread of dengue fever infection, especially in Cambodia. As mentioned previously, dengue fever vaccine in this study paper consists of two different levels of effectiveness (40% and 80%) and has no side effects on recipients. Moreover, its effectiveness will last for 5 years or more, which can protect a household from getting infected by the four types of dengue fever virus. Household members need to be injected with three doses of dengue fever vaccine 6 months apart. After receiving all three doses, recipients will be protected from dengue fever infection.

In addition, Figures 2 and 3 will also verify the precision and consistency of the explanation of our dengue fever vaccination program among the enumerators, who are the persons employed for taking a census of the population, when they explain and show the scenario illustration to the respondents.

Hence, this scenario will not just make things easier to understand for respondents. Moreover, if respondents give a wrong response to the scenario or if that they do not understand our dengue fever vaccination program scenario, we will use the illustration in the study to prevent scenario misspecification problems.

3.5. The Demand Model

Our study aims to determine the public demand for dengue fever vaccination. The public demand for a dengue fever vaccine with regard to both vaccine effectiveness levels (40% effectiveness and 80% effectiveness) are as follows:

$$Pr\ (Yes) = f\ (I, F, C, D, U, V)$$

We wanted to determine whether respondents in public agreed to pay a 1-time income tax surcharge by using their annual income tax liability according to household monthly income (I); family composition or size (F) refers to the number of family members; household characteristics (C) include age, gender, occupation, education, marital status; the dengue fever variable (D) refers to awareness of dengue fever issues, general knowledge about dengue fever, and experience with dengue fever disease infection; vaccine effectiveness understanding variables (U) refer to understanding that dengue vaccine has two

Figure 1: The double-bounded format with open-ended following questions diagram. Y Y = Yes/Yes, Y N = Yes/No, N Y = No/Yes, N N = No/No

