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Article *in* Acta tropica · November 2016

DOI: 10.1016/j.actatropica.2016.11.035

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Acta Tropica 166 (2017) 249–256

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Willingness to pay for a dengue vaccine and its associated determinants in Indonesia: A community-based, cross-sectional survey in Aceh

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ARTICLE INFO

Article history:
Received 19 July 2016
Received in revised form
25 November 2016
Accepted 27 November 2016
Available online 28 November 2016

Keywords:
Dengue fever
Dengue vaccine
Indonesia
Vaccine introduction
Vaccine demand
Willingness to pay

ABSTRACT

Vaccination strategies are being considered as a part of dengue prevention programs in endemic countries. To accelerate the introduction of dengue vaccine into the public sector program and private markets, understanding the private economic benefits of a dengue vaccine is therefore essential. The aim of this study was to assess the willingness to pay (WTP) for a dengue vaccine among community members in Indonesia and its associated explanatory variables. A community-based, cross-sectional survey was conducted in nine regencies of Aceh province, Indonesia, from November 2014 to March 2015. A pre-tested validated questionnaire was used to facilitate the interviews. To assess the explanatory variables influencing participants' WTP for a dengue vaccine, a linear regression analysis was employed. We interviewed 677 healthy community members; 476 participants (87.5% of the total) were included in the final analysis. An average individual was willing to pay around US-$ 4 (mean: US-$ 4.04; median: US-$ 3.97) for a dengue vaccine. Our final multivariate model revealed that working as a civil servant, living in the city, and having good knowledge on dengue viruses, a good attitude towards dengue, and good preventive practice against dengue virus infection were associated with a higher WTP ($P < 0.05$). Our model suggests that marketing efforts should be directed to community members who are working in the suburbs especially as farmers. In addition, the results of our study underscore the need for low-cost quality vaccines, public sector subsidies for vaccinations, and intensifying efforts to further educate and encourage households regarding other dengue preventive measures, using trusted individuals as facilitators.

1. Introduction

Dengue, an acute mosquito-borne viral infection, is rapidly spreading in all WHO regions with approximately 390 million new infections annually and 96 million symptomatic cases ranging from mild dengue fever (DF) to dengue hemorrhagic fever (DHF) and

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http://dx.doi.org/10.1016/j.actatropica.2016.11.035
0001-706X/

dengue shock syndrome (DSS) (Bhatt et al., 2013). Approximately half of the world's population is at risk of dengue infection, and about 70% of those at risk live in Southeast Asia and the Western Pacific region (Shepard et al., 2013). Within this region, Indonesia is the biggest country where dengue infection is prevalent. In the last 45 years, the incidence of registered dengue cases in Indonesia has rapidly increased from 0.05 to approximately 40 per 100,000 population (Karyanti et al., 2014).

The observed upward trend of reported dengue cases in Indonesia indicates, in part, that the dengue prevention and control programs in place have not been effective, or not effective enough, to reduce the number of dengue infections. Recently, a new dengue vaccine has been approved in some countries and vaccination has been considered as a part of the dengue prevention programs of endemic countries. However, the current lack of assessments of the economic and public acceptance of a dengue vaccine may cast uncertainty on the adoption of dengue vaccination strategies in certain regions, especially in middle-income countries (Lee et al., 2015). Middle-income countries such as Indonesia generally face hard decision making on whether and how to incorporate new and potentially expensive vaccines within their budget-constrained national vaccination programs (Hadisoemarto and Castro, 2013). Therefore, understanding the private economic benefits of potential dengue vaccines is necessary for an accelerated introduction of dengue vaccine into the public sector program and private markets.

So far, three studies regarding the willingness to pay (WTP) for dengue vaccine have been published (Hadisoemarto and Castro, 2013; Lee et al., 2015; Palanca-Tan, 2008); one of these was conducted in Bandung, Java Island, Indonesia (Hadisoemarto and Castro, 2013). As the cultural and economic backgrounds of that setting differ from those of other populations outside of Java Island, it is important to also assess the WTP among people from other backgrounds in Indonesia. Aceh is one of the regions in Indonesia where dengue infection is hyperendemic and the number of cases has risen significantly especially following the earthquake and tsunami disaster of 2004. This study sought to assess the WTP for a dengue vaccine and its associated modifiable determinants of community members in Aceh, Indonesia in order to generate recommendations for policy makers in dengue endemic areas.