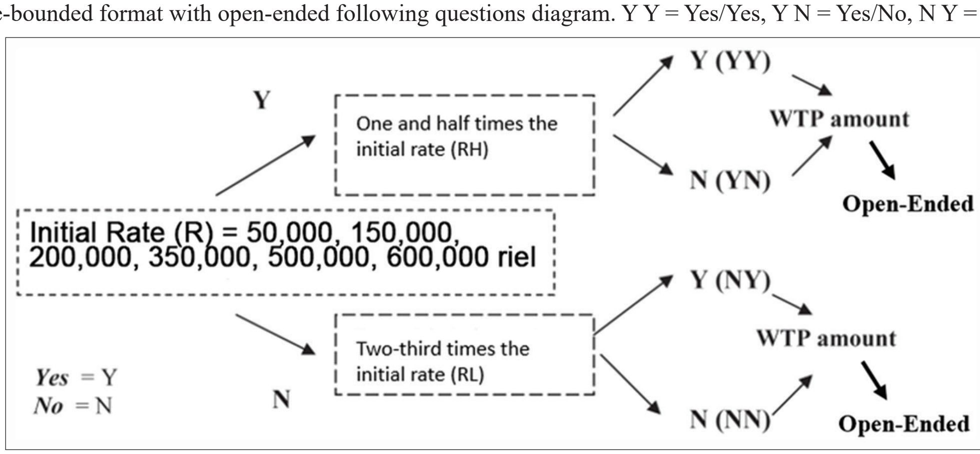


Figure 2: Dengue fever vaccine with 80% level of effectiveness

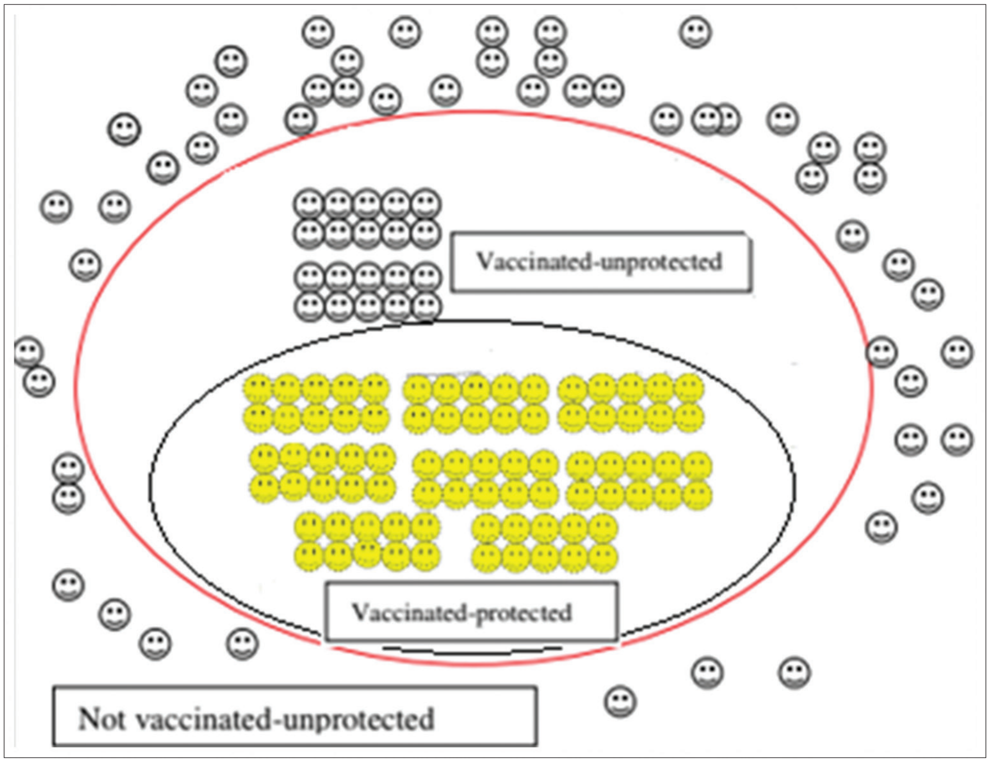
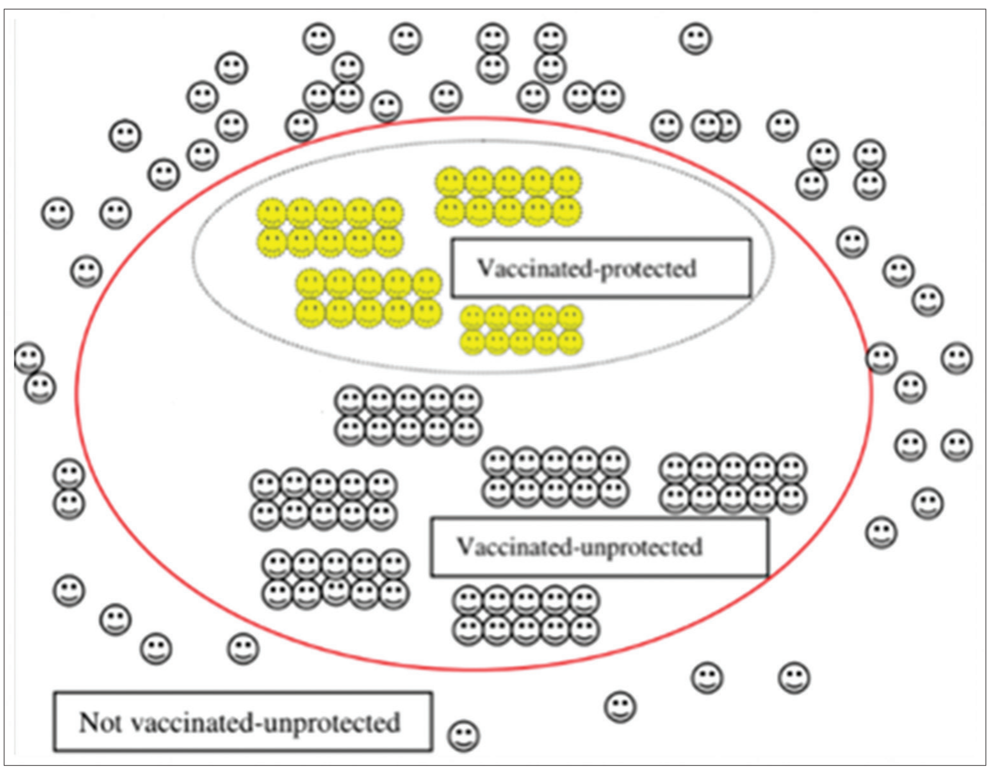


Figure 3: Dengue fever vaccine with 40% level of effectiveness



Source: (Do et al., 2006)

levels of effectiveness (40% and 80%); and effectiveness level of the vaccine (V) refers to a vaccine whose effectiveness is either 40% or 80%, respectively. We also created the table of variables description in the public demand for dengue fever vaccination program with coefficients expected sign as shown in Table 4.

4. RESULTS

A total of 600 people aged 20-60 years were successfully interviewed during the period July 2019-February 2020. The response rate for interviewees was 95%. Our study compensated for this by adding more survey interviews to obtain a total number of 600 survey interviews. We profiled respondents in terms of (1) sociodemographic characteristics, (2) knowledge, experiences, and awareness of dengue fever, and (3) understanding of vaccine effectiveness.

4.1. Sociodemographic Characteristics

Of the 600 people randomly selected in our survey in Phnom Penh, 57% were female with an average age of 31, and 60% were single. Almost two-thirds (65.7%) had completed at least a university degree, and 78.7% were employed in the private sector. The average household size was 4.5 persons, and those with household members aged <9 years old living in the same household accounted for 51.2% (Table 5).

4.2. Knowledge, Experience, and Awareness of Dengue Fever

Of the 600 respondents in our survey, only 89.5% answered correctly all 5 questions regarding knowledge, experience, and awareness of dengue fever. As for the knowledge of dengue fever (Table 6), more than 90% believed that the risk of dengue fever

Table 4: Variables descriptions in the public demand for dengue fever vaccination program with coefficients expected sign

Variables	Descriptions	Expected sign
Independent variables		
Household income		
Monthly income	Household monthly income (Continuous in logarithm form, riel)	Positive
Socioeconomic and demographic variables		
Gender	Male=1, 0 if otherwise (Female gender as a base)	N/A
Age	Respondents' age (Continuous, number of years)	Negative
Marital status	Married=1, 0 if otherwise (Single/Divorce/Widow/Separated as a base)	N/A
Schooling	The number of years in school of the respondents (continuous, years)	Positive
Private	Occupation status=1 if private, 0 otherwise (Public as a base)	N/A
Household	Number of household members (continuous, persons)	Negative
Children	1 if respondent has children aged <9 years living in the same household, 0 otherwise	Positive
Knowledge, experience, and awareness		
Knowledge	Dengue fever knowledge=1 if respondent answered all 5 questions correctly, 0 otherwise	Positive
Known	1 if respondent has any family member has had dengue fever, 0 otherwise	Positive
Curable	1 if respondent has heard that Dengue Fever is now curable, 0 otherwise	Positive
Understanding of vaccine effectiveness		
Understanding	1 if respondent passed all three questions on the understanding of vaccine effectiveness, 0 otherwise	Positive
Vaccine characteristic and program		
80% effectiveness	1=vaccine is 80% effectiveness, 0 otherwise (40% vaccine effectiveness is a base)	Positive

Table 5: Sociodemographic characteristics of respondents

Variable	Descriptive	Mean	S.D
Tax payment rate	Tax payment rate (As in logarithm form, in riel)	12.356	0.840
Monthly income	Household monthly income (Continuous in logarithm form, riel)	14.255	0.431
	Household monthly income (Continuous form, riel)	1,705,900.000	792,826.471
Male	Gender=1 if male, 0 if otherwise (Female as a base)	0.432	0.496
Age	Age of respondents (continuous, years)	30.793	7.648
Married	Marital status=1 if married, 0 otherwise	0.595	0.491
Schooling	The number of years in school of the respondents (continuous, years)	15.402	2.458
Private	Occupation status=1 if private, 0 otherwise (Public as a base)	0.787	0.410
Household	Number of household members (continuous, persons)	4.532	1.322
Children	1 if respondent has children aged <9 years living in the same household, 0 otherwise	0.512	0.500