2. Methods

2.1. Study site, sampling procedure and sample size

The study presented in this paper was conducted in nine regencies in Aceh province, Indonesia. Aceh comprises predominantly rural areas located in the north of Sumatra Island in the westernmost part of the Indonesian archipelago. It was the most severely affected area during the earthquake and tsunami disaster of 26 December 2004. The incidence of registered dengue cases in Aceh increased significantly from 2.76 per 100,000 population in 2003 to 46.66 per 100,000 in 2014 (Depkes RI, 2012; Kemenkes RI, 2015). A report by the Provincial Health Office indicated that the total number of registered dengue cases in Aceh was 2208 in 2014 (Provincial Health Office, 2015). Aceh has 23 regencies (*Kabupaten/Kotamadya*) with an estimated population of 4,906,800 in 2014 (BPS, 2015). To represent the population, nine regencies were randomly selected (Aceh Tengah, Aceh Besar, Aceh Utara, Aceh Singkil, Aceh Selatan, Aceh Timur, Aceh Tamiang, Langsa and Sabang). As a minimal sample size, 385 participants were required based on the following assumptions: (a) 50% vaccine acceptability rate; (b) 5% margin of error; and (c) 95% confidence level. The participants were selected based on a judgmental sampling method.

2.2. Study design and instruments

To assess the WTP for a dengue vaccine and its potential explanatory variables, a cross-sectional survey of communities was conducted from November 2014 to March 2015. To facilitate the interviews, a set of questionnaires adopted from previous studies was used (Abdullah et al., 2013; Dhimal et al., 2014; Filmer and Pritchett, 1999; Hadisoemarto and Castro, 2013). The questionnaires had been developed to measure participants' WTP for a dengue vaccine and to collect information on their demographic background, economic status, history of past episodes of DF, knowledge, attitude and practice (KAP) regarding dengue, and attitude towards vaccination practice. To validate the research instrument, a pilot study to assess the reliability of the questionnaires was conducted in two regencies of Aceh province (Aceh Barat Daya and Aceh Pidie Jaya) prior to the survey. The reliability of questionnaires for the KAP domain and other domains used in this study was reported elsewhere (Harapan et al., 2016a).

2.3. Study variables

2.3.1. Response variable

To assess the WTP for a dengue vaccine, it was hypothesized that a safe and fully protective dengue vaccine against dengue viruses was available. To determine the amount of money that participants would be willing to pay for a dengue vaccine, a list of dengue vaccine prices was provided in interval (the median: free; 10,000; 17,500; 37,500; 62,500; 87,500; 150,000 and 200,000 Indonesian Rupiah [IDR], equivalent to US-$ 0.73, 1.28, 2.75, 4.58, 6.41, 11.00 and 14.66, using a May 2016 exchange rate). For the analysis presented in this article, the median of the intervals and US-$ values were used. The participants were asked to answer whether they were "very likely", "likely", "undecided", "unlikely" or "very unlikely" to buy the vaccine at each particular price, in an ascending manner. This technique was a modification of the model proposed previously (Blomquist et al., 2009). If the participant refused to accept the free dengue vaccine, the interview was terminated. If the participant accepted the dengue vaccine and was willing to pay the lowest price (US-$ 0.73), the price was then increased until the participant was no longer willing to pay, i.e., "unlikely" or "very unlikely" as answer were reached. The WTP was defined as the highest accepted price, i.e., the highest price the participants said they were still "very likely" or "likely" willing to pay.

2.3.2. Explanatory variables

a Demographic data and personal history of past dengue fever

The basic demographic background such as age, gender, educational attainment, type of occupation, marital status, monthly income and type of residence were collected. The date of birth was recorded and converted into actual age. The educational attainment was defined as the highest level of formal education completed. Five general types of occupation were assigned to classify occupation based on the main job of the participants: (1) farmer; (2) civil servant; (3) private sector employee; (4) entrepreneur (owned a small-scale business, or traders in the market) and (5) student or university student. Monthly income was defined as the average amount of money earned by participants each month. Type of residence was divided into city (located in the capital city of a district [*kecamatan*] or regency [*kabupaten*]) and suburb (located in the villages [*desa*]). Inhabitants of the cities mostly worked as civil servants, in the market or had their own small business while inhabitants of the suburbs mostly worked as farmers. In addition, the participants' history of previous episodes of DF, and having family members who had suffered from DF, were also collected.

b Economic status

To collect data on their economic status, fifteen household assets owned by participants such as electronic devices, motorcycle, car, and characteristics of the house were recorded. The full list of these household assets was published elsewhere (Harapan et al., 2016a,b). The ownership of these assets was used to construct an asset index based on Principal Component Analysis (PCA) (Filmer and Pritchett, 1999).

c Knowledge, attitude and practice regarding dengue

A set of questionnaires was adapted from previous studies (Abdullah et al., 2013; Dhimal et al., 2014; Hadisoemarto and Castro, 2013) and used to assess KAP domain regarding dengue. The knowledge domain was divided into two parts: knowledge regarding dengue viruses (transmission, vector and prevention) and knowledge regarding DF (signs and symptoms of DF) with 15 and 13 questions, respectively. The possible responses to all questions within the knowledge domain were "yes" or "no." Each valid response was given a score of one, whereas an incorrect response was given a score of zero. To measure the attitude domain, the participants were asked to respond to the 15 attitude questions or statements related to dengue, on a five-point Likert-like scale ranging from "strongly agree" to "strongly disagree". A score of one to five could be achieved for each statement. To measure the practice domain, the participants were asked 16 questions related to measures they were taking to eliminate mosquito breeding sites and to prevent mosquito-man contact. Each valid response was given a score of one, whereas an incorrect response was given a score of zero. For each of the KAP domains presented, a higher score indicated a better knowledge, a more positive attitude and a better preventive practice, respectively.

d Attitude towards vaccination practice

Five statements related to vaccine safety and benefits and practices related to vaccination, modified from a previous study (Hadisoemarto and Castro, 2013), were used to measure the attitude towards vaccination practice. The possible responses were recorded on a five-point Likert-type scale ranging from "strongly agree" to "strongly disagree." A score of one to five could be received for each statement with higher scores indicating a more positive attitude.

2.4. Ethical considerations

Ethical approval for this study was obtained from the Ethical Clearance Committee of the School of Medicine, Syiah Kuala University, Banda Aceh, Indonesia. Participation in this study was voluntary, and participants received no incentive. Written informed consent was obtained from all participants prior to enrolment.

2.5. Statistical analysis

The scores for the KAP regarding dengue and for attitude towards vaccination practice were computed as the sum of the response scores within each domain. Additive scale scores ranged from 0 to 28, 15 to 75 and 0 to 16 for the KAP domains, respectively, and from 5 to 25 for attitude toward vaccination practice. For statistical analysis, the level of these domains was dichotomized into "good" and "poor" based on an 80% cut-off point from the possible maximum score.

The asset index for economic status was calculated based on PCA (Filmer and Pritchett, 1999) which summarized the information contained in asset variables to a smaller number of mutually orthogonal components of the data. The first principal component captured the most common variation among them and was used as the index of the underlying variables. The asset index (the first principal) was then used to classify the economic status into five quintiles: the 1st quintile representing the poorest and the 5th quintile representing the least poor. The first principal explained 21.99% of the variance of the data.

To assess the explanatory variables influencing participants' WTP for a dengue vaccine, a linear regression analysis was employed. This analysis is widely accepted and has been used in previous studies in the context of different vaccines (Birhane et al., 2016; Hansen et al., 2013; Sauerborn et al., 2005). Several stages were conducted prior to a final multivariate linear regression analysis. First, diagnostic procedures were performed to check how well the data met the linear regression assumptions using the multivariate model. Variance Inflation Factor (VIF) (O'Brien, 2007), Lagrange multiplier test (Breusch, 1978), Glejser test (Glejser, 1969) and Kolmogorov-Smirnov test (Yap and Sim, 2011) were used to assess the multicollinearity, autocorrelation, heteroscedasticity and normality assumption, respectively. A VIF lower than 10 and tolerance value (1/VIF) of greater than 0.1 were used as a cut-off point to indicate that there was no multicollinearity between variables. A p-value greater than 0.05 in the Lagrange multiplier, Glejser, and Kolmogorov-Smirnov tests was used as a cut-off point to indicate that there was no autocorrelation and heteroscedasticity, and to indicate normal distribution of residuals, respectively. Our initial diagnostic step indicated that the data violated two linear regression assumptions: the heteroscedasticity and normality.

Second, since the data violated two linear regression assumptions, an attempt to attain the validity of these assumptions was made using a function of natural logarithm (Ln) transformation of WTP values. After transformation, we found that our new multivariate model met all assumptions. The VIF scores ranged from 1.130 to 5.408 and the tolerance scores from 0.185 to 0.888 indicating that no multicollinearity was observed between the explanatory variables. None of the p-values for Lagrange multiplier or Glejser tests were lower than 0.05 and therefore no autocorrelation and heteroscedasticity existed. In addition, a p-value of 0.078 was found in the Kolmogorov-Smirnov test indicating a normal distribution of residuals.

Third, we examined the relation between the explanatory variables and transformed WTP using the new multivariate linear regression model. Because this study was an exploratory study, all explanatory variables that were significant at $P < 0.25$ in the initial multivariate linear regression model were retained and included in the final linear regression model. The $P < 0.25$ cut-off point was used as proposed previously (Dhimal et al., 2014; Koenraadt et al., 2006). Two-step linear regression analysis was used to ensure that all important explanatory variables were included in the final model. The coefficient and its corresponding 95% confidence interval (95% CI) and the direction of the linear association between explanatory and response variable were determined from the transformed model. In addition, the association between an explanatory and response variable was interpreted in relation to one of the categories designated as reference category. In our model, each predicted value of Ln WTP is in natural log scale and should follow a normal distribution.