Table 6: Knowledge, experience and awareness of dengue fever

Variable	Descriptive	Mean	S.D
Mosquitohome	1 If respondent believes that risk of dengue fever transmission has been reduced by having reducing mosquito's shelter, 0 otherwise	0.910	0.286
Sleepingnet	1 if respondent believes that we reduce the risk of getting dengue fever infection by sleeping under a net, 0 otherwise	0.895	0.307
Healthylook	1 if respondent believes that a healthy-looking person can get infected to dengue fever, 0 otherwise	0.902	0.298
Mosquitobite	1 if respondent believes that a person can get dengue fever infection from mosquito bites, 0 otherwise	0.905	0.293
Death	1 if respondent believes that a person can die by getting infected by the dengue fever virus, 0 otherwise	0.900	0.300
Known	1 if respondent knows anyone who had got infected by dengue fever virus, 0 otherwise	0.977	0.151
Curable	1 if respondent has heard that dengue fever is now curable, 0 otherwise	0.990	0.100
Transmission	1 if respondent believes that mosquitos are the major cause of dengue fever spreading, 0 otherwise	0.922	0.269
Children-Infect	1 if respondent believes that children are more likely to get dengue fever, 0 otherwise	0.952	0.215
Kidpriority	1 if respondent believes that the government should prioritize children as the first vaccinated group, 0 otherwise	0.908	0.289
Prevention	1 if respondent believes that dengue fever vaccine is the most advanced method to prevent dengue fever diseases, 0 otherwise	0.910	0.286

transmission would be reduced by reducing areas where mosquito shelter and breed and by sleeping under a mosquito net. They also believed that a healthy-looking person can get infected by dengue fever. More than 90% of respondents knew that a person can get infected by dengue from mosquito bites. Surprisingly, almost 8.8% of respondents believed that a person cannot die from getting infected.

Regarding the experiences of dengue fever, 97.7% of respondents had known someone who had dengue fever, and almost 99% of the respondents believed that dengue fever is now curable. On the other hand, 2.03% of respondents had never known anyone who had contracted dengue fever, and 1% did not believe that dengue fever was currently curable (Table 6).

In terms of dengue fever awareness, more than 90% of respondents believed that mosquitos are the major cause of dengue fever spreading and that children are tend to get infected. In addition, 90.8% of respondents thought that the government should prioritize children and vaccinate them first if a dengue fever vaccine becomes available, and 91% of respondents believed that dengue fever vaccine is the most advanced method to prevent dengue fever diseases.

4.3. Understanding of Dengue Fever Vaccine Effectiveness

Almost 100% of respondents demonstrated that they fully understand vaccine effectiveness of either the 40% or 80% variety by correctly answering all three questions regarding vaccine effectiveness. With the aid of our visual card, respondents had a better grasp of vaccine effectiveness during our explanation of either 40% or 80% effectiveness (Table 7).

4.4. Estimation of the Demand Model

Regarding the demand analysis, our study has divided it into two sections: (1) The result of analysis on factors influencing a household's willingness to pay a certain amount to support a dengue fever vaccination program, and (2) the estimation of mean willingness to pay (WTP). Our analysis of the demand for a free Dengue Fever vaccination program is discussed below.

4.4.1. The factors influencing a household's willingness to pay a certain amount to support dengue fever vaccination program

The study result shows that the factors influencing a household's willingness to pay a certain amount to support dengue fever vaccination program are income, gender (Male), occupation (Private), marital status (Married), and education (Number of years spent in school). As shown in the Table 8, income, occupation (Private), and education (Number of years spent in school) are all statistically significant with a 5% significance level. Meanwhile, gender (Male) and marital status (Married) are also statistically significant, at a 10% significance level. Moreover, based on results presented in Table 8, income, and education (Number of years spent in school) have positive coefficients. The results also showed that male respondents tend to pay more compare to the base group which was female respondents, and this might because of the culture of Cambodian people which male are the family leader and have higher power in decision making. Our study results also found that respondents who were married tend to pay higher WTP compared to the base group which were single/divorce/widow/separate, and this might because of married respondents tend think more about others, especially family members. In addition, our study results showed that people work in the public sector (Base group) tend to pay higher WTP compared to people working in the private sectors. This might because of our respondents in the private sector that we randomly selected were mostly junior employees with low salary and small income, while respondents working in the public sector that we randomly selected were mostly senior officials with higher income lever.

4.4.2. The estimation of the Tobit model

Our study was based on double-bounded format with the following open-ended question to make an estimation on households'

Table 7: Understanding of vaccine effectiveness

Variable	Descriptive	Mean	S.D
Understanding	1 If respondent passed all three questions on the understanding of vaccine effectiveness, 0 otherwise.	0.992	0.091

Table 8: Factors influencing a household's willingness to pay a certain amount to support a dengue fever vaccination program

Independent variable	Coefficient	Standard error	P value	Mean
Constant	−238,689.056	69,518.760	0.001	
Income	0.074***	0.005	0.000	1,705,900.000
Number of family member	5451.413	5451.413	0.076	4.532
Number of kids	−13,706.251	10,738.729	0.202	0.512
Age	840.281	631.211	0.183	30.793
Male	17748.043*	7647.557	0.020	0.432
Private	-36492.592***	9780.155	0.000	0.787
Married	30898.091*	13,207.687	0.019	0.595
Education	12703.760***	1789.196	0.000	15.402
Curable	−21,959.155	12,659.904	0.083	0.910
Known	−33,305.952	23,952.136	0.164	0.977
Knowledge	15,061.254	35,935.189	0.675	0.990
Vaccine understanding	37,121.323	39,091.814	0.342	0.992
Vaccine effectiveness	−3806.640	7772.036	0.624	0.500

*P<0.05; **P<0.01; ***P<0.001

Table 9: Significant variables in the Tobit model for vaccine with 40% effectiveness level

Independent variables	Coefficient	Standard error	P value	Mean
Primary index equation for model				
Constant	−108,077.267	36,150.085	0.003	
Male	11,560.152	9904.934	0.243	0.350
Private	−38,478.587	17,217.118	0.025	0.920
Education	6763.750	2044.935	0.001	14.957
Income	0.079	0.007	0.000	1,529,000.000
Married	23,302.743	9114.046	0.011	0.537
Disturbance standard deviation				
Sigma |	78,061.8827	3186.86302	0.000	

willingness to pay for a dengue fever vaccination program. Therefore, in the open-ended question, we can use the Tobit model to estimate the mean of households' willingness to pay to support the dengue fever vaccination program by using the formula as below:

$$E(WTP) = \Phi(\frac{Z}{\sigma}\beta)Z\beta + \sigma\phi(\frac{-Z}{\sigma}\beta)$$

- E(WTP): Is the mean of households' willingness to pay to support the dengue fever vaccination program
- Φ: Is the CDF of standard normal
- ϕ: Is the PDF of standard normal
- Z: Is the mean of economic variables
- β: Is the coefficient of variable
- σ: Is the sigma value.

Table 8 presents results showing that the factors influencing a household's willingness to pay to support dengue fever vaccination program are Income, Gender (Male), Occupation (Private), Marital Status (Married), and Education (Number of years spent in school). Income, Occupation (Private), and Education (Number of years spent in school) are all statistically significant, at a 5% significance level. Meanwhile, Gender (Male), and Marital Status (Married) are all statistically significant at a 10% significance level.