Finally, the mean estimated WTP in US-$ and its 95% CI were calculated as Exp $\left(X\hat{\beta} + \hat{\sigma}/2\right)$ where the $\hat{\beta}$ and $\hat{\sigma}^2$ were estimated regression coefficients and the mean squared error (MSE) of the multivariate regression model, respectively (Feng et al., 2014). For instance, for the final multivariate model, the mean estimated WTP in US-$ for participants who had good attitude towards vaccination practice was Exp $\left(0.249 + \left(1.097/2\right)\right)$ = US-$ 2.21. All analyses

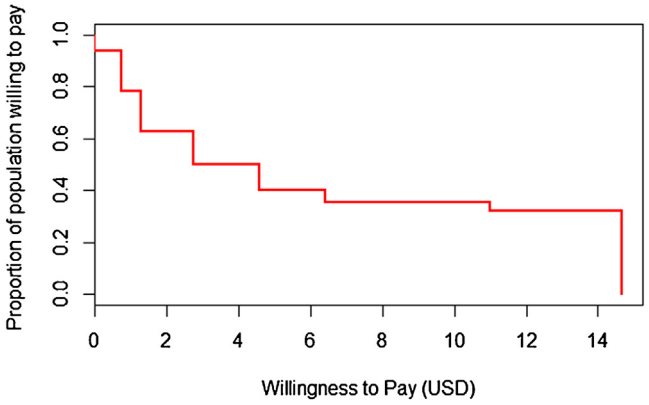

Fig. 1. Relationship between the presented price and proportion of participant who are willing to pay a dengue vaccine in Aceh, Indonesia.

were performed using Statistical Package for the Social Sciences software (SPSS for Windows, Version 15, Chicago, USA).

3. Results

3.1. Willingness to pay for a dengue vaccine

Data of 544 participants who provided complete information were included for analysis. The characteristics of the participants are presented in Table 1. We found that 509 participants were willing to accept a dengue vaccine, i.e., 6.4% (35/544) of the participants were unwilling to accept a dengue vaccine even if the vaccine was provided for free. In addition, 6.1% (33/544) stated that they would accept the vaccine only if it was provided for free. Therefore, only 476 participants (87.5% of those with complete data) who were willing to pay for a dengue vaccine were included in the final analysis.

The mean and median amounts of money the participants were willing to pay for a dengue vaccine were US-$ 4.04 (95% CI: 3.86–4.23) and US-$ 3.97 (95% CI: 3.74–4.23), respectively. Our J-shaped distribution revealed that more than 93.5% (509/544) of the total participants were willing to accept a dengue vaccine when it was provided for free (Fig. 1). This percentage started to decrease to approximately 87.5% (476/544) as the vaccine price went to US-$ 0.73, and decreased constantly to 58.45% and 32.90% for US-$ 2.75 and US-$ 11.00, respectively. At the highest price provided (US-$ 14.66), 29.77% (162/544) of the participants were still willing to pay for the dengue vaccine.

3.2. Factors associated with the willingness to pay for a dengue vaccine

The initial linear regression model revealed that age, gender, occupation, type of residence, having a personal history of DF, economic status, knowledge of dengue viruses, knowledge of DF, attitude towards dengue and preventive practice against dengue were to some degree associated with the WTP ($P < 0.25$) (Table 2). As this study was an exploratory study, all these explanatory variables were included in the final linear regression model.

Our final multivariate model revealed that occupation, type of residence, knowledge of dengue viruses, attitude towards dengue, and preventive practice against dengue were strongly associated with the WTP ($P < 0.05$) (Table 3). Participants who were working as civil servants and those living in the city had a higher WTP compared to farmers, entrepreneurs and private employees and those living in suburbs (higher approximately US-$ 2.66 and US-$ 2.76, respectively). In addition, participants who had good knowledge of dengue viruses, good attitude towards dengue and good preventive practice against dengue also had a higher WTP approximately US-$ 2.18 [95% CI: 0.12–4.23], US-$ 2.43 [0.37–4.48] and US-$ 2.18 [0.12–4.23], respectively compared to reference group. Age, sex, having a personal history of DF, economic status, knowledge of

Table 1
Descriptive statistics of study respondents (N = 544).