Thus, we will take only these statistically significant independent variables to run in the Tobit model to calculate the estimation of E(WTP) for both levels of vaccine effectiveness by using the Limdep program as show in the Table 9 for vaccine with 40% effectiveness and Table 10 for vaccine with 80% effectiveness.

From the calculation in the Tobit model using the formula above, we found that the mean of households' willingness to pay to support the dengue fever vaccination program is 98,841 riel and 149,124 riel for the 40% and 80% levels, respectively.

4.4.3. The estimation of the Tobit Model

Regarding our contingent valuation method (CVM), our study was based on a double-bounded format along with the following open-ended question to make an estimation of households' willingness to pay for a dengue fever vaccination program. We used the Logit and Probit Model to estimate the mean willing to pay for a dengue fever vaccination program by using the formula E(WTP) = α/β. From our calculation, we found an estimation of E(WTP) of dengue fever vaccination program for both models (Table 11).

Since the Logit Model has the higher Log likelihood function than in the Probit Model, our study will take the households' mean willingness to pay to support the dengue fever vaccination program from the Logit Model, thus, 392,429 riel and 315,482 riel for the vaccine with 40% and 80% effectiveness, respectively.

4.4.4. Mean willingness to pay

Regarding the split sample survey on two types vaccine effectiveness (40% and 80%), our results (Table 12) show that respondents with 80% vaccine effectiveness were willing to pay more, compared to what they were willing to pay for 40% (Lower) vaccine effectiveness. For instance, the Yes/Yes response to an initial tax payment of 50,000 riel, 50% of respondents supported the dengue fever vaccination program, whereas only 34% were willing to pay for the 40% effective vaccine.

Table 13 shows that the E(WTP) of the vaccine with 80% effectiveness is147,803 higher than the E(WTP) of the vaccine with 40% effectiveness, which is 100,109. This makes sense because households are willing to pay more for a vaccine with

Table 10: Significant variables in the Tobit model for vaccine with 80% effectiveness level

Independent variables	Coefficient	Standard error	P value	Mean
Primary index equation for model				
Constant	−22,5741.823	46,824.792	0.000	
Male	33,621.401	11,205.478	0.003	0.513
Private	−35,920.446	13,061.816	0.006	0.653
Education	14,270.850	2696.050	0.000	15.847
Income	0.074	0.007	0.000	1,882,800.000
Married	19,820.906	12,388.565	0.110	0.653
Disturbance standard deviation				
Sigma |	94,789.9157	3869.78211	0.000	

Table 11: The result of mean willingness to pay for dengue fever vaccination program by using Logit and Probit model

Model	Vaccine effectiveness			
	40%		80%	
	WTP	Log likelihood function	WTP	Log likelihood function
Logit model	392,429	506.2477	315,482	490.0306
Probit model	392,046	506.2299	320,772	489.8935

Table 12: Distribution of responses by various initial rate of tax payment in double-bounded format

Vaccine effectiveness	Y/Y				Y/N				N/Y				N/N			
	40%		80%		40%		80%		40%		80%		40%		80%	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Initial rate=50,000	17	34	25	50	21	42	18	36	7	14	7	14	6	12	0	0
Initial rate=150,000	0	0	6	12	22	44	26	52	2	4	8	16	26	52	11	22
Initial rate=200,000	0	0	0	0	19	38	25	50	0	0	0	0	31	62	25	50
Initial rate=350,000	0	0	0	0	12	24	13	26	4	8	4	8	34	68	33	66
Initial rate=500,000	0	0	0	0	5	10	6	12	1	2	15	30	44	88	29	58
Initial rate=600,000	0	0	0	0	1	2	1	2	0	0	2	4	50	100	47	94

n=number of respondents; %=percentage of respondents willing and able to pay for our dengue fever vaccination program with different rate of tax payment (in riel) and vaccine effectiveness (in percent); Y/Y=Yes/Yes; Y/N=Yes/No; N/Y=No/Yes; N/N=No/No; and total number of respondents per rate of tax payment and each vaccine effectiveness equal to 50 persons

Table 13: The mean WTP for dengue fever vaccination program of Logit and Tobit model for both effectiveness level

	E(WTP)	
Vaccine effectiveness	40%	80%
Logit model	392,429	315,482
Tobit model	98,841	149,124

greater effectiveness. While for the Logit Model it doesn't make sense because the E(WTP) of the vaccine with 40% effectiveness is higher than the E(WTP) of the vaccine with 80% effectiveness. Therefore, our study chose the mean WTP from the Tobit model to be the household's mean willingness to pay for supporting the dengue fever vaccination program.

Compare our result to other research studies in a few countries such as Vietnam (US$ 67.4 for three doses), Indonesia (US$ 16.16 for three doses), Philippines (US$ 81.3–96.9 for three doses), Brazil (US$ 33.6 for three doses), and our study in Cambodian (98,841-149,124 Riel or US$24 – US$36 for three doses; Cambodian Exchange Rate US$1=4,106 Riel).

4.5. Cost-Benefit Analysis of Dengue Fever Vaccination Program

The cost of illness of dengue fever includes direct medical cost and indirect cost. The direct cost of dengue fever are the cost of drug and the cost of hospitalization. Meanwhile, the indirect cost of dengue fever is the productivity loss from being ill. From a study research in Yogyakarta found that the direct cost of dengue fever in average was US$ 350 and indirect cost of dengue fever in average was US$ 142. Therefore, the cost of illness of dengue fever in average was US$ 492 (Supadmi, Izzah, Suwantika, Perwitasari, & Abdulah, 2019). The cost of dengue fever vaccine was around US$20–US$25 per dose. Moreover, we need to inject three doses of dengue fever vaccine 6 months apart to get the full protection from dengue fever virus. Therefore, the total cost of dengue fever vaccine for the full protection is around US$60–US$75. Thus, the social cost of dengue fever vaccine is US$75 (Pang & Loh, 2017). Our study result shows that household's WTP for dengue fever vaccination program is 98,841-149,124 Riel or US$24 – US$36 (Cambodian Exchange Rate US$1=4,106 Riel). Thus, the social benefit that we can get from the dengue fever vaccination program is US$36. Therefore, we found that this dengue fever vaccination program's social benefit is less than its social cost. Then, it is not worth to launch this dengue fever vaccination program.

5. DISCUSSION AND CONCLUSION

The result showed that there was a potential-demand for dengue fever vaccination program. Our study used Logit, Probit, and Tobit model to calculate the mean WTP for dengue fever vaccination program, and we found that the result from Tobit model is more reliable and makes sense accordance to household's behavior. From Tobit Model, the mean of households' willingness to pay to support the dengue fever vaccination program were 98,841 Riel and 149,124 Riel for 40% and 80% level, respectively.

Our study had two limitations. First, this study concluded survey of Cambodian residents only in Phnom Penh metropolitan area which does not represent the whole country of Cambodia. Second, the question in our questionnaire might be too easy to answer since it was general questions about the knowledge, experience, and awareness of dengue fever. That might be the reasons that almost all respondents answer correctly for all questions which made no difference for our result.

The study results would suggest some policy implications as follow. First, it recommends that policymakers should not provide a dengue fever vaccination program because this dengue fever vaccination program's social benefit is less than its social cost. Then, it is not worth to launch this dengue fever vaccination program.

Second, the government should use a combination of strategies to prevent dengue fever infection. Cleaning up and treating areas where mosquitos proliferate and providing mosquito nets would be the most indispensable parts of this combined prevention strategy. The Cambodian government should also launch a dengue fever prevention campaign along with access to information about dengue fever, especially for kids.

Last, the government should provide knowledge, skills, and promote the dengue fever awareness for behavior change nationwide, for example, by knowing how to detect one's own dengue fever status, knowing about risks, knowing how to protect oneself from dengue fever, being careful about one's health in general, and living in a clean environment. The government should employ a combination of all the above strategies to halt dengue fever.

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