Variable	N (%)
Age group (year)	
17–29	266 (48.9)
30–44	198 (36.4)
45–59	72 (13.2)
60–84	8 (1.5)
Sex	
Male	168 (30.9)
Female	376 (69.1)
Education	
Primary school	57 (10.5)
Junior high school	32 (5.9)
Senior high school	213 (39.2)
Diploma	106 (19.5)
University graduate	136 (25.0)
Occupation	
Farmer	110 (20.2)
Civil servant	144 (26.5)
Private employee	71 (13.1)
Entrepreneur	105 (19.3)
Student/university student	114 (21.0)
Marital status	
Unmarried	205 (37.7)
Married	319 (58.6)
Widowed	20 (3.7)
Monthly income (Indonesian Rupiah)	
<1 million	276 (50.7)
1 – ≤ 2 million	115 (21.1)
2 – ≤ 3 million	86 (15.8)
>3 million	67 (12.3)
Type of residence	
Suburb	387 (71.1)
City	157 (28.9)
Having family member(s) who suffered from dengue fever	
Yes	108 (19.9)
No	436 (80.1)
Having personally experienced dengue fever	
Yes	48 (8.8)
No	496 (91.2)
Economic status	
Poorest quintile	107 (19.7)
2nd	110 (20.2)
3rd	109 (20.0)
4th	111 (20.4)
Richest quintile	107 (19.7)
Knowledge of dengue viruses	
Poor	279 (51.3)
Good	265 (48.7)
Knowledge of dengue fever	
Poor	352 (64.7)
Good	192 (35.3)
Attitude towards dengue	
Poor	394 (72.4)
Good	150 (27.6)
Preventive practice against dengue	
Poor	366 (67.3)
Good	178 (32.7)
Attitude towards vaccination practice	
Poor	441 (81.1)
Good	103 (18.9)

Table 2
Factors associated with the willingness to pay for a dengue vaccine (N = 476).

Parameter	Unstandardized coefficients				US-$ estimate			P-value
	B	95% CI of B		SE	Mean	95% CI		
		Lower	Upper			Lower	Upper	
Intercept	0.694	0.084	1.303	0.310	3.484	1.415	5.554	0.026
Age (*18–29 years*)								
30–44	−0.230	−0.525	0.064	0.150	1.383	−0.687	3.452	0.125
45–59	−0.001	−0.397	0.395	0.202	1.739	−0.330	3.809	0.996
60–84	0.215	−0.608	1.038	0.419	2.158	0.089	4.228	0.608
Sex (*Male*)								
Female	0.160	−0.059	0.380	0.112	2.044	−0.025	4.113	0.152
Education (*Primary school*)								
Junior high school	−0.171	−0.687	0.345	0.262	1.468	−0.602	3.537	0.516
Senior high school	0.011	−0.413	0.434	0.216	1.760	−0.309	3.829	0.960
Diploma	−0.011	−0.505	0.483	0.251	1.722	−0.348	3.791	0.965
University graduate	0.272	−0.230	0.775	0.256	2.286	0.217	4.356	0.287
Occupation (*Farmer*)								
Civil servant	0.436	−0.006	0.878	0.225	2.693	0.624	4.763	0.053
Private employee	0.164	−0.310	0.638	0.241	2.051	−0.018	4.120	0.497
Entrepreneur	0.197	−0.167	0.562	0.186	2.121	0.052	4.191	0.288
Student/university student	0.365	−0.094	0.824	0.234	2.508	0.439	4.578	0.119
Marital status (*Unmarried*)								
Married	−0.118	−0.425	0.189	0.156	1.548	−0.522	3.617	0.451
Widowed	−0.232	−0.818	0.353	0.298	1.380	−0.689	3.449	0.436
Monthly income (*<1 million IDR*)								
1- < 2 million IDR	0.070	−0.206	0.347	0.141	1.868	−0.201	3.938	0.617
2– ≤ 3 million IDR	0.024	−0.335	0.383	0.183	1.783	−0.286	3.853	0.895
>3 million IDR	0.193	−0.238	0.624	0.219	2.112	0.042	4.181	0.380
Type of residence (*Suburb*)								
City	0.442	0.206	0.677	0.120	2.708	0.638	4.777	0.000
Having family member(s) who suffered from dengue	−0.061	−0.332	0.209	0.137	1.637	−0.432	3.707	0.655
Having personally experienced dengue fever	0.262	−0.127	0.650	0.198	2.262	0.192	4.331	0.186
Economic status (*Poorest quintile*)								
2nd	−0.110	−0.439	0.220	0.168	1.560	−0.509	3.630	0.514
3rd	−0.248	−0.586	0.089	0.172	1.358	−0.711	3.428	0.149
4th	−0.219	−0.569	0.130	0.178	1.398	−0.671	3.467	0.218
Richest quintile	−0.326	−0.711	0.059	0.196	1.257	−0.813	3.326	0.097
Good knowledge of dengue viruses	0.184	−0.036	0.403	0.112	2.092	0.022	4.161	0.101
Good knowledge of dengue fever	−0.124	−0.336	0.087	0.108	1.538	−0.532	3.607	0.248
Good attitude towards dengue	0.306	0.064	0.549	0.123	2.365	0.296	4.434	0.013
Good preventive practice against dengue	0.225	0.012	0.438	0.108	2.180	0.110	4.249	0.039
Good attitude towards vaccination practice	0.234	−0.051	0.518	0.145	2.199	0.130	4.268	0.107
Mean squared error (MSE)	1.109							
F value	3.931 ($P < 0.001$)							
R^2	0.209							

CI: confidence interval.
IDR: Indonesian rupiah.
US-$: United States dollar.
SE: standard error.

DF and attitude towards vaccination practice had no significant association with the WTP.

4. Discussion

This study was conducted to assess the WTP for a hypothetical dengue vaccine and its associated determinants among healthy community members in nine regencies of Aceh province, Indonesia. The mean amount participants of our study were willing to pay was US-$ 4.04. A higher WTP was positively associated with living in the city, working as a civil servant, and having a good knowledge on dengue viruses, a good attitude towards dengue and good preventive practice against dengue. These findings are comparable with those from previous studies in Bandung, Indonesia (Hadisoemarto and Castro, 2013), the Philippines (Palanca-Tan, 2008), Vietnam, Thailand and Colombia (Lee et al., 2015). We were surprised to see that the mean WTP and the percentage of participants willing to pay the highest vaccine price were higher in Aceh than in the economically more prosperous city of Bandung (Hadisoemarto and Castro, 2013). However, the WTP in Aceh was lower than in the Philippines (Palanca-Tan, 2008), Vietnam, Thailand and Colombia (Lee et al., 2015). It seems that these differences are not directly influenced by the per capita Gross Domestic Product (GDP) of the regions (BPS, 2016) or per capita GDP of these countries (World Bank, 2016) but rather by the direct income of the households. Although our study indicated that monthly income and economic status had no association with WTP, a previous study reported that household income was one of the most important determinants of a higher WTP (Lee et al., 2015). Comparisons across these studies are however difficult because they used different hypothetical scenarios (e.g., of vaccine effectiveness, protection time, dose, administration procedure) and different vaccine prices because the exact price was not

Table 3
Final model of factors associated with the willingness to pay for a dengue vaccine (N = 476).

Parameter	Unstandardized coefficients				US-$ estimate			P-value
	B	95% CI of B		SE	Mean	95% CI		
		Lower	Upper			Lower	Upper	
Intercept	0.653	0.253	1.053	0.204	3.324	1.267	5.382	0.001
Age (*Other age groups*)								
30–44	−0.290	−0.509	−0.072	0.111	1.294	−0.763	3.351	0.009
Sex (*Male*)								
Female	0.136	−0.072	0.345	0.106	1.982	−0.075	4.040	0.199
Occupation (*Farmer, entrepreneur, private employee*)								
Civil servant	0.433	0.195	0.671	0.121	2.667	0.610	4.724	0.000
Student/university student	0.229	−0.037	0.496	0.136	2.176	0.118	4.233	0.091
Type of residence (*Suburb*)								
City	0.469	0.246	0.693	0.114	2.766	0.708	4.823	0.000
Having personally experienced dengue fever	0.202	−0.143	0.548	0.176	2.118	0.060	4.175	0.251
Economic status (*Poorest and 2nd quintile*)								
3rd	−0.248	−0.586	0.089	0.172	1.358	−0.711	3.428	0.149
4th	−0.115	−0.384	0.154	0.137	1.543	−0.515	3.601	0.402
Richest quintile	−0.086	−0.351	0.178	0.135	1.587	−0.471	3.644	0.522
Good knowledge of dengue viruses	0.231	0.025	0.437	0.105	2.180	0.122	4.237	0.028
Good knowledge of dengue fever	−0.114	−0.318	0.089	0.104	1.543	−0.515	3.600	0.271
Good attitude towards dengue	0.340	0.105	0.576	0.120	2.431	0.374	4.488	0.005
Good preventive practice against dengue	0.232	0.024	0.440	0.106	2.182	0.124	4.239	0.029
Good attitude towards vaccination practice	0.249	−0.028	0.526	0.141	2.218	0.161	4.276	0.078
Mean squared error (MSE)	1.097							
F value	7.727 ($P < 0.001$)							
R^2	0.190							

CI: confidence interval.
US-$: United States dollar.
SE: standard error.

known when the studies were conducted. In addition, the cultural and social backgrounds of respondents could also influence their WTP.

Our study revealed that neither age, gender, educational attainment, marital status, monthly income, personal history of DF nor economic status had an association with the WTP of participants. In a dengue vaccination context, previous studies also found that age (Palanca-Tan, 2008; Lee et al., 2015), gender (Hadisoemarto and Castro, 2013; Palanca-Tan, 2008), educational attainment (Hadisoemarto and Castro, 2013; Lee et al., 2015), knowing a person who had had DF (Hadisoemarto and Castro, 2013; Lee et al., 2015), or having family members who had suffered from DF (Palanca-Tan, 2008) had no or no consistent association with WTP. The summary of the factors and their association with WTP for a dengue vaccine are presented in Table 4. In other vaccination contexts, age (Sauerborn et al., 2005; Slunge, 2015; Udezi et al., 2010), gender (Birhane et al., 2016; Udezi et al., 2010), marital status (Sauerborn et al., 2005; Udezi et al., 2010), educational attainment (Sauerborn et al., 2005; Slunge, 2015; Udezi et al., 2010;), or a history of previous infection (Hou et al., 2014; Udezi et al., 2010) had no or no consistent effect on WTP, either.

Interestingly, there was no association between the monthly income or economic status and the WTP of our study population. In previous studies, per capita income and economic status had positive associations with the WTP for a dengue vaccine (Hadisoemarto and Castro, 2013; Lee et al., 2015; Palanca-Tan, 2008) or other vaccines (Birhane et al., 2016; Sauerborn et al., 2005; Slunge, 2015) indicating that individuals with a higher income can afford a more expensive vaccine. However, a study on a hypothetical malaria vaccine in Nigeria found income to be negatively associated with the WTP for this vaccine (Udezi et al., 2010). There are, at least two possible explanations for these observations. First, the socioeconomic variables might behave differently across countries due to the diverse contexts of specific local situations. Second, these findings might be due to the high proportion of participants stating their WTP the highest vaccine price in the list (Fig. 1), possibly because this price was still substantially lower than the WTP of those participants.

As expected, we found participants working as civil servants and living in the cities to have a higher WTP compared to those working as farmers and living in the suburbs. Previous studies found that employment status was not associated with the WTP for other vaccines (Birhane et al., 2016; Hou et al., 2014; Udezi et al., 2010), possibly because the local situations are different. It should be noted that we found no difference in WTP between farmers and participants with other types of occupation, except civil servants. In the context of Aceh and Indonesia in general, civil servants (i.e., individuals working in the government sectors) have a higher socioeconomic status, a higher educational attainment and a better KAP regarding dengue (Harapan et al., 2016c). In our present study we found that knowledge on dengue viruses (a component of knowledge regarding dengue), attitude and practice regarding dengue are predictor factors for a higher WTP. This, in part, explains the higher WTP among civil servants who are living in the cities.

In addition, those with good knowledge of dengue were willing to pay more for a dengue vaccine. This supports previous findings from Bandung, Indonesia, showing that parents with the best knowledge of dengue had a significantly higher WTP for a pediatric dengue vaccine compared to parents with the least knowledge (Hadisoemarto and Castro, 2013). An association of good knowledge regarding the disease with a higher WTP were also observed for other vaccines such as rabies vaccine in the Philippines (Birhane et al., 2016), and pneumococcal and influenza vaccine in China (Hou et al., 2014). A possible explanation for this is that good knowledge will produce better behavior and improve the attitude towards vaccination. Good behavior and positive attitude towards

Table 4
Summary of studies regarding willingness to pay for a dengue vaccine and associated factors.

Variables	Present study	Hadisoemarto and Castro (2013)[a]	Lee et al. (2015)[b]			Palanca-Tan (2008)[c]	Palanca-Tan (2008)[d]
Location	Aceh, Indonesia	Java, Indonesia	Vietnam	Thailand	Colombia	Manila	Manila
Mean WTP	4.0	2.6	24.5	47.2	30.3	27.1–32.3	55.6–68.6
Median WTP	3.9	1.9	8.7	23.3	7.5	20.0–30.0	60.0
Dengue vaccine price	–	–	Yes	Yes	Yes	Yes	Yes
Age	Yes	Yes	Yes	No	No	Yes	No
Gender	No	No	No	No	No	Yes	No
Education	No	Yes	Yes	No	Yes	–	–
Know previous dengue cases	No	No	Yes	No	No	No	No
Previous vaccine purchase	–	–	Yes	–	No	–	–
Income	No	–	Yes	Yes	Yes	Yes	Yes
Economic status	No	Yes	–	–	–	–	–
Knowledge of dengue	No[e]	No	–	–	–	No	No
Attitude towards dengue (dengue seriousness)	Yes	–	No	No	Yes	–	
Attitude to vaccination	No	No	–	–	–	–	–
Practice against dengue	Yes	No	Yes	No	No	Yes	Yes

[a] Analysis based on scenario: the vaccine was 100% safe and protective against dengue and required a single dose (injection).
[b] Analysis based on scenario: the vaccine had 70–95% efficacy for 10–30 years, had no side effect, was safe and required three doses in six months interval (injection). The mean and median of WTP were parametric estimates (per dose).
[c] Analysis based on scenario: the vaccine was completely safe, had no side effects, available as an injection or oral drops and 100% protective against all four serotypes of dengue viruses for 1 year. The mean and median of WTP were non-parametric estimates.
[d] Analysis based on scenario: the vaccine was completely safe, had no side effects, available as an injection or oral drops and 100% protective against all four serotypes of dengue viruses for 10 year. The mean and median of WTP were non-parametric estimates.
[e] Combination between knowledge of dengue viruses and knowledge of dengue fever.

vaccination, in turn, are two important factors for the WTP for a vaccine. However, in other studies knowledge had no correlation with the WTP for a dengue vaccine (Palanca-Tan, 2008), an influenza vaccine (Worasathit et al., 2015) and a tick-borne disease vaccine (Slunge, 2015). There are, at least, two possible explanations for these different findings. First, knowledge may play a different role for the WTP as different vaccinations are influenced by different factors. Second, the measured knowledge might have no direct association with WTP. In this study, for example, not all knowledge regarding dengue was associated with WTP. Only knowledge on dengue viruses (how dengue viruses are transmitted, the vectors of dengue viruses, and how to prevent infection with dengue viruses) was associated with the WTP while knowledge on DF (knowing signs and symptoms of DF) had no association. Therefore, it could be essential to include this information when designing information packages for dengue vaccine introduction programs, in order to improve the acceptance and the WTP in the future.

Furthermore, we found that both good attitude and good preventive practices against dengue were associated with a higher WTP. In the dengue vaccine context, two previous studies did not assess the role of attitude towards dengue on WTP (Hadisoemarto and Castro, 2013; Udezi et al., 2010) while another found that the perceived seriousness of dengue was not associated with WTP (Lee et al., 2015). However, the evidence shows that there is an association between [the attitude towards, and perception of a disease] and [vaccination behavior and WTP] (Slunge, 2015; Worasathit et al., 2015). Attitude towards dengue was also associated with attitude towards dengue vaccination practice (Harapan et al., 2016d). The association of practice regarding dengue with WTP for a dengue vaccine had been explored in two previous studies (Hadisoemarto and Castro, 2013; Palanca-Tan, 2008). Interestingly, dengue prevention measures were associated with WTP in Manila, Philippines (Palanca-Tan, 2008), while no such association was found in Bandung, Indonesia (Hadisoemarto and Castro, 2013), possibly because dengue prevention practices in the communities are influenced mainly by local tradition and culture (Dhimal et al., 2014). Furthermore, in Manila, both knowledge and practice regarding dengue had no association with WTP (Palanca-Tan, 2008), while in Bandung (Hadisoemarto and Castro, 2013) and in our present study, they were both associated with WTP.

There was a relatively large fraction of participants (29.77%) who were willing to purchase dengue vaccine at the highest price provided (US-$ 14.66) indicating that there could be a market for the vaccine. However, in the Indonesian context, approximately 45% of the population is not covered by any health insurance, and social insurance schemes in Indonesia do not usually cover vaccination services (Hadisoemarto and Castro, 2013). Therefore, the provision of partially or fully subsidized vaccines will be necessary to achieve a high vaccination coverage.

It is important to note the methodological limitations of this study. First, to measure the maximum amount of money that a respondent would be willing to pay for a dengue vaccine, the interviewers went through a list of vaccine prices in an ascending manner starting from a free vaccine bid. This might have caused an anchoring effect bias and therefore a risk of underestimating the WTP. In the present study, although about 30% of respondents were willing to pay the dengue vaccine in the highest bid (US-$ 14.66), a study in Thailand, Vietnam and Colombia found a much larger fraction of respondents who were willing to purchase vaccines at higher price points (Lee et al., 2015). Therefore, it is recommended that similar future studies use a single or double bounded dichotomous choice question, with different bid levels randomly assigned to respondents. Second, the possibility of social desirability bias cannot be excluded in which participants might tend to give favorable answers to some questions in the WTP section. To minimize the psychological pressure during the interview of this section, we used a five-point Likert-like scale ranging from “very likely” to “very unlikely” rather than “yes” and “no”. Finally, “hypothetical bias”, the risk that participants misstate their actual preferences in a hypothetical survey compared to a real-life situation (List and Gallet, 2001), is also a possibility.

5. Conclusion

Our study revealed that there were significant modifiable determinants for WTP, including knowledge of dengue viruses, attitude towards dengue and preventive practice against dengue. In addi-

tion, a higher WTP was associated with living in the city and working as a civil servant, suggesting their suitability as market targets for a dengue vaccine. However, to increase the acceptance and WTP of community members and to achieve a high vaccination coverage, the provision of partially or fully subsidized vaccines combined with introduction programs to educate and encourage households regarding dengue preventive measures (and to improve attitude and awareness) will be necessary in the context of Indonesia.

Funding

None.

Authors' contributions

HH was responsible for the study design, conducting the study, data interpretation, and wrote the first draft and final manuscript. AB, AR, PA, RF, SS, RAB, AD, IA, MI, JA, FH, DD and MM collected and interpreted the data. SA and SP were responsible for data analyses, data interpretation, and revised the first draft and final manuscript. HH, MM, AI, RTS, ZS and SP were responsible for data interpretation, critically revised the first draft for intellectual content and wrote the final manuscript. UK contributed to data interpretation and manuscript writing. All authors read and approved the final manuscript.

Competing interests

None declared.

Acknowledgment

We would like to thank Dr. Panji Fortuna Hadisoemarto from the Department of Public Health, Faculty of Medicine, Padjadjaran University, for providing the SES questionnaire.

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